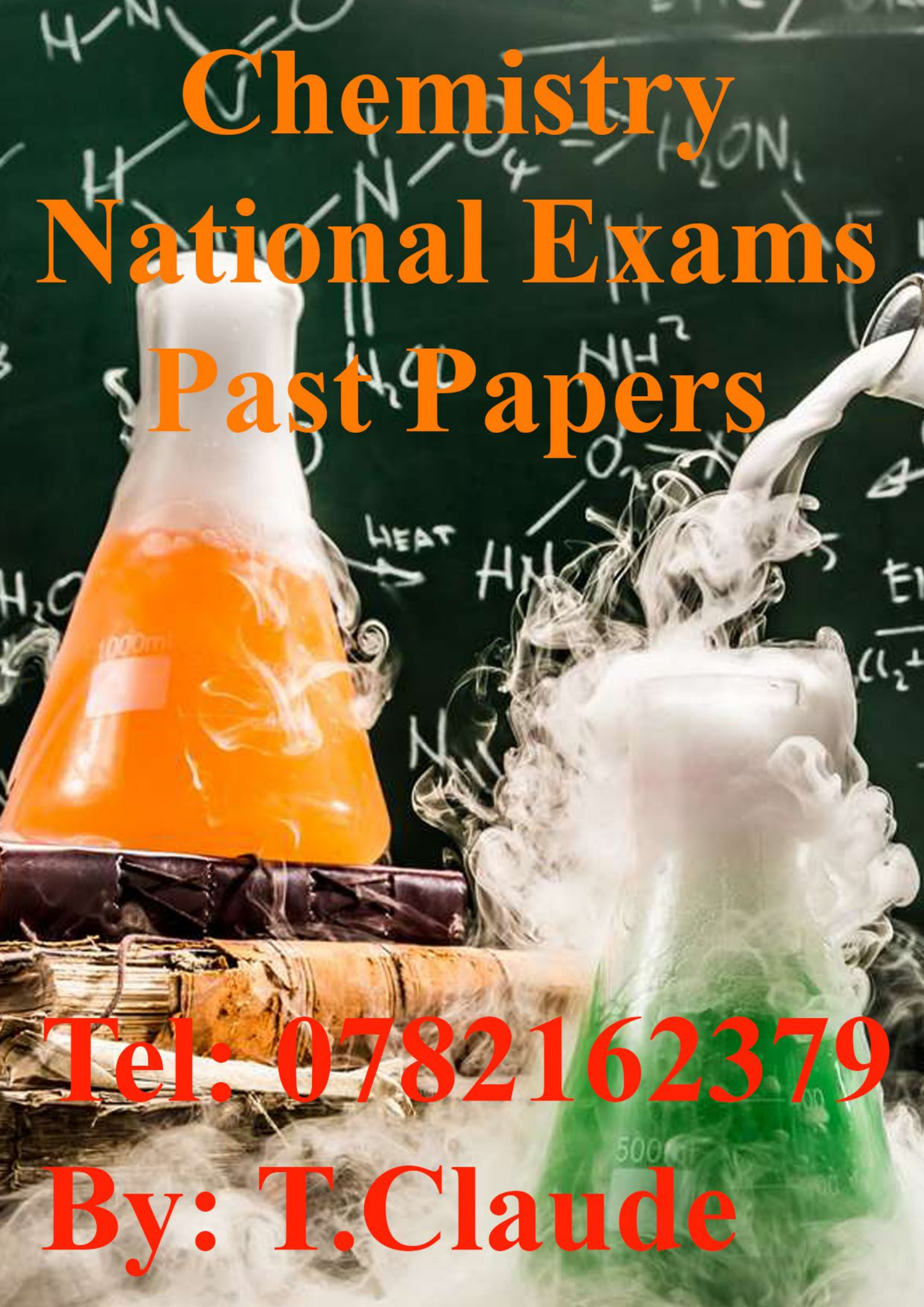
Chemistry
National Exams
Past Papers
Tel: 0782162379
By: T.Claude

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Top 10 study tips

1. Have all your materials ready before you begin studying: pencils, pens, papers, calculators if necessary etc.
2. Be positive. Make sure your brain holds on to the information you are learning by reminding yourself how important it is to remember the work and get the marks.
3. Take a walk outside. A change of scenery will stimulate your learning. You'll be surprised at how much more you take in after being outside in the fresh air.
4. Break up your learning sections into manageable parts. Trying to learn too much at one time will only result in a tired, unfocused and anxious brain.
5. Keep your study sessions short but effective and reward yourself with short, constructive breaks.
6. Teach your concepts to anyone who will listen. It might feel strange at first, but it is definitely worth reading your revision notes aloud.
7. Your brain learns well with colours and pictures. Try to use them whenever you can.
8. Be confident with the learning areas you know well and focus your brain energy on the sections that you find more difficult to take in.
9. Repetition is the key to retaining information you have to learn. Keep going – don't give up!
10. Sleeping at least 8 hours every night, eating properly and drinking plenty of water are all important things you need to do for your brain. Studying for exams is like strenuous exercise, so you must be physically prepared.

" If you can't explain it simply, you don't understand it well enough".

Albert Einstein

On the day of the exam ...

1. Make sure you have all the necessary stationery for your exam, i.e. pens, pencils, eraser, protractor, compass, calculator (with new batteries). Make sure you bring your ID document and examination admission letter.
2. Arrive on time, at least one hour before the start of the exam.
3. Go to the toilet before entering the exam room. You don't want to waste valuable time going to the toilet during the exam.
4. Use the 10 minutes reading time to read the instructions carefully.
5. This helps to 'open' the information in your brain. Start with the question you think is the easiest to get the flow going.
6. Break the questions down to make sure you understand what is being asked. If you don't answer the question properly you won't get any marks for it. Look for the key words in the question to know how to answer it.

Try all the questions. Each question has some easy marks in it so make sure that you do all the questions in the exam.

7. Never panic, even if the question seems difficult at first. It will be linked with something you have covered. Find the connection.
8. Manage your time properly. Don't waste time on questions you are unsure of. Move on and come back if time allows.
9. Check weighting – how many marks have been allocated for your answer? Do not give more or less information than is required.
10. Write big and bold and clearly. You will get more marks if the marker can read your answer clearly.

Source: Alfie Bouwer, Sivalingam Chetty et al; 2014, ***Mind the gap, Life sciences study guide grade 12,*** Department of basic education, Pretoria, South Africa.

Note: Through the questions herein are fully answered, it is highly recommended that you first read and understand the question, make your trials and then compare with what is given in the solution. It is also advisable that you read through the book several times before the final examinations.

I am certain that if a student can answer all these questions in this document with ease, he/she should be able to pass with a distinction in the ordinary level national chemistry examination.

" Everyone is a genius. But if you judge a fish by its ability to climb a tree, it will spend its whole life believing that it is stupid. "
Albert Einstein

"Never say you have failed until you have reached your last attempt, and never say it's your last attempt until you have succeded. "

" There are no secrets to success. It's all about preparing, hard work and learning from failure. "

CHEMISTRY III

025

12th Nov. 2002 08.30 – 11.30 am

RWANDA NATIONAL EXAMINATIONS COUNCIL

P.O.BOX, 3817 KIGALI-TEL/FAX : 86871

ORDINARY LEVEL NATIONAL EXAMINATIONS 2001 / 2002

SUBJECT: CHEMISTRY III

DURATION: 3 HOURS

INSTRUCTIONS:

- This paper consists of **three** sections **A**, **B** and **C**
- Answer **ALL** questions in section A. **(55 marks)**
- Answer **THREE** questions in section B. **(30 marks)**
- Answer only **one** question in section C **(15 marks)**
- Calculators may be used.

SECTION A: ANSWER ALL QUESTIONS **(55 MARKS)**

1. The table below contains some information about two elements.

Elements	Protons	Neutrons	Electrons
Sodium	11	12	
Oxygen		10	8

(a) Complete the table. **(1 mark)**
(b) What is the isotopic mass (mass number) of oxygen? **(1 mark)**
(c) Write the electronic configuration of sodium. **(2 marks)**
d) Sodium reacts with oxygen to form sodium oxide. Write a balanced equation of the reaction. **(1 mark)**

2. Limestone ($CaCO_3$) is a mineral that is heated to produce lime (CaO). Lime is used in the manufacture of iron, cement and glass.
a) What is the chemical name for limestone? **(1 mark)**
b) The decomposition of Limestone is shown in the equation
$CaCO_3 \rightarrow CaO + CO_2$
Calculate the mass of lime (CaO) that would be produced from 2kg of limestone ($CaCO_3$). (Relative atomic masses: C = 12, O = 16, Ca = 40).
(2 marks)

3. Air is a mixture of many gases, some of which are shown in the table below. **(1.5 marks)**
a) Complete the table below.

Name	Chemical formula	Approximate percentage in air
Nitrogen		
Carbon dioxide	CO_2	
Inert gases	Ne, Ar etc.	1

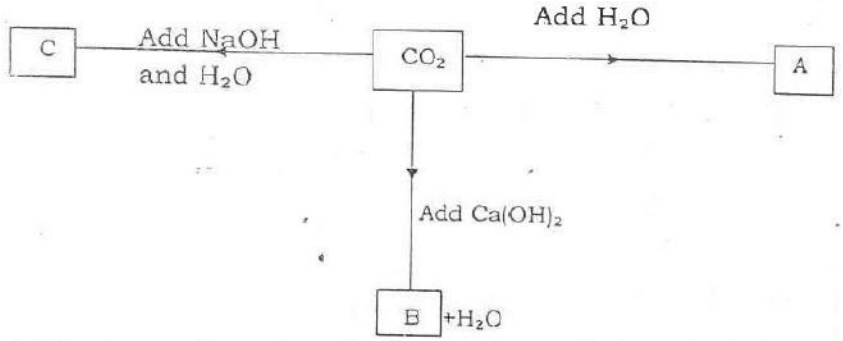
b) Mention one way in which carbon dioxide is removed from the atmosphere and one way in which it is supplied to the atmosphere.
(2 marks)

4. Hydrogen peroxide (H_2O_2) is used as a bleaching agent and as a source of oxygen.
(a) What is a bleaching agent? **(1 mark)**
(b) Write a balanced equation for the production of oxygen from hydrogen peroxide. **(1 mark)**
(c) The rate of decomposition of H_2O_2 is very slow at room temperature; suggest two ways of speeding up the decomposition. **(2 marks)**

5. The following is an exothermic reaction and takes place in presence of iron as a catalyst.
$N_2\,(g) + 3H_2\,(g) \rightleftharpoons 2NH_3$
(a) What do you understand by exothermic reaction? **(1 mark)**
(b) What does the sign $\rightleftharpoons$ mean in the equation? **(1 mark)**
(c) What would be the effect on the amount of ammonia produced if the pressure was increased beyond 600 atm? **(1 mark)**

(d) What would be the effect on the amount of ammonia produced if the temperature was increased beyond 600°C? **(1 mark)**

6. Some reactions involving carbon dioxide, CO_2 are shown below. Study the chart below and answer the questions that follow.



a) What are the chemical names and chemical formulae for substances A, B and C? **(3 marks)**

b) Write a balanced equation for the formation of substances A, B and C. **(1 mark)**

7. The molecular formulae of two organic substances X and y are given below.

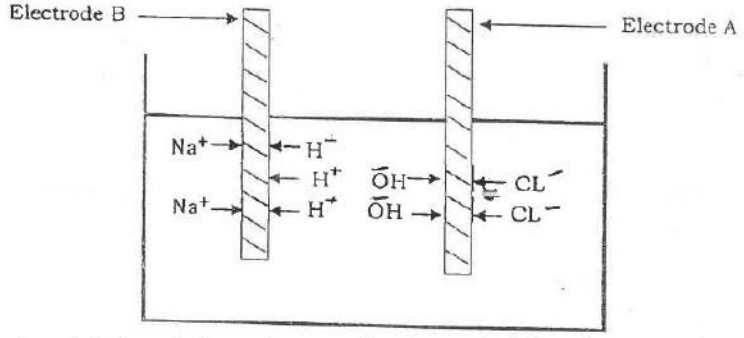
X = C_4H_{10}, Y: C_4H_8

a) Write two structural formulae of substance X and give their chemical names. **(2 marks)**

b) Write one structural formula of Y and give its chemical name. **(1 mark)**

c) Write a balanced chemical equation for the reaction of X with chlorine. **(1 mark)**

8. The diagram below shows the direction of movement of ions during electrolysis of dilute sodium chloride solution (NaCl).



a) Which of the electrode A and B is the anode? **(1 mark)**

b) Which element (substance) is formed at electrode B? Write an equation for the reaction taking place at B. **(2 marks)**

c) At electrode A, there are two different gases that are likely to form. What chemical test would you use to show the presence of a gas which is the main product? **(1 mark)**

9. The table below shows the reactivity of some metals with water and dilute sulphuric acid. Study the table very carefully and answer the questions that follow.

Metal	**Reaction with water**	**Reaction with dilute sulphuric acid**
Calcium	Hydrogen formed fast	Not advisable
Copper	No reaction	No reaction
Iron	Rust was formed slowly	Hydrogen formed slowly.
Magnesium	Hydrogen formed slowly	Hydrogen formed quickly.

a) Which of the above substances is the most reactive? **(1 mark)**

b) Which of the above substances is the least reactive? **(1 mark)**

c) Why is it not advisable to react calcium with dilute sulphuric acid? **(1 mark)**

d) How would you show that hydrogen is evolved when magnesium reacts with dilute sulphuric acid? **(1 mark)**

10. Copper can be extracted from an ore called copper pyrites whose formula is $CuFeS_2$.

a) Give the chemical names of the elements present in copper pyrites. **(1 mark)**

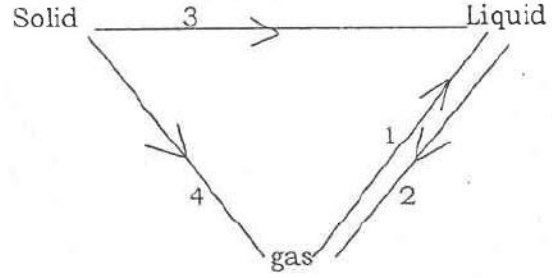
b) Copper is obtained by heating the ore in controlled supply of air with sand (SiO_2).

The reaction is $2CuFeS_2 + 2SiO_2 + 5O_2 \rightarrow 2Cu + 4SO_2 + 2FeSiO_3$. **(2 marks)**

How much copper would be obtained by heating 36.7g of $CuFeS_2$?

Atomic mass: Cu = 63.5, Fe = 56, S = 32.

11. The figure below shows some changes of state. The direction of the arrow shows the change of state it is.



a) Name changes or processes 1, 2, 3 and 4. **(2 marks)**

b) State two differences between a solid and a gas. **(2 marks)**

12. Calculate the percentage composition of oxygen in one mole of Aluminium sulphate $Al_2(SO_4)_3$. Relative atomic masses are: Al = 27, S = 32, O = 16. **(3 marks)**

13. Study the table below and answer the questions that follow.

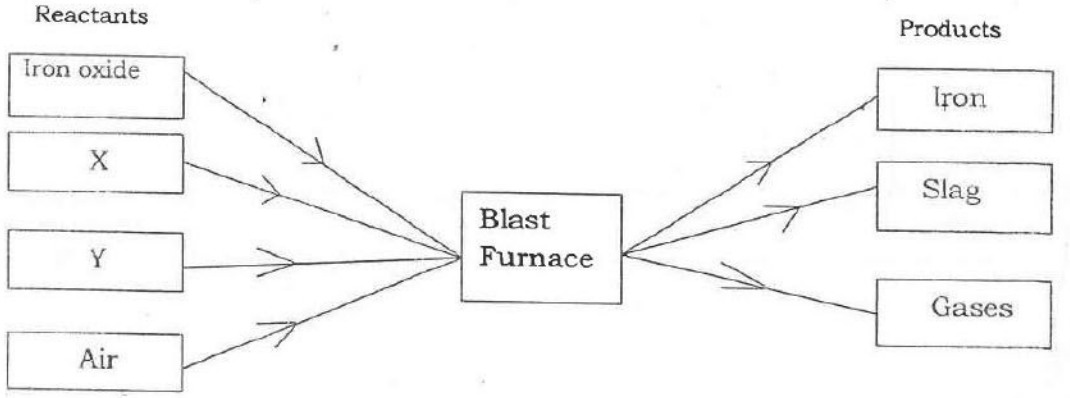
Substance	**Melting point (°C)**	**Boiling point (°C)**
Methanol	- 94	65
Ethanol	- 117	79
Water	0	100

a) Which of the three substances is the most volatile? **(1 mark)**
b) Which substance becomes a liquid at the highest temperature? **(1 mark)**
c) Write the chemical formula for ethanol. **(1 mark)**

14. An organic compound contains 52.17% of carbon, 13% of hydrogen and the rest being oxygen.
a) Calculate the empirical formula of the compound. **(3 marks)**
b) Given that the relative molecular mass is 92, determine its molecular Formula. **(2 marks)**

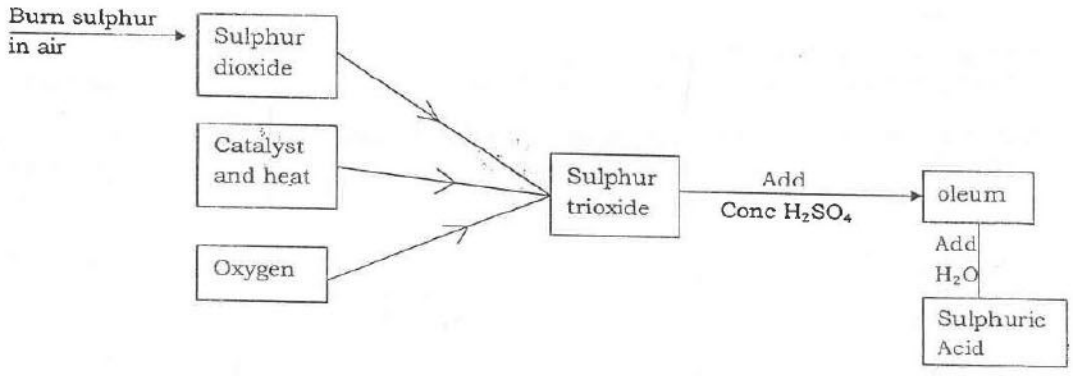
SECTION B: Attempt any THREE questions in this section. (3O marks)

15. The ore haematite contains iron oxide. The following flow diagram (chart) shows how iron is extracted from its ore haematite. Study the diagram and answer the questions that follow.



a) Name substances X and Y. **(2 marks)**
b) The chemical reaction for the formation of iron is
Fe_2O_3 (s) + 3CO (g) → 2Fe (s) + $3CO_2$ (g)
From the above equation, identify which substance is a reducing agent and which substance is an oxidizing agent. **(2 marks)**
c) Give the chemical names of three substances in the slag. **(3 marks)**
d) The blast furnace should be located (built) where conditions are suitable for an industry. Mention three conditions to consider before deciding where to put the industry. **(3 marks)**

16. Below is a simplified flow diagram for the manufacture of sulphuric acid. Study the diagram and answer the questions that follow.



a) Write a balanced equation for the formation of sulphur dioxide from oxygen and sulphur dioxide. **(2 marks)**

b) Starting with $50cm^3$ of sulphur dioxide and $5Ocm^3$ of oxygen.

i) Calculate the volume of sulphur trioxide formed. **(2 marks)**

ii) Calculate the volume of oxygen that remains unreacted. **(1 mark)**

c) Name the catalyst used in the formation of sulphur trioxide. **(1 mark)**

d) Write an equation to show how concentrated sulphuric acid reacts with:

i) Copper **(1 mark)**

ii) Carbon **(1 mark)**

e) Name two environmental problems that can be caused by the presence of sulphur dioxide in the atmosphere. **(2 marks)**

17. The following is a periodic table showing some elements. Use the table and the elements shown to answer the equations that follow.

1	2 ← groups →										3	4	5	6	7	8
H																He
												C	N	O	F	
Na	Mg										Al		P	S	Cl	
K	Ca														Br	

a) How many electrons does an atom of element F contain? **(1 mark)**

b) Write the electronic configuration of the element C. **(1 mark)**

c) Give the symbols of two elements that belong to alkaline metals. **(1 mark)**

d) Give the formula of the compound formed between elements Mg and P. **(2 marks)**

e) Select one element that will form a basic oxide, one element that will form an acidic oxide and one element that will form an amphoteric oxide. **(3 marks)**

f) Use a dot and a cross to show the bonding in CH_4. **(2 marks)**

18. a) Explain how you would obtain a pure sample of zinc sulphate and a pure sample of copper powder. **(8 marks)**

b) Write an ionic equation from the following chemical reaction.

$ZnSO_4$ (aq) + $BaCl_2$ (aq) → $ZnCl_2$ (aq) + $BaSO_4$ (aq). **(2 marks)**

19. a) With the aid of a well labelled diagram, describe an experiment to prepare hydrogen chloride gas (HCl) from sodium chloride (NaCl). **(8 marks)**

b) Write an equation to show how HCl reacts with:

i. Ammonia gas **(1 mark)**

ii. Manganese IV oxide. (MnO_2) **(1 mark)**

SECTION C: Answer only one question in this section. (15 MARKS)

20. To determine the concentration of a solution of sulphuric acid, 25cm^3 of sulphuric acid was added to 2M of potassium hydroxide solution. The volume of potassium hydroxide required was 34 ml.

a) State three pieces of apparatus that would be used in this experiment. **(3 marks)**

b) How would you tell that the acid is completely neutralized by the base? **(1 mark)**

Given that the equation of the reaction is:

$2KOH\ (aq) + H_2SO_4\ (aq) \rightarrow K_2SO_4\ (aq) + 2H_2O$.

c) Calculate the number of moles of potassium hydroxide used in the titration. **(2 marks)**

d) Calculate the concentration of sulphuric acid in g/dm^3. **(5 marks)**

Relative atomic masses are H = 1, S = 32, O = 16, K = 39.

e) Suggest two uses of sulphuric acid and two uses of potassium hydroxide. **(4 marks)**

21. In an experiment to determine how hydrogen is produced when magnesium powder reacts with dilute hydrochloric acid, the volume of hydrogen produced, was measured at different intervals. The following results were obtained.

Time (seconds)	0	5	10	20	30	40	50	60
Volume of H_2 collected (cm^3)	0	32	52	78	93	95	95	95

a) Plot a graph of volume of H_2 produced (on the y-axis) versus time (x-axis). **(9 marks)**

b) Why is the volume of H_2 constant in the last three results? **(1 mark)**

c) Suggest a suitable instrument or piece of apparatus that can be used to measure the volume of H_2. **(1 mark)**

d) Why is the volume of H_2 = 0cm^3 when the time = 0 seconds? **(1 mark)**

e) How would you prove that hydrogen gas is evolved in each experiment? **(1 mark)**

f) State two industrial uses of hydrogen gas. **(2 marks)**

22. With the help of equations where possible, state the chemical test that would be used to distinguish each pair of the following substances and state the observation in each case:

a) $Zn(NO_3)\ (aq)$ and $Fe(NO_3)\ (aq)$. **(3 marks)**

b) $NaCl\ (aq)$ and $Na_2CO_3\ (aq)$ **(3 marks)**

c) Ethane and Ethanol **(3 marks)**

d) SO_2 and Cl_2 gases, **(3 marks)**

e) $Pb(NO_3)_2$ and $Cu(NO_3)_2\ (s)$ **(3 marks)**

MARKING SCHEME OF ORDINARY LEVEL CHEMISTRY NATIONAL EXAMINATION 2001/2002

Section A: Answer all questions

1. a)

Elements	Protons	Neutrons	Electrons
Sodium	11	12	11
Oxygen	8	10	8

b) Isotopic mass (mass number of oxygen) = protons + neutrons
= 8 + 10 = 18.

c) Electronic configuration of sodium: 2: 8: 1

d) $4Na + O_2 \rightarrow 2Na_2O$

2. a) Calcium carbonate

b) $CaCO_3 \rightarrow CaO + CO_2$

Mm of $CaCO_3$ = 40 + 12 + 16 x 3 = 100

Mm of CaO = 40 + 16 = 56.

From the equation: 100g of $CaCO_3$ gives 56 g of CaO

1g of $CaCO_3$ = $\frac{56}{100}$ of CaO

2000 g of $CaCO_3$ will produce $\frac{56}{100} \times 2000 = 1120$ g of CaO

3. a)

Name	Chemical formula	Approximate percentage of air
Nitrogen	N_2	78
Carbon dioxide	CO_2	0.03
Inert gases	Ne, Ar etc...	1

b) One way CO_2 is removed from the atmosphere is through photosynthesis and one way in which CO_2 is supplied to the atmosphere is through respiration.

4. a) A bleaching agent is a chemical substance which decolorizes other substances.

b) $2H_2O_2 \rightarrow 2H_2O + O_2$

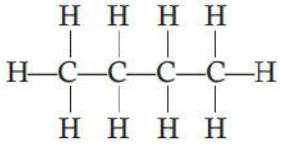
c) Two ways of speeding up the decomposition are:

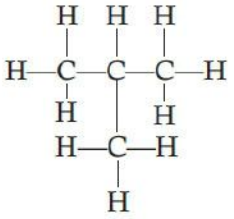
i) Increasing the concentration of hydrogen peroxide.
ii) Using manganese (IV) oxide as a catalyst.

5. a) An exothermic reaction is a reaction in which heat is given out.
   b) It means a reversible reaction.
   c) Increasing pressure: Increasing the amount of Ammonia produced.
   d) Increasing temperature: Decreasing the amount of Ammonia produced.

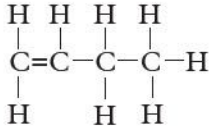
6. a) A: Carbonic acid, H_2CO_3
      B: Calcium carbonate, $CaCO_3$
      C: Sodium hydrogen carbonate, $NaHCO_3$
   b) $2NaOH + H_2O + CO_2 \rightarrow Na_2CO_3 + 2H_2O$

7. X = C_4H_{10}; Y = C_4H_8
   a) Two structural formulae of X and their chemical names.


: n-butane


: 2-methylpropane

   b) One structural formula of Y and its name.


: 1-butene or but-1-ene

   c) $C_4H_{10} + Cl_2 \rightarrow C_4H_9Cl + HCl$

8. a) Electrode A.
   b) Hydrogen. $2H^+ + 2e^- \rightarrow H_2$ (g)
   c) The main product is oxygen, it is tested using a glowing splint, it re-lights a glowing splint.

9. a) Calcium
   b) Copper

c) Calcium reacts with dilute sulphuric acid forming calcium sulphate which is insoluble and so prevents further reaction of calcium with H_2SO_4.

d) It burns with a pop sound.

10. a) Chemical names present in copper pyrites are: Copper, Iron, Sulphur

b) First find Mm of $CuFeS_2$: 63.5 + 56 + 32 X 2 = 183.5 g/mole

(2 X 183.5) g of $CuFeS_2$ produces 2 X 63.5 = 127 g of copper

36.7 of $CuFeS_2$ will produce $\frac{127}{2\times183.5} \times 36.7\ g = 12.7\ g$

11. a) 1 – Condensation

2 – Evaporation

3 – Melting

4 – Sublimation

b) Two differences between a solid and a gas

Solid	Gas
Its particles are very close to each other	Its particles are far apart
Proper shape	It takes the shape of the container

12. Rmm of $Al_2(SO_4)_3$ = 27 X 2 + 3 X 32 + 16 X 12 = 342

% of oxygen $= \frac{192\times100}{342} = 56.1\ \%$

13. a) Methanol

b) Water

c) C_2H_5OH or $CH_3\text{-}CH_2\text{-}OH$

14. a) Percentage of oxygen = 100 – (52.17 + 13) = 34.83%

Empirical formula of the compound:

C		H		O
$\frac{52.17}{12}$	:	$\frac{613}{1}$	:	$\frac{34.83}{16}$
4.34	:	13	:	2.17
$\frac{4.34}{2.17}$	:	$\frac{13}{2.17}$	:	$\frac{2.17}{2.17}$
2	:	6	:	1

Empirical formula is C_2H_6O

(b) Molecular formula of the compound:

$(C_2H_6O)\ n = 92$

$(12 \times 2 + 1 \times 6 + 16)n = 92$

$46\ n = 92$

$n = 2$

Molecular formula is $C_4H_{12}O_2$

SECTION B: Attempt any THREE questions in this section

15. a) X: Coke (carbon)

Y: lime stone

b) $Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$

Fe_2O_3 is the oxidizing agent.

CO is the reducing agent

c) Slag is calcium silicate: $CaSiO_3$

Chemical names substances in the slag are: calcium, silicon, oxygen.

d) An industry should be built in a place where there is/are: raw material, electric power, water and transport.

16. a) $2SO_2 + O_2 \rightarrow 2SO_3$

b) i) From the equation:

2V of SO_2 + 1V of $O_2 \rightarrow$ 2V of SO_3

1V of $SO_2 + \frac{1}{2}V$ of $O_2 \rightarrow$ 1 V of SO_3

50cm^3 of $SO_2 + \frac{1}{2} \times 50\ cm^3$ of $O_2 \rightarrow$ 5Ocm^3 of SO_3.

5Ocm^3 of SO_2 + 25cm^3 of $O_2 \rightarrow$ 50 cm^3 of SO_3.

ii) Volume of O_2 that remained unreacted = 50 - 25 = 25cm^3

c) Catalyst: V_2O_5

d) i) $Cu + 2H_2SO_4 \rightarrow CuSO_4 + SO_2 + 2H_2O$

ii) $C + 2H_2SO_4 \rightarrow 2SO_2 + CO_2 + 2H_2O$

e) Acid rain which increases soil acidity; dissolves minerals away (soil infertility and destroys stone works of buildings.

17. a) 9 electrons

b) 2, 4

c) Na, K

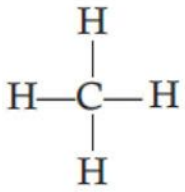
d) Mg_3P_2

e) Basic oxide: K, Na or Ca

Acidic oxide: S or C

Amphoteric oxide: Al

f)



18.a) Zinc powder and copper (II) sulphate solution are mixed. The reaction takes place.

i.e. $Zn\ (s) + CuSO_4\ (aq) \rightarrow ZnSO_4\ (aq) + Cu\ (s)$

After the reaction is over, filtration is done to separate zinc sulphate solution from a brown solid of copper.

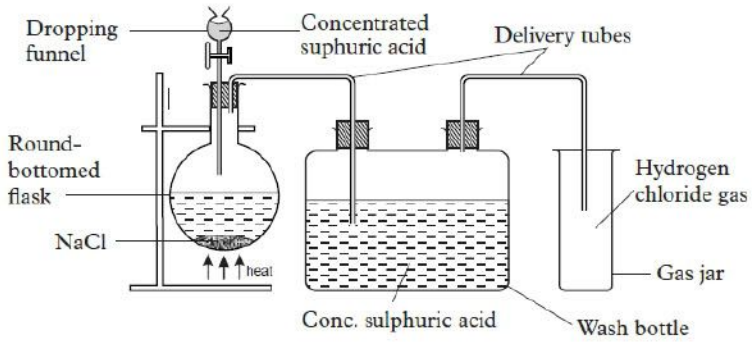
b) $ZnSO_4\ (aq) + BaCl_2\ (aq) \rightarrow BaSO_4\ (aq) + ZnCl_2\ (aq)$

Ionically:

$Zn^{2+}(aq) + SO_4^{2-}(aq) + Ba^{2+}(aq) + 2Cl^-(aq) \rightarrow BaSO_4(s) + Zn^{2+}(aq) + 2Cl^-(aq)$

Ionic equation: $Ba^{2+}\ (aq) + SO_4^{2-}\ (aq) \rightarrow BaSO_4\ (s)$

19.a)



Procedure

i. Place sodium chloride in a round-bottomed flask and set up the apparatus as shown in figure above.

ii. Add concentrated sulphuric acid drop wise until the sodium chloride is immersed.

iii. Heat the flask gently and collect several gas jars of the gas that you will use to test for the chemical properties of the gas.

iv. Direct dry hydrogen chloride gas through the inverted funnel to a beaker of water.

Insert moist blue and red litmus papers in a gas jar full of hydrogen chloride.

b) i) $NH_3 + HCl \rightarrow NH_4Cl$

ii) $MnO_2 + 4HCl \rightarrow MnCl_2 + Cl_2 + 2H_2O$.

SECTION C: Attempt one question from this section

20. a) Burette, Pipette, Conical flask

b) When the colour of the indicator in the solution just changes.

c) $2KOH\ (aq) + H_2SO_4\ (aq) \rightarrow K_2SO_4\ (aq) + 2H_2O\ (l)$

Number of moles of KOH = M X V = 0.034 dm^3 X 2 $moles.dm^{-3}$ = 0.068 mole

d) From the equation, two moles of KOH react with one mole of H_2SO_4.

0.068 mole of KOH will react with 0.034 mole of H_2SO_4

Molarity of acid $= \frac{n}{V} = \frac{0.034\ mole}{0.025\ dm^3} = 1.36\ mole/dm^3$

The concentration of sulphuric acid in g/dm^3 = M X Mm

Mm of H_2SO_4 = (1 X 2 + 32 + 4 X 16) = 98 g/mole

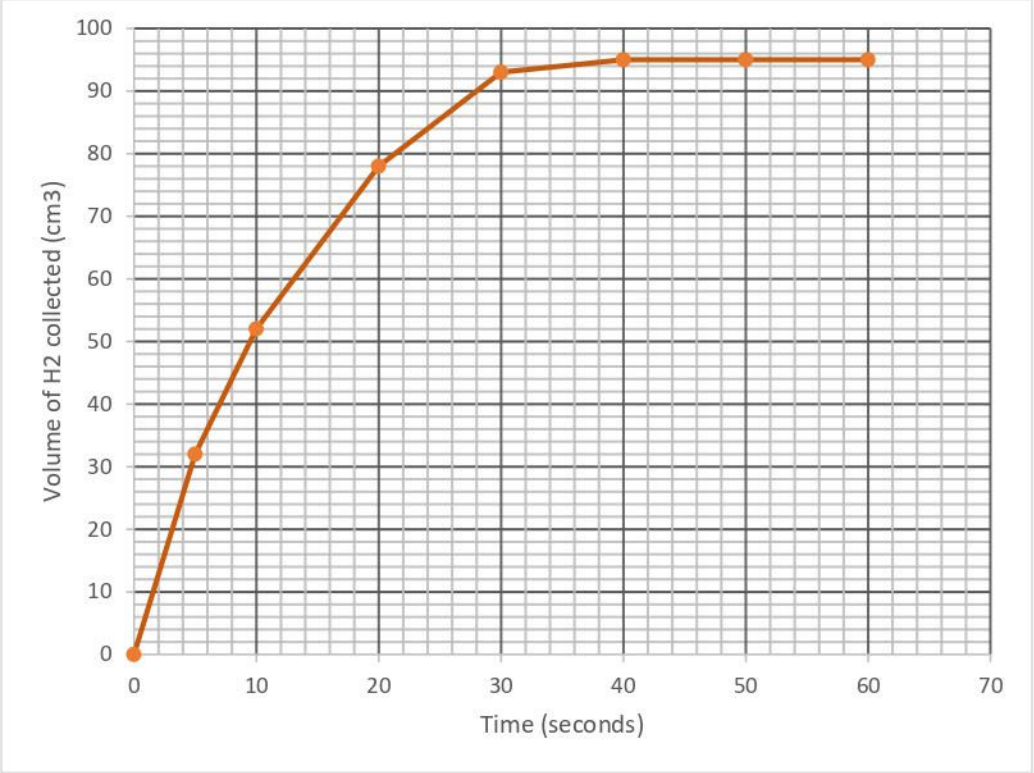
The concentration of sulphuric acid in g/dm^3 = 1.36 mole/dm3 X 98 g/mole

= 133.28 g/dm^3.

e) Two uses of H_2SO_4

- Used to manufacture fertilizers.
- Used in preparation of salts
- Used in manufacture of soft soap.

21. a) A graph of volume of H_2 versus time:



b) Because the reaction is over.
c) Syringe
d) The reaction has not yet started.
e) Using a burning splint, if a pop sound is observed, then the gas is hydrogen.
f) Uses of H_2:
- Manufacture of margarine (fats)
- Used as fuel.

22. To distinguish between each of the following substances.

a) $Zn(NO_3)$ (aq) and $Fe(NO_3)_3$ (aq)

Reagent: Ammonia solution (NH_4OH)

With Zn^{2+}, a white precipitate which dissolves in excess ammonia solution will be observed.

$Zn^{2+} + 2OH^- \rightarrow Zn(OH)_2$

With Fe^{3+}, a brown precipitate insoluble in excess NH_3 (aq) (NH_4OH)

$Fe^{3+} + 3OH^- \rightarrow Fe(OH)_3$

b) **NaCl (aq) and Na_2CO_3 (aq)**

Reagent: Acidified silver nitrate solution.

With Cl^-, a white precipitate is observed.

$Ag^+ + Cl^- \rightarrow AgCl$ (s)

With $CO_3^{2-} + 2H^+ \rightarrow CO_2 + H_2O$

c) Ethane and ethanol

Reagent: bromine water

Observations: With ethane, it decolorizes bromine Water.

With Ethanol: no observable change

d) **SO_2 and Cl_2 gases**

Reagents: Acidified $KMnO_4$ or $K_2Cr_2O_7$

Using $KMnO_4$ (purple)

With SO_2: the purple colour of $KMnO_4$ turns to colourless.

With Cl_2: no observable change.

Using $K_2Cr_2O_7$

With SO_2, the colour of $K_2Cr_2O_7$ changes from orange to green.

With Cl_2: no observable change.

e) **$Pb(NO_3)_2$ and $Cu(NO_3)_2$ (s)**

Reagents: NaOH solution

Observations: With Pb^{2+}, a white precipitate soluble in excess NaOH solution to form a colourless solution.

$Pb^{2+} + 2OH^- + Pb(OH)_2$ white precipitate.

With Cu^{2+}, a blue precipitate insoluble in excess NaOH.

i.e. $Cu^{2+} + 2OH^- \rightarrow Cu(OH)_2$ blue precipitate.

Or Reagent NH_3 (aq)

With Pb^{2+}: a white precipitate soluble in excess NaOH.

With Cu^{2+}: a blue precipitate soluble in excess forming a deep blue solution.

CHEMISTRY III

025

10th Nov. 2003 08.30 – 11.30 am

RWANDA NATIONAL EXAMINATIONS COUNCIL

P.O.BOX, 3817 KIGALI-TEL/FAX : 86871

ORDINARY LEVEL NATIONAL EXAMINATIONS 2002 / 2003

SUBJECT: CHEMISTRY III

DURATION: 3 HOURS

INSTRUCTIONS:

- This paper consists of **three** sections **A**, **B** and **C**
- Answer **ALL** questions in section A. **(55 marks)**
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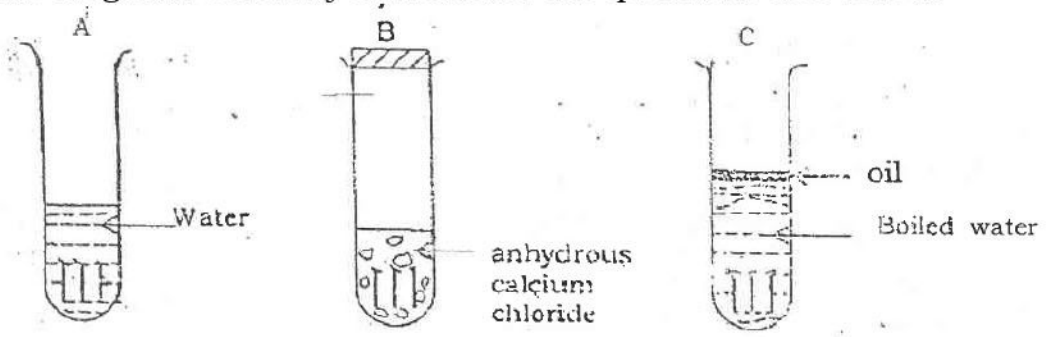
SECTION A: ANSWER ALL QUESTIONS **(55 MARKS)**

1. Air is a mixture of several different gases.
   a) Name a gas in air that supports combustion. **(1 mark)**
   b) Name a gas that causes global warming. **(1 mark)**
   c) Name a gas that is chemically inactive. **(1 mark)**
   d) Name a gas that makes the biggest part of air. **(1 mark)**

2. The iron nails were placed in test tubes under different conditions. Study the diagrams carefully and answer the questions that follow.



   a) In which of the test tubes will the nails rust? **(1 mark)**
   b) What is the purpose of anhydrous calcium chloride in tube B? **(1 mark)**
   c) Why is boiled water used in tube C? **(1 mark)**

3. The table below shows the melting points and boiling points in degrees centigrade of substance A to C. Study the table and answer the questions that follow.

Substance	Melting point	Boiling point
A	1009	2506
B	-256	- 248
C	- 10	63

   a) What do you understand by melting point? **(2 marks)**
   b) Which substance is a gas at room temperature of 2O°C? **(1 mark)**
   c) Which substance is a metal? **(1 mark)**

4. a) Write the chemical formula for the following compounds.
      i) Sulphuric acid **(1 mark)**
      ii) Sodium Phosphate. **(1 mark)**
   b) Complete the following equation. **(1.5 marks)**
      Sulphuric Acid + Sodium carbonate →

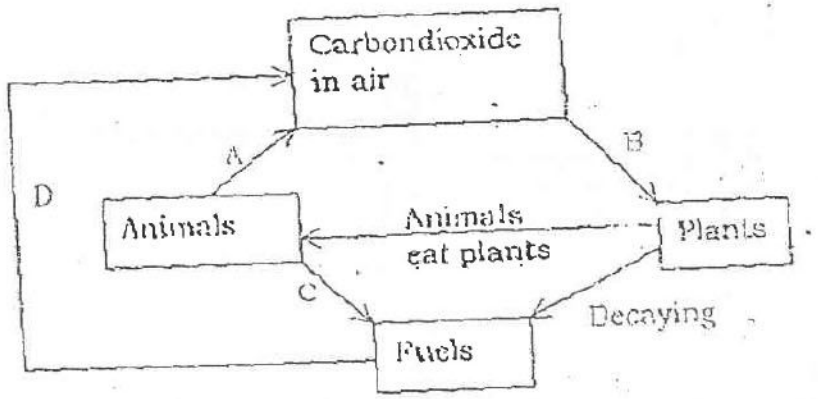
5. Study the following equation and answer the questions that follow.
   Fe_2O_3 (s) + 3CO (s) → 2Fe (s) + 3 CO_2 (g)
   a) Name the oxidizing agent in the above reaction. **(1 mark)**
   b) Calculate the mass of Fe_2O_3 that would be required to produce 112 grams of Fe. Atomic masses are: Fe = 56, O = 16, C = 12. **(2.5 marks)**

6. a) Copy and complete the table below about electrolysis of 2 electrolytes. **(2 marks)**

Electrolyte	**Product at anode**	**Product at cathode**
Dilute H_2SO_4		
$CuSO_4$ solution using copper electrodes		

b) For both electrolytes in the above table, write ionic equations to show the reactions taking place at the Cathode. **(2 marks)**

7. The diagram below shows a carbon cycle.

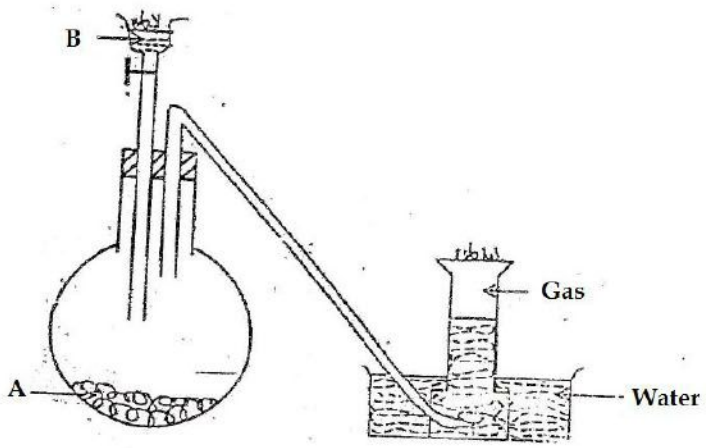


a) Name the processes A, B, C and D. **(2 marks)**
b) What does the word fuel mean? **(1 mark)**
c) Give one example of a fuel that is used in your home. **(1.5 marks)**

8. a) What do you understand by the word catalyst? **(2 marks)**
b) Give the name of the catalysts used in the following reactions:
i) Decomposition of hydrogen peroxide (H_2O_2). **(1.5 marks)**
ii) Reaction between Zinc (Zn) and dilute Sulphuric acid (H_2SO_4). **(1.5 marks)**
iii) Contact process. **(1.5 marks)**

9. Hydrogen contains 82.8% by mass of carbon and the rest is hydrogen.
a) Calculate the empirical formula of the hydrocarbon. **(2 marks)**
b) If the relative molecular mass of the hydrocarbon is 58, calculate its molecular formula. (Relative atomic masses are: C = 12, H = 1) **(2 marks)**

10. The apparatus below is used to prepare only one of the two gases mentioned below.
Hydrogen, Ammonia.



a) Which of the mentioned gases can be prepared in the laboratory using the apparatus (diagram) shown? **(1 mark)**

b) State the names of the substances A and B indicated in the diagram. **(2 marks)**

c) Give a reason why the other gas cannot be prepared using the apparatus shown. **(1 mark)**

11. When most nitrates are heated, one or two gases may be given off from the nitrates of the metals Potassium, Zinc, Sodium and Copper.

a) Choose two nitrates that give off 2 gases on heating. **(2 marks)**

b) Choose one nitrate that gives off one gas on heating and write a balanced equation for the reaction. **(1 mark)**

12. The table below shows the periodic table. Use it to answer the following questions.

H							**He**
			C	**N**	**O**		
Na						**Cl**	**Ar**
K						**Br**	

a) Which of the elements Na and K is more reactive? **(1 mark)**

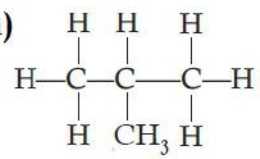
b) Which of the elements Cl and Br is more reactive? **(1 mark)**

c) Select one element that will form an ionic bond (electrovalent bond). **(1 mark)**

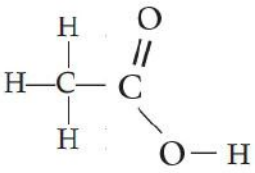
d) Write the electronic configuration of K. **(1 mark)**

13. Name the following organic substances.

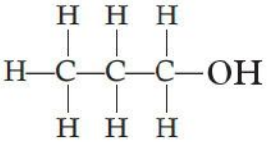
a)



b)



c)



14. Complete the following table. **(4 marks)**

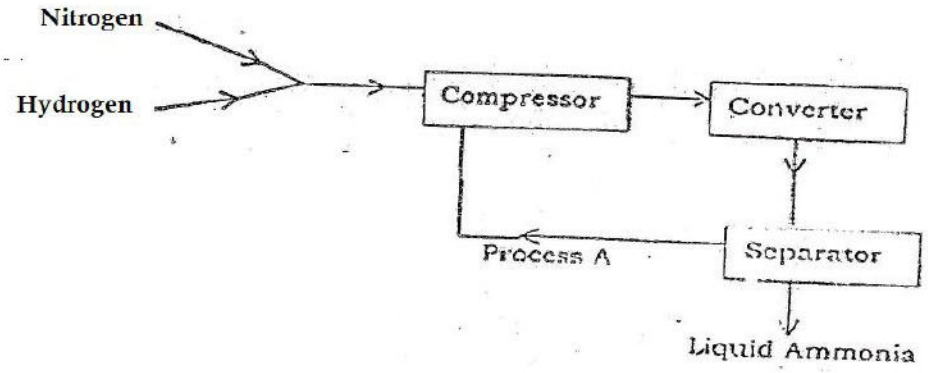
Experiment	**Observation**	**Inference / conclusion**
Add NaOH solution to solution X	A blue precipitate	
Add NaOH solution to solution Y		Solution Y contains Fe
Add NaOH solution to solution Z	A white precipitate that dissolves in excess NaOH	
Add NaOH solution to solution W		Solution W contains CO_3

15. Balance the following equations.
    a) $Al + HCl \rightarrow AlCl_3 + H_2$ **(2 marks)**
    b) $Al + CuSO_4 \rightarrow Cu + Al_2(SO_4)_3$ **(2 marks)**

SECTION B: Attempt any THREE questions in this section. (3O marks)

16. a) State one anion that causes permanent hardness of water and one anion that causes temporary hardness of water. **(2 marks)**
    b) State a simple chemical test that can be carried out to distinguish the anion in temporary hard water from the anion in permanent hard water. You must clearly state the observations that would be made. **(2 marks)**
    c) With help of balanced equations, state the observations made when carbon dioxide is bubbled into lime water for a long time and the solution is then boiled. **(6 marks)**

17. Study the simplified flow diagram below and answer the questions that follow.

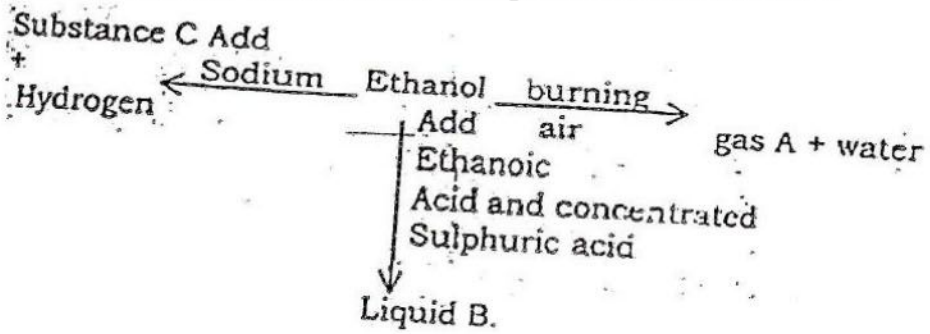


    a) Name the source of nitrogen and hydrogen. **(2 marks)**
    b) The reaction that takes place in the converter under certain conditions of temperature in presence of a catalyst.
    i) What is the name of the catalyst used? **(1 mark)**
    ii) State the optimum temperatures and pressure used in the converter. **(2 marks)**
    iii) Name process A and give a reason why it is important. **(2 marks)**
    c) Write balanced equations to show how Ammonia reacts with:

(3 marks)

i) HCl ii) CuO iii) H_2O

18. The following question is about some of the reactions of Ethanol. Study the chart below and answer the questions that follow.



a) Write the structural formula of Ethanol. **(1 mark)**

b) Write an equation to show how Ethanol reacts with ethanoic acid. **(2 marks)**

c) Give the names of substances or compounds A, B and C. **(3 marks)**

d) Describe the steps taken during fermentation of alcohol. **(4 marks)**

19. a) With the help of relevant equations, describe how Copper can be extracted and purified. **(7 marks)**

b) State three similarities between copper and aluminium. You may consider uses as similarities also. **(3 marks)**

20. a) What is Polymerization? **(2 marks)**

b) By choosing only two polymers you are familiar with:

i) Write an equation to show how each polymer is prepared from the monomer. **(4 marks)**

ii) State two uses of each polymer. **(4 marks)**

c) Explain why exposing some polymer products is an environmental hazard. **(2 marks)**

SECTION C: Answer only one question in this section. (15 MARKS)

21. If you are given only distilled water (H_2O), dilute hydrochloric acid (HCl), solid sodium carbonate (Na_2CO_3) , zinc metal (Zn) and Magnesium Sulphate solid ($MgSO_4$).

N.B: The order of reactivity series is sodium, Magnesium, Zinc and Hydrogen.

By use of equations, outline how you would prepare pure samples of:

a) Zinc Carbonate **(7.5 marks)**

b) Magnesium chloride. **(7.5 marks)**

22. Read the following passage and answer the questions that follow. To a black powder. A was added dilute H_2SO_4 and a blue solution B, was formed. When NaOH solution was added to B, a blue precipitate C was formed. When C was strongly heated the black powder A was formed.

When Na_2CO_3 solution was added to B, a green blue precipitate D was formed. When D was strongly heated, the black powder A was formed.

a) Name and write the formula of substances A, B, C and D. **(8 marks)**

b) Write balanced equations for the reactions mentioned in the passage. **(7 marks)**

23. a) With the aid of a well labelled diagram, describe an experiment to prepare chlorine gas from Manganese IV oxide (MnO_2). **(9 marks)**

b) Write equations to show how Cl_2 reacts with:

i) Iron (Fe)

ii) Iron II chloride ($FeCl_2$)

iii) H_2O

iv) NaOH **(4 marks)**

c) State two uses of Chlorine. **(2 marks)**

MARKING SCHEME OF ORDINARY LEVEL CHEMISTRY NATIONAL EXAMINATION 2002/2003

Section A: Answer all questions

1. a) Oxygen, O_2
   b) CO_2
   c) Nitrogen, N_2
   d) Nitrogen

2. a) In test tube A
   b) To absorb any moisture in the test tube:
   c) It is air free.

3. a) Melting point is the temperature at which a substance changes from solid to liquid state.
   b) Substance B.
   c) Metal is A

4. a) i) H_2SO_4
      ii) Na_3PO_4
   b) Sulphuric acid + sodium carbonate → sodium sulphate + water + carbon dioxide.

5. a) The oxidizing agent is Fe_2O_3.
   b) Mm of Fe_2O_3 = 56 X 2 + 16 X 3 = 160 g/mole
      From the equation 112 g of Fe are produced from 160 g of Fe_2O_3
      Mass of Fe_2O_3 required to produce 112 g of iron is 160 g.

6. a)

Electrolyte	Product at anode	Product at cathode
Dilute H_2SO_4	H_2O and O_2	H_2 gas
$CuSO_4$ solution using copper electrodes	Cu^{2+}	Cu

   b) For dilute H_2SO_4 at cathode, ionic equation: $2H^{2+} + 2e^- \rightarrow H_2$
      For $CuSO_4$ solution at cathode, ionic equation: $Cu^{2+} + 3e^- \rightarrow Cu$

7. a) A – Respiration

B - Photosynthesis.

C – Fossilisation

D – Combustion

b) Fuel means any substance that can produce energy after burning.

c) Charcoal, paraffin, etc.

8. a) A catalyst is a chemical substance that speeds up the rate of reaction.

b) i) MnO_2: Manganese (IV) oxide

ii) $CuSO_4$: Copper (II) sulphate

iii) V_2O_5: Vanadium Pentoxide or Vanadium (V) oxide

9. a) Percentage of H = 100 – 82.8 = 17.2 %

	C	H
Moles	$\frac{82.8}{12}$	$\frac{17.2}{1}$
	= 6.9	= 17.2
Ratio	$\frac{6.9}{6.9}$	$\frac{17.2}{6.9}$
	1 :	$\frac{5}{2}$

$1 \times 2 : \frac{5}{2} \times 2$

$2 : 5$

Empirical formula: C_2H_5

b) $(C_2H_5)n = 58$

$(12 \times 2 + 5)\, n = 58$

$29\, n = 58$

$n = \frac{58}{29} = 2$

Molecular formula = $(C_2H_5)_2 = C_4H_{10}$

10. a) Hydrogen

b) A – Zinc

B - Dilute H_2SO_4

c) It is not collected over water since it is very soluble in water.

11. a) Nitrates of zinc and copper

b) Potassium nitrate: $2KNO_3 \xrightarrow{\Delta} 2KNO_2 + O_2$

12.a) Potassium (K).
b) Chlorine (C1)
c) Na
d) 2: 9: 9: 1.

13.a) 2-methyl propane
b) Ethanoic acid
c) Propanol

14.

Experiment	Observation	Inference / conclusion
Add NaOH solution to solution X	A blue precipitate	Cu^{2+} may be present
Add NaOH solution to solution Y	A green precipitate	Solution Y contains Fe
Add NaOH solution to solution Z	A white precipitate that dissolves in excess NaOH	Pb^{2+}, Zn^{2+} or Al^{3+} may be present
Add NaOH solution to solution W	A gas which turns lime water milky.	Solution W contains CO_3^{2-}

15.a) $2Al + 6HCl \rightarrow 2AlCl_3 + 3H_2$
b) $2Al + 3CuSO_4 \rightarrow 3Cu + Al_2(SO_4)_3$

SECTION B: Attempt any THREE questions in this section

16.a) SO_4^{2-} of Ca / Mg
HCO_3^- of Ca / Mg
b) Use of $BaCl_2$ solution:
With SO_4^{2-}, a white precipitate is observed.
With HCO_3^-, no observable reaction.
c) When CO_2 is bubbled through lime water, immediately a milky precipitate is observed.
i.e. $Ca(OH)_2 + CO_2 \rightarrow CaCO_2 + H_2O$: milky precipitate.
When excess CO_2 is bubbled, the milky precipitate disappears and a colourless solution is observed.
i.e. $CaCO_3 + H_2O + CO_2 \rightarrow Ca(HCO_3)_2(aq)$

When the solution is boiled, $Ca(HCO_3)_2$ decomposes into a milky precipitate again. i.e $Ca(HCO_3)_2 \rightarrow CaCO_3 + CO_2 + H_2O$

17.a) N_2 from atmospheric air

H_2 from natural gas (methane)

b) i) Finely divided iron.

ii) Temperature 450 - 5OO°C.

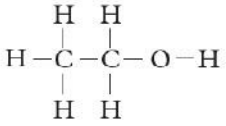
iii) Recycling, it takes back in reacted nitrogen and hydrogen in the compressor so that they can react.

c) i) $NH_3 + HCl \rightarrow NH_4Cl$.

ii) $2NH_3 + 3CuO \rightarrow 2Cu + 3H_2O + N_2$

iii) $NH_3 + H_2O \rightarrow NH_4OH$

18.a)



b) $CH_3COOH + C_2H_5OH \rightarrow CH_3COOC_2H_5 + H_2O$

c) A - CO_2: carbon dioxide

B – $CH_3COOC_2H_5$: Ethyl ethanoate

C – CH_3CH_2ONa: Sodium ethoxide

d)

i) $2C_6H_{10}O_5 + H_2O \xrightarrow{enzyme} 2C_{12}H_{22}O_{11}$

Starch Maltose

ii) $C_{12}H_{22}O_{11} + H_2O \xrightarrow{enzyme} 2C_6H_{12}O_6$

Maltose Glucose

iii) $C_6H_{12}O_6 \xrightarrow{enzyme} 2C_2H_5OH + 2CO_2$

Glucose Ethanol Carbon dioxide (by-product)

19.a) Principle one is $CuFeS_2$

- It is heated in oxygen:

$2CuFeS_2 + 4O_2 \rightarrow Cu_2S + 3SO_2 + 2FeO$

Silicon dioxide is added to the mixture to remove FeO

i.e.$FeO+SiO_2 \rightarrow FeSiO_3$.

- Copper I sulphite is then heated in air

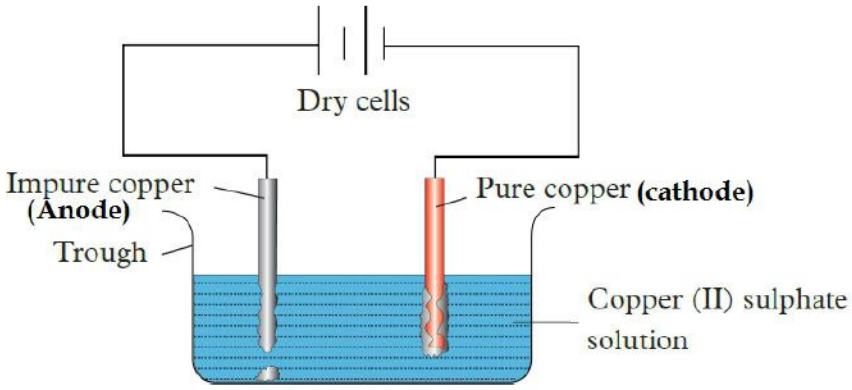
i.e. $Cu_2S + O_2 \rightarrow 2Cu + SO_2$

The copper obtained is not pure, it is purified by electrolysis.

Here, impure copper is made anode.

Pure copper is made cathode.

Electrolyte is $CuSO_4$



At the cathode; $Cu^{2+} + 2e^- \rightarrow Cu$

At the anode: $Cu \rightarrow Cu^{2+} + 2e^-$

i.e. the anode dissolves and goes in solution as Cu^{2+}, Cu^{2+} ions are then discharged at the cathode; $Cu^{2+} + 2e^- \rightarrow Cu$. The impurities are left in the solution.

b) Three similarities between copper and Aluminium.

They are used in making electric cables since they are all good conductors of electricity.

They are all used in making Alloys e.g. bronze is made of copper and tin. Duralumin is made of aluminium, copper, magnesium and manganese.

Both do not react with dilute H_2SO_4.

20. a) Polymerization is a process whereby a large organic molecule is built from hundreds or thousands of small molecules called monomers joined together.

b) i) Monomer: $CH_2 = CH_2$

Polymer: $[CH_2 - CH_2]n$: polyethene

Monomer: $CH_2 = CHCl$: vinyl chloride

Polymer: $[CH_2 - CHCl]n$: polyvinyl chloride

ii) Two uses of each polymer: **polythene** is used for making bottles, plastic bags and insulating cables. **PVC** is used in the making of plastic ropes, artificial leather and in insulation of electrical wires.

c) Polymer products do not decompose.

Polymer products do not allow water to penetrate through them.

SECTION C: Attempt one question from this section

21. a) **First:** $Zn + 2HCl \rightarrow ZnCl_2 (aq) + H_2 (g)$

Second: $Na_2CO_3 (s) + H_2O (l) \rightarrow Na_2CO_3 (s)$

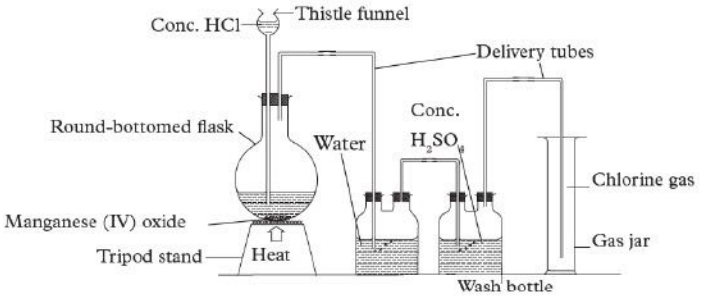
Third: $ZnCl_2 (aq) + Na_2CO_3 (aq) \rightarrow ZnCO_3 (s) + NaCl (aq)$

Then filter off to remain with $ZnCO_3$.

b) 1st: Dissolve $MgSO_4$ in water to get $MgSO_4$ solution.
2nd: $Zn + 2HCl \rightarrow ZnCl_2 + H_2$
3rd: Dissolve Na_2CO_3 also in water.
4th: $MgSO_4\ (aq) + Na_2CO_3\ (aq) \rightarrow MgCO_3\ (s) + Na_2CO_3\ (aq)$
Filter to get $MgCO_3$
5th: $MgCO_3 + 2HCl \rightarrow MgCl_2 + H_2O + CO_2$
Then warm to evaporate the water and crystallize.

22.a) A - CuO: Copper (II) oxide.
B – $CuSO_4$: Copper (II) sulphate.
C - $Cu(OH)_2$: copper (II) hydroxide
D - $CuCO_3$: copper (II) carbonate.
b) $CuO + H_2SO_4 \rightarrow CuSO_4 + H_2O$
$CuSO_4 + 2NaOH \rightarrow Cu(OH)_2 + Na_2SO_4$
$Cu(OH)_2 \rightarrow CuO + H_2O$
$CuSO_4 + Na_2CO_3 \rightarrow CuCO_3 + Na_2SO_4$

23.a)



b) i) $2\ Fe + 3Cl_2 \rightarrow 2FeCl_3$
ii) $2\ FeCl_2 + Cl_2 \rightarrow 2\ FeCl_3$
iii) $Cl_2 + H_2O \rightarrow HCl + HOCl$
iv) $2\ NaOH + Cl_2 \rightarrow 2NaCl + H_2O$
c) Uses of Cl_2: Used in the manufacture of plastics e.g polyvinyl chloride, PVC.
Used in the sterilization of water (purification of water).

CHEMISTRY III

025

12th Nov. 2004 08.30 – 11.30 am

RWANDA NATIONAL EXAMINATIONS COUNCIL

P.O.BOX, 3817 KIGALI-TEL/FAX : 86871

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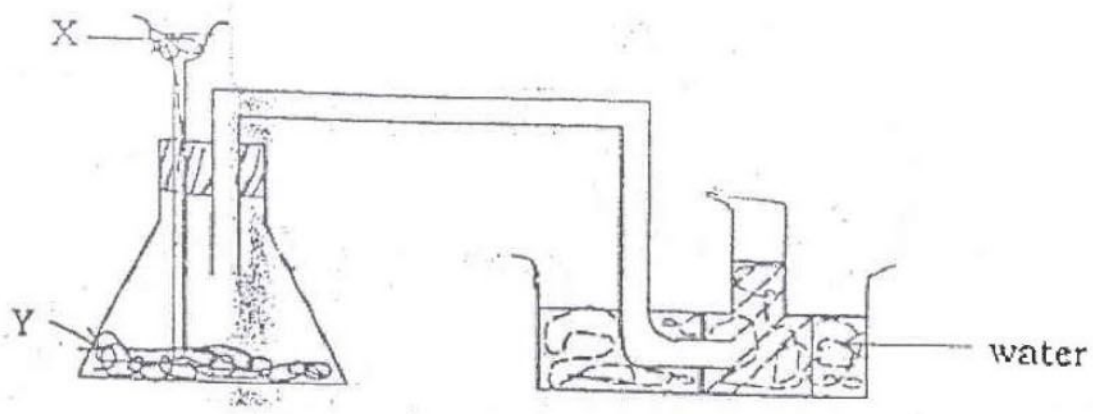
SECTION A: ANSWER ALL QUESTIONS **(55 MARKS)**

1. a) The figure below is a set-up of apparatus for the preparation of hydrogen.

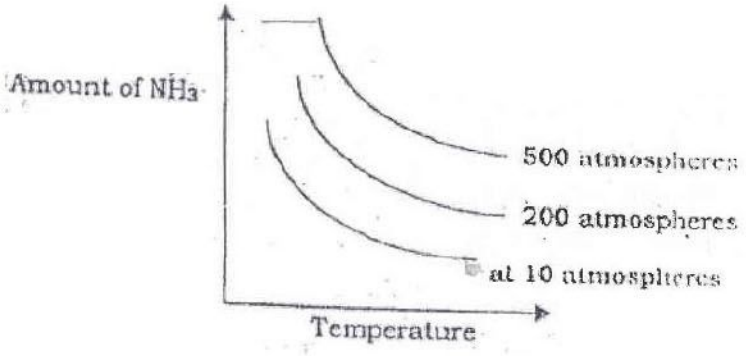


a) Identify X and Y:
X is: ..... **(1 mark)**
Y is: ..... **(1 mark)**
b) Write an equation for the formation of hydrogen. **(1 mark)**

2. Nitrogen reacts with Hydrogen to produce ammonia as shown by the following equation.

$$N_2\,(g) + H_2\,(g) \rightarrow NH_3\,(g) + Heat$$

The sketch graph below shows the amount of ammonia produced at various temperatures and pressures.



a) How does the amount of ammonia vary with temperature? **(1 mark)**
b) How does the amount of ammonia vary with pressure? **(1 mark)**
c) Suggest the catalyst for the reaction between nitrogen and hydrogen. **(1 mark)**

3. The table below shows an experiment carried out on an aqueous solution of salt A. Study the table and answer the questions that follow.

Experiment on salt A	**Observation**
Add dilute NaOH solution	A white precipitate which doesn't dissolve in excess
Add aqueous ammonia	A white precipitate insoluble in excess.
Add dilute HCl solution	A white precipitate that dissolves on boiling.

9. A compound X of molecular mass 42 contains 85.7% carbon and the rest is hydrogen.
   a) Calculate the empirical formula of X: (C = 12, H = 1). **(3 marks)**
   b) Determine the molecular formula of X. **(2 marks)**

10. Oxygen can be prepared from hydrogen peroxide in the presence of a catalyst.
   a) Name the catalyst that is used in the above preparation. **(1 mark)**
   b) Write a balanced equation for the reaction. **(1 mark)**
   c) State two ways of increasing the rate of formation of oxygen. **(2 marks)**

11. Copy the following table in your answer booklet and match the ions in list A with their corresponding confirmatory chemical tests in list B. **(4 marks)**

List A	**List B**
a) SO_4^{2-}	Aqueous ammonia
b) CO_3^{2-}	HCl (aq) and $BaCl_2$
c) Zn^{2+}	H^+

12. Match the substances in List A with the corresponding environmental problems in List B. **(3 marks)**

List A	**List B**
a) Carbon dioxide	Ozone layer depletion
b) Sulphur dioxide	Greenhouse effect
c) Chlorofluorohydrocarbons	Acid rain
	Soil erosion.

13. Suggest the structural formulae for the following organic substances.
   a) Methanoic acid
   b) Sodium ethanoate
   c) Propene **(3 marks)**

14. Sulphur dioxide and oxygen gases react according to the following equation:

$$2SO_2 + O_2 \rightarrow 2SO_3 + \text{Heat.}$$

   100 liters of SO_2 were mixed with 100 liters of oxygen.
   a) Calculate the volume of SO_3 produced. **(1 mark)**
   b) Calculate the total volume of the gas present after the reaction. **(2 marks)**

15. Calculate the percentage of sulphur in $Fe_2(SO_4)_3$. **(3 marks)**
   Fe = 56, S = 32. O: 16.

SECTION B: Attempt any THREE questions in this section. (3O marks)

16. 20 cm^3 of sodium hydroxide solution reacted with 30cm^3 of 1M of sulphuric acid.
   a) Write a balanced equation for the reaction. **(1 mark)**

b) Calculate the molarity of sodium hydroxyde and hence its concentration in gr/dm^3. (Na = 23, O = 16, H = 1) **(5 marks)**

c) Name the products formed when concentrated sulphuric acid reacts with the following:
i) Boiling it with sugar
ii) Heating with ethanol at 170°C
iii) Heating with sodium chloride.
iv) Adding water to it. **(4 marks)**

17. The table below shows the number of protons, neutrons and electrons in substances W, X, Y and Z. Use the table to answer the following questions.

Substance	Number of Protons	Number of Neutrons	Number of Electrons
W	6	6	6
X	9	10	10
Y	12	12	10
Z	19	20	19

a) Which of the substances is:
i) A cation? **(1 mark)**
ii) An anion? **(1 mark)**

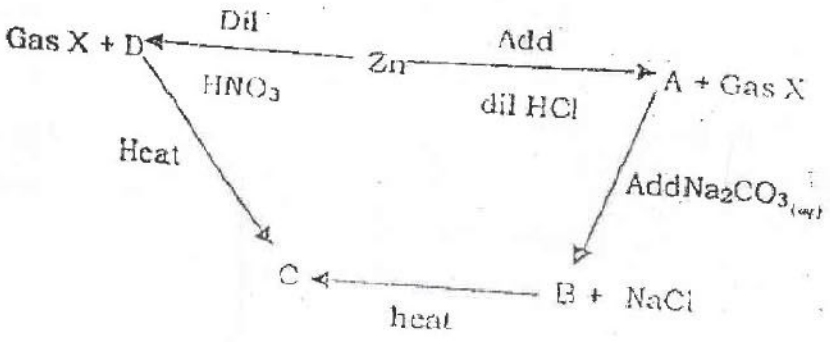
b) Write the electronic configuration of Z. **(1 mark)**

c) What is the mass number (relative mass) of Y? **(1 mark)**

d) Write a chemical formula between Z and W when they have chemically combined. **(1 mark)**

e) Z reacts very vigorously with water to make an alkaline solution. With the aid of relevant equations, explain how a pure sample of Z chloride can be obtained starting with Z, H_2O and HCl. **(5 marks)**

18. The following question is about some of the reactions of Zinc and its compounds. Study the chart below and answer the questions that follow.



a) Name substances A, B, C, D and Gas X. **(5 marks)**

b) Write a balanced equation to show how substance D is converted to C on heating and state all the observations you would make when D is changing to C. **(5 marks)**

19. With aid of relevant diagrams, describe:
    a) An experiment to show that rusting of iron requires both oxygen and water. **(6 marks)**
    b) State four ways of preventing rusting. **(4 marks)**

20. With aid of a well labelled diagram,
    a) Explain how sodium hydroxide can be manufactured (prepared on a large scale). **(8 marks)**
    b) Suggest two uses of sodium hydroxide. **(2 marks)**

SECTION C: Answer only one question in this section. (15 MARKS)

21. The table below shows results of an experiment to determine the rate of reaction between Zinc and Sulphuric Acid in presence of a catalyst. Study the table below and answer the questions that follow.

Time (seconds)	0	5	10	15	25	30	35
Volume of H_2 collected (cm^3)	0	10	20	25.5	32	32	32

    a) Suggest the catalyst for the reaction. **(1 mark)**
    b) Plot a graph of volume of gas evolved (Y-axis) against time (X-axis). **(9 marks)**
    c) Explain why the volume of the gas increases and then remains constant after 25 minutes. **(2 marks)**
    d) Suggest the ions present in the mixture at the end of the experiment. **(3 marks)**

22. Read the following passage and answer the questions that follow: To a black powder, P was added dilute H_2SO_4 and a blue solution Q was formed. When NaOH solution was added to solution Q, a blue precipitate & was formed. When R was strongly heated, the black powder L was formed. When Na_2CO_3 solution was added to Q, a green-blue precipitate S was formed. When S was strongly heated, a black powder was formed.
    a) Name and write the formula of substances P, Q, R and S. **(8 marks)**
    b) Write balanced equations for the reactions mentioned in the passage. **(7 marks)**

23. a) With the aid of a well labelled diagram, describe an experiment to prepare dry carbon dioxide gas from solid calcium carbonate and dilute HCl Acid. **(9 marks)**
    b) Why can't dilute H_2SO_4 be used in this experiment?
    c) Write balanced equations to show how CO_2 reacts with the following:
    i) H_2O **(2 marks)**
    ii) NaOH. **(2 marks)**
    d) State two uses of carbon dioxide. **(2 marks)**

MARKING SCHEME OF ORDINARY LEVEL CHEMISTRY NATIONAL EXAMINATION 2003/2004

Section A: Answer all questions

1. a) X is Zinc
   Y is dilute H_2S0_4
   b) $Zn + H_2SO_4 \rightarrow ZnSO_4 + H_2$

2. a) The amount of ammonia increases with decrease in temperature and vice versa.
   b) The amount of ammonia increases with increase in pressure.
   c) Finely divided iron.

3. i) Cation in salt A is Pb^{2+}
   ii) $Pb^{2+} + 2Cl^- \rightarrow PbCl_2$
   iii) Filter the mixture to obtain $Pb(OH)_2$, and then warm to evaporate any soluble substance in it.

4. a) Anode is electrode X.
   b) Pure copper.
   c) $CuSO_4$ solution.
   d) $Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$

5. a) i) SO_2, SO_3
   ii) FeO, Fe_2O_3, Fe_3O_4
   b) i) Sulphur dioxide: covalent bond
   ii) Iron oxide: ionic bond.

6. a) $PbO + H_2 \rightarrow Pb + H_2O$
   b) Mm of PbO = 206 + 16 = 223 g/mole
   From the equation:
   223 of PbO produces 2O7 g of Pb
   6.85 g of lead II oxide will produce $\frac{207}{223} \times 6.85\ g = 6.35\ g\ of\ lead$

7. a) 3 electrons
   b) i) M_2O_3
   ii) MCl_3
   iii) NM

8. a) R < X < Q
   b) QCl
   c) No

9. a) Percentage of H = 100 – 85.7 = 14.3 %

	C	H
Moles	$\frac{85.7}{12}$	$\frac{14.3}{1}$
	= 7.14	= 14.3
Ratio	$\frac{7.14}{7.14}$	$\frac{14.3}{7.14}$
	1 :	2

   Empirical formula: CH_2

   b) $(CH_2)n = 42$

   $(12 + 2)\ n = 42$

   $14\ n = 42$

   $n = \frac{42}{3} = 3$

   Molecular formula = $(CH_2)_3 = C_3H_6$

10. a) MnO_2
    b) $2H_2O_2 \rightarrow 2H_2O + O_2$
    c) - Increasing the concentration of H_2O_2.
       - Increasing temperature (heat) of the reactants.

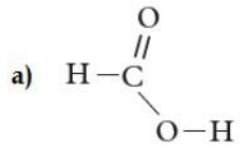
11.

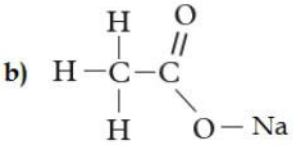
List A		**List B**
a) SO_4^{2-}	→	HCl (aq) and $BaCl_2$
b) CO_3^{2-}	→	H^+
c) Zn^{2+}	→	Aqueous ammonia

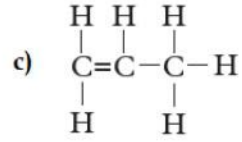
12.

List A		**List B**
a) Carbon dioxide	→	Greenhouse effect
b) Sulphur dioxide	→	Acid rain
c) Chlorofluorohydrocarbons	→	Ozone layer depletion

13.

a) 

b) 

c) 

14.a) $2SO_2 + O_2 \rightarrow 2SO_3$ + heat.

2 Volumes of SO_2 + 1 Volume of O_2 produce 2Volumes of SO_3.

1 Volume of SO_2 reacts with 1/2 Volume of O_2 produces 1 Volume of SO_3.

100 cm_3 of SO_2 + $\frac{1}{2} \times 100\ cm^3$of O_2 to produce 100 cm_3 of SO_3.

100 cm_3 of SO_2 + 50 cm^3 of O_2 produces 100 cm^3 of SO_3

Volume of $S0_3$ = 100 cm^3.

b) Total volume of the gas present after the reaction:

= Volume of SO_3 produced + volume of unreacted oxygen.

Volume of unreacted oxygen = 100 - 50 = 50 cm^3

Total volume of the gas after the reaction = 100 + 50 = l50 cm^3

15.Mm of $Fe_2(SO_4)_3$ = (56 X 2) + (32 X 3) + 16 X 12= 112+96+ 192 = 400 g/mole

% of S in $Fe_2(SO_4)_3 = \frac{96}{400} \times 100 = 24\ \%$

SECTION B: Attempt any THREE questions in this section

16.a) $2NaOH\ (aq) + H_2SO_4\ (aq) \rightarrow Na_2SO_4\ (aq) + 2H_2O\ (l)$

b) V_b = 20cm^3; n_a = 2; n_b = 1

V_a = 30 cm^3; M_a = 1; Mb = ?

$n_a V_a M_a = n_b V_b M_b$

$$M_b = \frac{M_a \times V_a \times n_a}{V_b \times n_b} = \frac{1 \times 30 \times 2}{1 \times 20} = \frac{60}{20} = 3mole/l$$

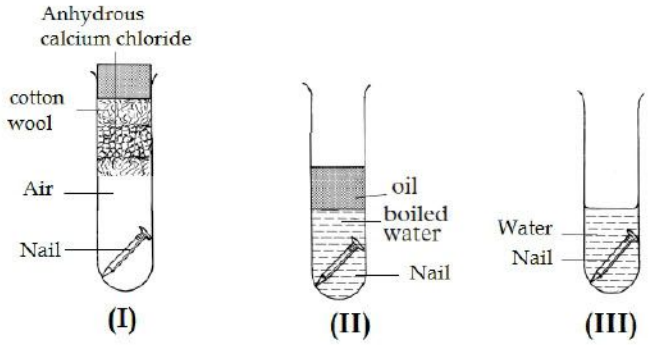
Concentration of NaOH in g/ dm^3= Molarity X Molar mass
Molar mass of NaOH = 23 + 16 + 1 = 40 g/mole
Concentration of NaOH in g/ dm^3 = 3 mole/ dm^3 X 40 g/mole = 120 g/dm^3

c) i) Carbon and steam
ii) Ethene and water
iii) Sodium hydrogen sulphate and hydrogen chloride gas
iv) Fumes and a lot of heat.

17.a) i) Cation is Y.
ii) Anion is X.
b) Electronic configuration of Z is 2, 8, 8, 1.
c) Mass number of Y = 12 + 12 = 24
d) Z_4W
e) Z first reacts with water forming a hydroxide,
i.e. $2Z + 2H_2O \rightarrow 2ZOH + 2H_2$
ZOH is then reacted with HCl,
i.e. $ZOH + HCl \rightarrow ZCl + H_2O$
Then the mixture i.e. $ZCl + H_2O$ are heated to drive off the water which evaporates leaving a pure sample of ZCl.

18.a) A: $ZnCl_2$ = Zinc chloride
B: $ZnCO_3$ = Zinc carbonate
C: ZnO = Zinc oxide
D: $Zn(NO_3)_2$ = Zinc nitrate
b) $2Zn(NO_3)_2 \rightarrow 2ZnO + 4NO_2 + O_2$
Observations: a yellow residue when hot and white on cooling (ZnO) observed.
A broom gas (NO_2) observed.
A colourless gas which relights a glowing splint (O_2) observed.

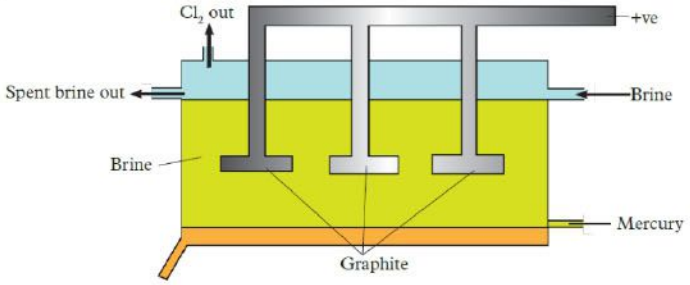
19.a)



- In experiment (i), there is no moisture (water) since $CaCl_2$ is used to absorb any moisture that may be present. So, no rusting takes place.
- In experiment (ii), there is no air. Oil is used to prevent the entry of air hence no rusting takes place.
- In experiment (iii) nails will rust since the test-tube is exposed, so there is both moisture and air.

b) By oiling / greasing
- By painting
- Galvanizing
- Tin plating.

20.a)



Concentrated sodium chloride (brine) is the electrolyte. The anodes are graphite. The cathode is mercury.

At cathode: $2Na^+ + 2e^- \rightarrow 2Na$

$Na + Hg \rightarrow Na/Hg$ (sodium amalgam)

At anode: $2Cl^- \rightarrow Cl_2 + 2e^-$

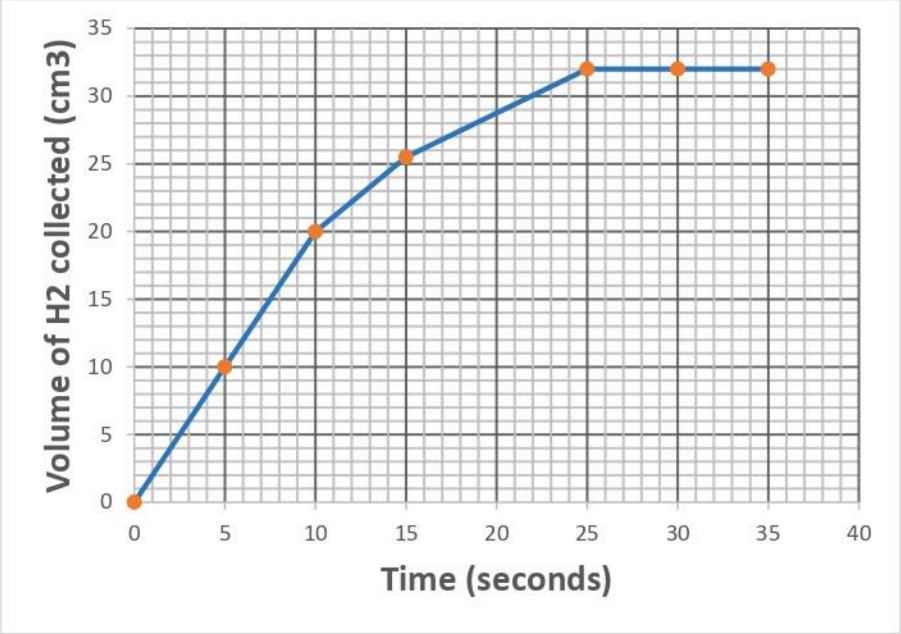
N.B: Sodium amalgam is passed through water where sodium reacts with water to form sodium hydroxide.

b) Used in the laboratory for absorbing CO_2 and other acidic gases.
Used in the manufacture of soap.

SECTION C: Attempt one question from this section

21.a) Copper II sulphate

b)



c) When the reaction is proceeding, the volume of the gas increases until the reaction is over. When the reaction is over, the volume of the gas remains constant.

d) Zn^{2+}; CO_3^{2-}

22.a) P: Copper (II) oxide, CuO

Q: Copper (II) sulphate, $CuSO_4$

R: Copper (II) hydroxide, $Cu(OH)_2$

S: Copper (II) carbonate, $CuCO_3$

b) i) $CuO + H_2SO_4 \rightarrow CuSO_4 + H_2O$

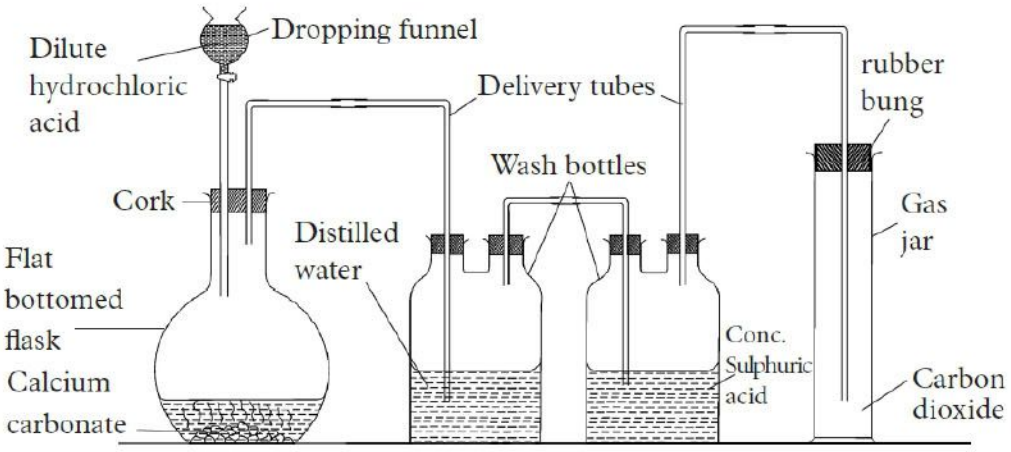
ii) $CuSO_4 + 2NaOH \rightarrow Cu(OH)_2 + Na_2SO_4$

iii) $CuSO_4 + Na_2CO_3 \rightarrow CuCO_3 + Na_2SO_4$

iv) $Cu(OH)_2 \xrightarrow{\Delta} CuO + H_2O$

v) $CuCO_3 \xrightarrow{\Delta} CuO + CO$

23.a)



b) Dilute H_2SO_4 can't be used in this experiment because when H_2SO_4 reacts with $CaCO_3$, they form $CaSO_4$ which is insoluble and, hence prevents further reaction between the acid and the carbonate.

c) i) $CO_2 + H_2O \rightarrow H_2CO_3$

ii) $2NaOH + CO_2 \rightarrow Na_2CO_3 + H_2O$

d) Uses of CO_2: used in fire extinguishers; used in breweries; used by plants to make food.

CHEMISTRY III

025

22nd Nov. 2005 08.30 – 11.30 am

REPUBLIC OF RWANDA

NATIONAL EXAMINATIONS COUNCIL
P.O.BOX 3817 KIGALI

ORDINARY LEVEL NATIONAL EXAMINATIONS 2005

SUBJECT: CHEMISTRY III

DURATION: 3 HOURS

INSTRUCTIONS:

- This paper consists of **three** sections **A**, **B** and **C**
- Answer **ALL** questions in section A. **(55 marks)**
- Answer **THREE** questions in section B. **(30 marks)**
- Answer only **one** question in section C **(15 marks)**
- Calculators may be used.

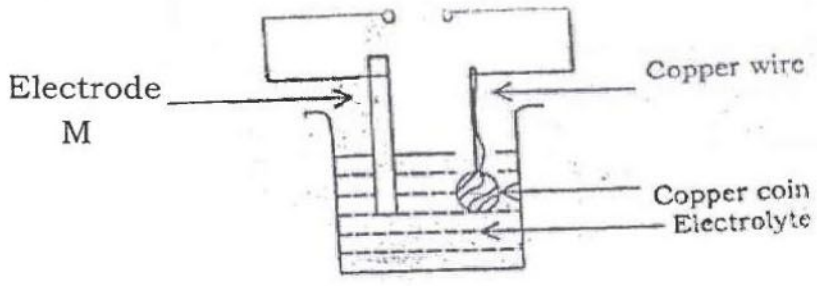
SECTION A: ANSWER ALL QUESTIONS **(55 MARKS)**

1. Element X has atomic number 13 and element Y has atomic number 8.
   a) Give the electronic arrangement of element X. **(1 mark)**
   b) In which group of periodic table is element X? **(1 mark)**
   c) State the name of the bond formed when X combines with Y. **(1 mark)**
   d) Give the formula (using X and Y as symbols) of the compound formed when X combines with Y. **(1 mark)**

2. Acid rain can cause damage to plant life and animal life. It is formed when gases produced in industries are allowed to escape and react with moisture in the atmosphere. If this rain has a PH of less than seven then it is acidic. Sulphur dioxide and an oxide of nitrogen are the main gases responsible for acid rain.
   a) Give the name of the acid formed when sulphur dioxide dissolves in water. **(1 mark)**
   b) Write a balanced equation for the reaction of sulphur dioxide with water. **(1 mark)**
   c) Give the name of the oxide of nitrogen that dissolves in water to form an acid. **(1 mark)**
   d) Give the name of an acid produced in the reaction in (c). **(1 mark)**

3. This question concerns the following compounds: Ammonium Chloride, Barium chloride, Copper (II) nitrate, Hydrated copper (II) sulphate, Potassium nitrate.
   a) From the above list of compounds select one which, on heating
      i) Changes from blue to white. **(1 mark)**
      ii) Gives off brown fumes. **(1 mark)**
      iii) Forms two gases as the only products. **(1 mark)**
   b) Aqueous solutions of two of the above compounds were mixed and a white precipitate was formed.
      i) Give the names of the two compounds. **(1 mark)**
      ii) Write an ionic equation for the reaction including state symbols. **(2 marks)**

4. The diagram below shows a copper coin electroplated with silver.



   a) Name the electrolyte which should be used in this process. **(1 mark)**
   b) Name the metal used as electrode M. **(1 mark)**
   c) Give the polarities of the two electrodes, that is, the positive and the negative electrodes. **(2 marks)**
   d) Give an ionic equation for the reaction which occurs on the surface of the copper coin. **(1 mark)**

5. The table below shows the results of tests carried out on salt P. Study the table and answer the questions which follow.

Tests on salt P solution	**Observations**
Add dilute NaOH solution	A white precipitate which dissolves in excess
Add dilute ammonia solution	A white precipitate which dissolves in excess
Add dilute H_2SO_4 solution	No change
Add aqueous HNO_3 followed by $AgNO_3$ solution.	A white precipitate

(a) State the name or the formula of the cation in P. **(1 mark)**
(b) State the name or the formula of the anion in P. **(1 mark)**
(c) Give the formula of the white solid formed in test (d). **(1 mark)**
(d) Classify the hydroxide of the cation in P as basic or acidic or neutral or amphoteric. **(1 mark)**

6. An oxide of copper was reduced to copper by passing dry hydrogen gas over the hot oxide. After the reduction process, more hydrogen was allowed to pass over the solid product as it cooled. 0.4g of the oxide of copper was decreased to 0.32g of copper.
a) Calculate the number of moles of copper produced. **(2 marks)**
b) Calculate the number of moles of oxygen atoms produced. **(2 marks)**
c) In what ratio does copper combine with oxygen? **(1 mark)**
(Atomic mass: Cu = 64, O = 16)

7. Ammonia gas is prepared by heating ammonium chloride with calcium hydroxide. It is dried by passing it over calcium oxide and collected by upward delivery.
i) Why is conc sulphuric acid not used to dry ammonia gas? **(2 marks)**
ii) Describe a chemical test for ammonia gas. **(1 mark)**
iii) A student attempted to collect ammonia gas over water. Why did the student not succeed? **(1 mark)**
iv) What can be deduced about the density of ammonia from the method which was used to collect it in the above experiment? **(1 mark)**

8. Calculate the percentage of oxygen in the salt $CuSO_4.5H_2O$. **(4 marks)**
(Cu = 64, S = 32, O = 16, H = 1)

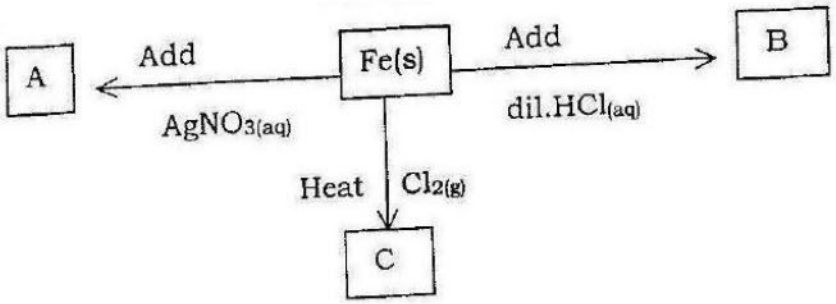
9. Give the meaning of the following terms. **(4 marks)**
i) Isotopes ii) Allotropes.

10. Iron is extracted from haematite (Fe_2O_3) by reduction using carbon monoxide.
a) Write a balanced equation for the reaction. **(2 marks)**
b) Give two ways in which the environment is affected by the process of extracting iron. **(2 marks)**

11. a) An organic compound of molecular formula C_4H_8 reacts with bromine water (aqueous bromine) to form a colourless product. Write the structural formula of C_4H_8. **(1 mark)**
    b) One of the members of a family of organic compounds has the formula C_5H_{12}. Give the name of the organic compound whose formula is C_5H_{12}. **(1 mark)**

12. An organic compound contains 40% of carbon, 53.3% of oxygen and 6.7% of hydrogen by mass.
    a) Calculate the empirical formula of the compound. **(3 marks)**
    b) Given that its relative molecular mass is 90, determine its molecular formula. **(2 marks)**

13. Some reactions involving iron are shown below:



    a) Give the formulae of the products formed in box A. **(1 mark)**
    b) Give the formulae of the products formed in box B. **(1 mark)**
    c) What is the formula of the compound formed in box C? **(1 mark)**

SECTION B: Attempt any THREE questions in this section. (3O marks)

14. In an experiment, it was found that $25cm^3$ of sodium carbonate solution reacted with $20cm^3$ of 2 $mole.dm^{-3}$ hydrochloric acid (2M HCl) as follows:

    $Na_2CO_3 + 2HCl \rightarrow 2NaCl + CO_2 + H_2O$

    a) Calculate the number of moles of HCl in $20cm^3$ of 2 $mole.dm^{-3}$ HCl. **(2 marks)**
    b) Calculate the concentration of sodium carbonate $mole.dm^{-3}$. **(3 marks)**
    c) Calculate the mass of sodium carbonate in grams present in 1 dm^3 of solution. (Na = 23, C = 12, O = 16. **(2 marks)**
    d) Describe how a pure dry sample of sodium chloride would be obtained from a mixture of sodium carbonate and hydrochloric acid assuming that the two reagents have reacted completely leaving none of the two regents in excess. **(3 marks)**

15. Sulphur dioxide and oxygen react to form sulphur trioxide according to the equation:
    $2SO_2(s) + O_2(g) \rightleftharpoons 2SO_3(g)$; Exothermic reaction in the forward direction.
    a) What does the symbol $\rightleftharpoons$ mean? **(1 mark)**
    b) What is the effect of increasing temperature:

i) On the rate of the reaction? **(1 mark)**

ii) On the amount of sulphur trioxide present at equilibrium? **(1 mark)**

c) i) This reaction forms the basis of the industrial manufacture of sulphuric acid.

ii) State the temperature and pressure at which the reaction is carried out. **(1 mark)**

iii) How is the sulphur trioxide converted into sulphuric acid? **(4 marks)**

d) State 2 large scale uses of sulphuric acid. **(2 marks)**

16. a) With the aid of a well labelled diagram, describe the preparation of dry hydrogen chloride gas from concentrated sulphuric acid and sodium chloride. **(8 marks)**

b) Write balanced equations to show how hydrogen chloride gas reacts with: **(2 marks)**

i) Ammonia gas

ii) Hot iron metal

17. a) With aid of a labelled diagram, describe how you would prepare dry carbon dioxide gas from calcium carbonate (marble chips). **(6 marks)**

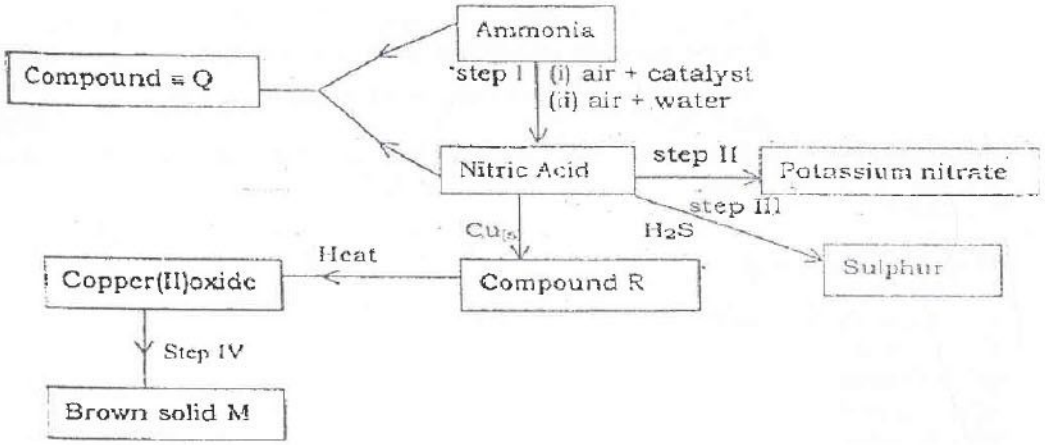
b) Write balanced equations to show how carbon dioxide reacts with

i) Hot magnesium

ii) Hot carbon. **(2 marks)**

c) Briefly explain the effect of carbon dioxide as a "greenhouse gas". **(2 marks)**

18. The chart below shows some reactions starting with ammonia. Study it and answer the questions that follow.



a) Give the name of the catalyst used in step I. **(1 mark)**

b) Name the process that takes place in step II. **(1 mark)**

c) Is the change from H_2S to sulphu6oxidation or reduction? Give a reason for your answer. **(2 marks)**

d) Give the chemical name of a compound that would react with the aqueous solution of R to form solid M. **(1 mark)**

e) Give the chemical formula of compound Q. **(1 mark)**

f) Calculate the percentage by mass of nitrogen present in compound Q. (H = 1, N = 14, O = 16) **(2 marks)**

g) Give the names of three elements found in most artificial fertilizers. **(1 mark)**

h) State one environmental disadvantage of using artificial fertilizers. **(1 mark)**

SECTION C: Answer only one question in this section. (15 MARKS)

19. A student reacted metal H with a colourless liquid in a beaker. A vigorous reaction was observed and a colourless gas J was given out. On standing, a white precipitate L was formed. He filtered the precipitate L and collected the colourless filtrate M. He dried the solid L. On heating, the solid L gave out a vapour which condensed into a colourless liquid l and a solid O remained. When cold liquid I was added to solid O, heat was given out. When carbon dioxide was bubbled through liquid M, a white precipitate P was observed which disappeared on further bubbling of carbon dioxide. A colourless solution Q remained.

NB: The letters used in this question are not the actual symbols of any elements implied.

a) Identify the substances represented by the following letters: H, I, J, K, M, O, P, Q. **(8 marks)**

b) Using the actual symbols or formulae of the substances identified, write an equation for the reaction that occurred between:

i) Metal H and substance I. **(2 marks)**

ii) Substance P, water and carbon dioxide. **(2 marks)**

c) Chlorine gas is bubbled through a colourless aqueous solution of potassium bromide. Describe what is observed and write an equation for the reaction that occurs. **(3 marks)**

20. a) Draw a well labelled diagram showing electrolysis of dilute sulphuric acid (so called electrolysis of water). **(7 marks)**

b) Write equations to show the reactions taking place at the cathode and anode. **(2 marks)**

c) If 5ml of gas are collected at the cathode, what volume of gas is collected at the anode? **(1 mark)**

d) Give one example of:

i) A strong electrolyte

ii) A weak electrolyte

iii) A Conductor

iv) A non-conductor

v) A non-electrolyte **(5 marks)**

MARKING SCHEME OF ORDINARY LEVEL CHEMISTRY NATIONAL EXAMINATION 2005

Section A: Answer all questions

1. a) X: 2: 8: 3
   b) Group 3
   c) Ionic
   d) X_2Y_3

2. a) Sulphurous acid.
   b) $SO_2 + H_2O \rightarrow H_2SO_3$
   c) Nitrogen dioxide
   d) Nitric acid / Nitrous acid.

3. a) i) Hydrated copper II sulphate.
   ii) Copper II nitrate
   iii) Ammonium chloride.
   b) i) Hydrated copper II sulphate and barium chloride.
   ii) $Ba^{2+}(aq) + SO_4^{2-}(aq) \rightarrow BaSO_4$ (White precipitate)

4. a) Copper (II) sulphate
   b) Silver / Platinum
   c) M is the positive electrode
   d) $Ag^{+}(aq) + 1e^{-} \rightarrow Ag(s)$

5. a) Aluminium ion (Al^{3+})
   b) Chloride ion (Cl^{-})
   c) AgCl
   d) Amphoteric

6. a) Number of mole of copper $= \frac{m}{Mm} = \frac{0.32\ g}{64\ g/mole} = 0.005\ mole$
   b) Mass of oxygen = 0.40 g – 0.32 g = 0.08 g
   Number of moles of oxygen $= \frac{0.08\ g}{16\ g/mole} = 0.005\ mole$
   c)

	Cu	O
	0.005	0.005
	$\frac{0.005}{0.005}$	$\frac{0.005}{0.005}$

1 1

Ratio of Cu : O = 1 : 1

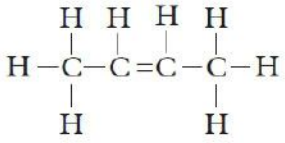
7. i) It reacts with it.
   ii) Pass ammonia through a gas jar of HCl, white fumes are observed.
   i.e. $NH_3 + HCl \rightarrow NH_4Cl$
   iii) Ammonia gas is very soluble in water.

8. Mm of $CuSO_4.5H_2O$ = 64 + 32 + 16 X 4 + 5 (1 X2 + 16) = 250 g/mole
   Mass of oxygen = 64 + 90 = 144 g
   % of oxygen = $\frac{144 \times 100}{250} = 57.6\ \%$

9. i) Isotopes are atoms of the same element with same atomic number but different mass numbers.
   ii) Allotropes are different forms in which an element can exist.

10. a) $Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$
    b) - It causes soil erosion
    - It may cause global warming.

11. a)



    b) Pentane

12. (a) Empirical formula of the compound:

C		H		O
$\frac{40}{12}$	:	$\frac{6.7}{1}$	:	$\frac{53.3}{16}$
3.33	:	6.7	:	3.33
$\frac{3.33}{3.33}$	:	$\frac{6.77}{3.33}$	:	$\frac{3.33}{3.33}$
1	:	2	:	1

Empirical formula is CH_2O

(b) Molecular formula of the compound:
(CH_2O) n = 180

$(12 + 2 + 16)n = 90$

$30\ n = 90$

$n = 3$

Molecular formula is $C_3H_6O_3$

13.a) A = $Fe(NO_3)_2 + 2Ag$

b) B = $FeCl_2 + H_2$

c) C = $FeCl_3$

SECTION B: Attempt any THREE questions in this section

14.a) Number of moles of HCl = n X V = 2 moles.dm^{-3} X 0.02 dm^3 = 0.04 mole

b) From the question:

2 moles of HCl reacts with 1 mole of Na_2CO_3

0.04 mole of HCl will react with 0.02 mole of Na_2CO_3

c) Concentration of sodium carbonate in mole per dm^3.

Molarity $= \frac{n}{V} = \frac{0.02\ mole}{0.025\ dm^3} = 0.8\ mole/dm^3$

Mass of sodium carbonate present in 1 dm^3 = M X Mm

Mm of Na_2CO_3 = 23 X 2 + 12 + 16 X 3 = 106 g/mole

Mass of Na_2CO_3 per dm^3 = 0.8 mole/dm^3 X 106 g/mole = 84.8 g/dm^3

d) Evaporate the mixture to dryness.

15.a) Reversible reaction.

b) i) It increases

ii) It decreases.

c) i) Temperature: 45O°C - 500°C

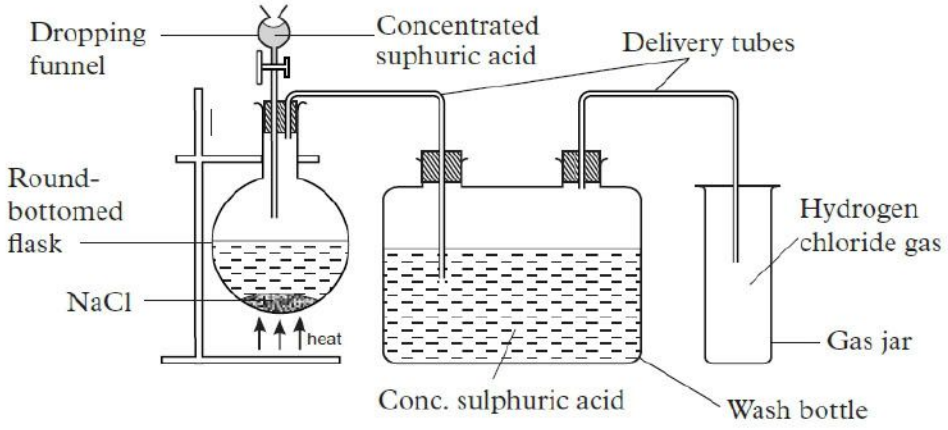
ii) SO_3 is first dissolved in concentrated sulphuric acid.

i.e. $SO_3 + H_2SO_4$

d) - It is used in the manufacture of fertilizers.

- Used in the manufacture of soaps and detergents.

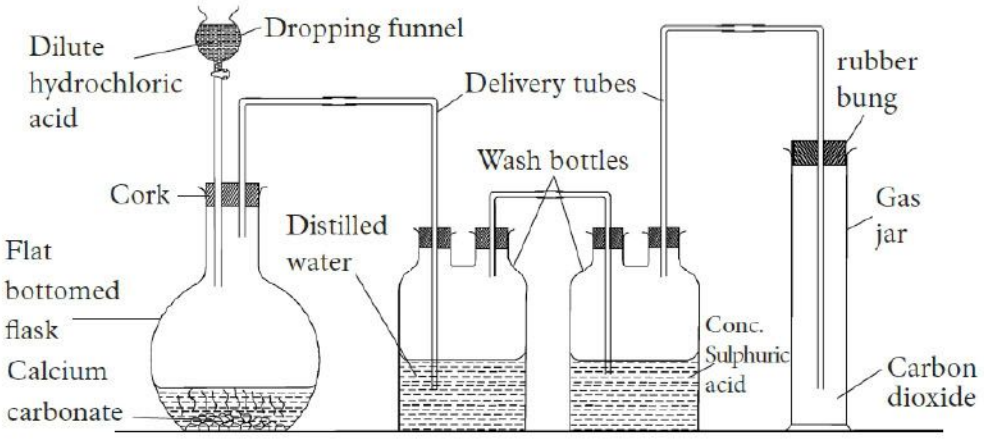
16.a)



b) i) $HCl + NH_3 \rightarrow NH_4Cl$

ii) $Fe + 2HCl \rightarrow FeCl_2 + H_2$

17.a)



b) i) $CO_2 + 2Mg \rightarrow 2MgO + C$

ii) $CO_2 + C \rightarrow 2CO$

c) When CO_2 accumulates in the atmosphere; it forms a blanket preventing the penetration of reflected radiations here causing global warming.

18.a) Platinum - Rhodium gauze

b) Neutralization

c) Oxidation. **Reason:** H_2 has been removed from H_2O.

d) A compound of any metal above copper in the reactivity series.

e) NH_4NO_3

f) Mm of NH_4NO_3 = 14 + 1 X 4+14+16 X 3 = 80

% of nitrogen $= \frac{28}{80} \times 100 = 35\ \%$

g) Nitrogen, phosphorus and potassium.

h) May cause water pollution or land pollution.

SECTION C: Attempt one question from this section

19.a) H = Ca; I = water; J = H_2; L = $Ca(OH)_2$; M = $Ca(OH)_2$; O = CaO;
P = $CaCO_3$; Q = $Ca(OH)_2$.

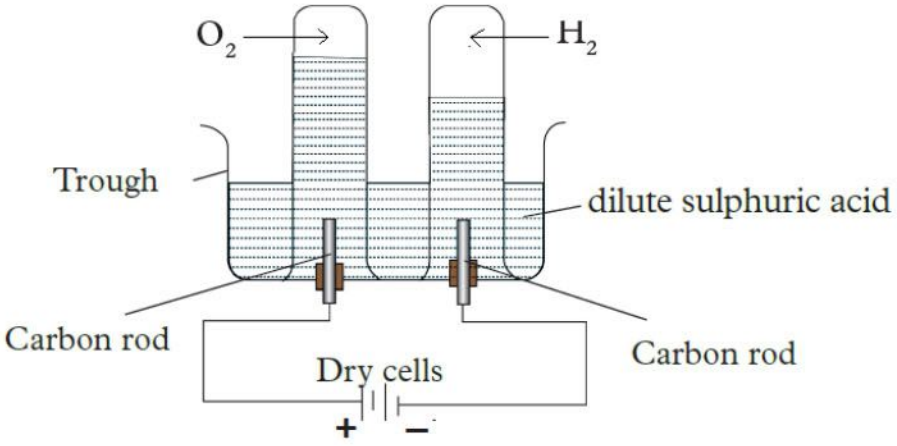
b) i) $Ca + 2H_2O \rightarrow Ca(OH)_2 + H_2$

ii) $CaCO_3 + H_2O + CO_2 \rightarrow Ca(HCO_3)_2$

c) There is colour change from colourless to red.

$2KBr + Cl_2 \rightarrow 2KCl + Br_2$

20. a)



b) At cathode (-): $4H^+(aq) + 4e^- \rightarrow 2H_2(g)$

At anode (+): $4OH^-(aq) - 4e^- \rightarrow 2H_2O(l) + O_2(g)$

c) At anode: Volume of oxygen = 5 ml $\times \frac{1}{2} = 2.5\ ml$

d) i) HCl

ii) NH_3

iii) Iron

iv) Glass

v) Glucose

CHEMISTRY III

025

13th Nov. 2006 08.30 – 11.30 am

RWANDA NATIONAL EXAMINATIONS COUNCIL

P.O BOX 3817 KIGALI-TEL/FAX : 586871

ORDINARY LEVEL NATIONAL EXAMINATIONS 2006

SUBJECT: CHEMISTRY III

DURATION: 3 HOURS

INSTRUCTIONS:

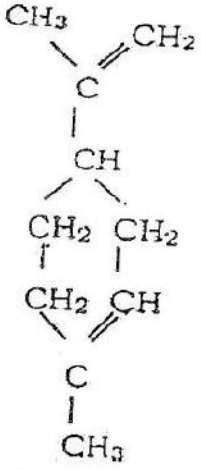
- This paper consists of **three** sections **A**, **B** and **C**
- Answer **ALL** questions in section A. **(55 marks)**
- Answer **THREE** questions in section B. **(30 marks)**
- Answer only **one** question in section C **(15 marks)**
- Calculators may be used.

SECTION A: ANSWER ALL QUESTIONS (55 MARKS)

1. Hydrogen gas was passed over hot copper (II) oxide until the reaction was over.
   a) Write a balanced equation for the reaction. **(1 mark)**
   b) Identify the oxidizing agent in the reaction. **(1 mark)**
   c) Name the salt formed when copper (II) oxide reacts with sulphuric acid. **(1 mark)**

2. This question concerns the following solutions: $CuSO_4$ (aq); KCl_4 (aq); H_2SO_4 (aq); $AgNO_3$ (aq); NH_3 (aq); $MgSO_4$ (aq). Each solution may be used once or not at all. Choose from the above list the formula of a solution which:
   a) Is alkaline. **(1 mark)**
   b) Is used to test for chloride ions. **(1 mark)**
   c) Forms a white precipitate when mixed with barium nitrate solution. **(1 mark)**
   d) Produces hydrogen gas when added to magnesium. **(1 mark)**

3. Limonene is a liquid hydrocarbon found in an orange peel. Its structure shown below:



   a) What is meant by term "hydrocarbon"? **(1 mark)**
   b) What is the molecular formula of limonene? **(1 mark)**
   c) Some limonene was mixed with a few drops of aqueous bromine (bromine water). What colour change would you see in the aqueous bromine? **(1 mark)**
   d) Which functional group present in the structure of limonene is responsible for reacting with bromine? **(1 mark)**

4. a) What is meant by "hard water"? **(1 mark)**
   b) Explain the difference between permanent hardness and temporary hardness of water. **(2 marks)**
   c) Using a relevant equation, explain how temporary hard water can be changed into soft water. **(2 marks)**

5. Magnesium and nitrogen combine to form a compound called magnesium nitride. Magnesium has atomic number 12 and nitrogen has atomic number 7.
   a) Give the electronic arrangement of magnesium. **(1 mark)**
   b) State the type of bond formed when magnesium combines with nitrogen. **(1 mark)**
   c) Give the formula of magnesium nitride. **(1 mark)**

6. Sodium (Na) is obtained by the electrolysis of molten sodium chloride.
   a) Explain why sodium chloride conducts electricity in the molten state but not in the solid state. **(1 mark)**
   b) Give an equation for the reaction at the cathode during this electrolysis. **(2 marks)**
   c) Give an equation for the reaction at the anode during this electrolysis. **(2 marks)**

7. The table below shows the results of tests carried out on salt X. Study the table and answer the questions which follow.

Tests on salt X solution	**Observations**
Add dilute NaOH solution	A white precipitate which dissolves in excess reagent
Add dilute ammonia solution	A white precipitate which dissolves in excess reagent
Add barium nitrate solution	A white precipitate
Add silver nitrate solution	No observable change.

   (a) Give the name or the formula of the cation in X. **(1 mark)**
   (b) Give the name or the formula of the anion in X. **(1 mark)**
   (c) What can you conclude from the test in (d) in the above table? **(1 mark)**
   (d) What type of hydroxide is formed by the cation in X? **(1 mark)**

8. C_4H_{10} is a hydrocarbon which belongs to a class of alkanes.
   a) Give the name of the above alkane. **(1 mark)**
   b) Write down the structural formulae of 2 isomers of C_4H_{10} and name the branched isomer. **(2 marks)**

9. Phosphine, PH_3, is a compound which has similar properties to those of ammonia gas. The atomic number of P is 15 and that of H is 1.
   a) What type of bond is formed between P and H? **(1 mark)**
   b) Draw a diagram to show bonding in PH_3. You may show electrons in the outer shell only. Use a cross (X) to show electrons from P and a dot (.) to show electrons from H. **(2 marks)**

10. The following methods are commonly used to separate mixtures: filtration, chromatography, simple distillation and fractional distillation. State the method that would be used to:
    a) Separate ethanol and water. **(1 mark)**

b) Separate the dyes in ink. **(1 mark)**
c) Obtain pure water from sea water. **(1 mark)**
d) Separate chalk particles and water. **(1 mark)**

11. The molecular formula of ethanoic acid is $C_2H_4O_2$.
    a) Write the structural formula of ethanoic acid. **(1 mark)**
    b) What observation would be made if the above acid is mixed with sodium carbonate solution? **(1 mark)**
    c) What type of organic compound is formed when ethanoic acid is reacted with ethanol? **(1 mark)**

12. a) State two conditions necessary for iron to rust. **(2 marks)**
    b) In which way is rusting similar to respiration? **(1 mark)**

13. Ethane is a useful organic compound which can be converted into many other organic products. One such product is poly(ethene).
    a) Poly(ethene) is a polymer, explain the meaning of the term polymer. **(1 mark)**
    b) Ethene is "unsaturated" whereas poly(ethene) is saturated. What is meant by "unsaturated" with reference to ethene? **(1 mark)**
    c) State one use of poly(ethene). **(1 mark)**

14. Aluminium chloride is prepared by reacting chlorine with hot aluminium according to the equation:
    $2\ Al\ (s) + 3\ Cl_2\ (g) \rightarrow 2\ AlCl_3\ (s)$
    a) Calculate the mass of $AlCl_3$ that would be produced from 0.54g of Aluminium. **(2 marks)**
    b) What is the volume of Cl_2 (measured at r.t.p) that would react with 0.54g of aluminium? (Al = 27, Cl = 35.5, 1 mole of any gas at r.t.p (room temperature and pressure) has a volume of $24dm^3$ or $24000cm^3$). **(2 marks)**

15. Incomplete combustion of carbon produces carbon monoxide. Carbon monoxide is also produced by a charcoal stove (sigiri) when there is insufficient air (oxygen)
    a) Why is carbon monoxide poisonous when it is inhaled (breathed in)? **(2 marks)**
    b) Write a balanced equation for the reaction between carbon and oxygen to form carbon monoxide **(1 mark)**
    c) Why is it advisable to use a charcoal stove (sigiri) in a well-ventilated room? **(2 marks)**

SECTION B: Attempt any THREE questions in this section. (3O marks)

16. When ammonium chloride (NH_4CI) is heated with calcium hydroxide ($Ca(OH)_2$), a salt, water and ammonia gas are produced.
    a) Write a balanced equation for the reaction between ammonium chloride and calcium hydroxide. **(2 marks)**

b) Ammonium salts often sublime when heated" What is meant by the term sublimation? Calculate the percentage by mass of nitrogen in NH_4Cl. (N = 14, H = l, Cl = 35.5) **(2 marks)**

c) Ammonia gas is manufactured on a large scale by the Haber process according to the equation:

$$N_2\,(g) + 3H_2\,(g) \rightarrow 2\,NH_3\,(g)$$

How is nitrogen obtained for use in the Haber process? **(2 marks)**

d) State the temperature range and the catalyst used in the above process. **(2 marks)**

e) State one large scale use of ammonia. **(2 marks)**

17. Diamond and graphite are macromolecular forms of carbon. Their physical properties are different because they have different structures.

(a) What name is generally used to describe different forms of the element? **(1 mark)**

(b) In terms of their different structures, explain briefly the physical properties shown by graphite and diamond below:

i) Graphite is soft and can be used as a lubricant while diamond is a very hard substance. **(4 marks)**

ii) Graphite is a good conductor if electricity while diamond is a poor conductor of electricity. **(4 marks)**

iii) State one use of diamond. **(1 mark)**

18. An experiment was carried out to determine the mass of calcium oxide in a solid sample. The sample was dissolved in water to make 25.0 cm^3 of calcium hydroxide. This solution required 7.50 cm^3 of nitric acid to just neutralize it. The concentration of nitric acid was 0.050 $mole.dm^{-3}$ (0.050M)

a) Write an equation for the reaction between calcium oxide and water to form calcium hydroxide. **(1 mark)**

The equation for the reaction between Ca(OH)2 and HNO_3 is:

$$Ca(OH)_2\,(aq) + 2HNO_3\,(aq) \rightarrow 2Ca(NO_3)_2\,(aq) + 2H_2O\,(l)$$

i) Calculate the number of moles of nitric acid. **(1 mark)**

ii) How many moles of $Ca(OH)_2$ were in 25.0cm^3 of the solution? **(1 mark)**

iii) The number of moles of $Ca(OH)_2$ is equal to the number of moles calcium oxide (CaO). Use your answer in (ii) to calculate the mass of CaO in the original sample. (Ca = 40, O = 16) **(3 marks)**

c) Carbon dioxide gas is passed through calcium hydroxide solution (lime water). A white precipitate is observed. More carbon dioxide is passed through the precipitate which dissolves to give a colourless solution. Explain these observations as fully as you can, using equations to show the reaction taking place. **(4 marks)**

19. Aluminium is a widely used metal. It is extracted by electrolysis of a molten mixture of aluminium oxide and cryolite. The electrolytic cell uses graphite anodes and graphite lining as the cathode.
    a) Why is cryolite used in this process? **(1 mark)**
    b) Write equations to show what is formed at the
        i) Cathode ii) Anode **(4 marks)**
    c) Why do the graphite anodes have to be replaced after a period of time? **(1 mark)**
    d) How might this process of extraction affect the environment? **(2 marks)**
    e) Give one use of aluminium and explain one property of aluminium on which this use is based. **(2 marks)**

SECTION C: Answer only one question in this section. (15 MARKS)

20. a) Oxygen gas is prepared by adding hydrogen peroxide solution drop by drop to manganese (IV) oxide in a flat-bottomed flask. The gas is collected over water.
        i) Draw a labelled diagram to show the preparation and collection of oxygen gas. **(5 marks)**
        ii) What is the role of manganese (IV) oxide in this reaction? **(1 mark)**
    b) Different elements are burned in gas jars of oxygen and each product is shaken with water. Each mixture is tested with litmus paper to find out if it is acidic or alkaline. In each case, state whether the mixture is acidic or alkaline and write an equation for the reaction between the oxide and water.
        i) Sulphur **(2 marks)**
        ii) Sodium **(2 marks)**
        iii) Carbon **(2 marks)**
    c) Give one large scale use of oxygen. **(1 mark)**
    d) Each year, a lot of money is used to protect iron against corrosion/rusting. State two methods used to prevent rusting. **(2 marks)**

21. a) A salt consists of a metal cation (or aluminium ion, NH_4^+) and an anion derived from an acid, therefore, many salts are prepared by reacting acids with different substances. For each of the salts below, choose the acid and another substance that would be reacted together to produce that salt.
        i) Magnesium chloride. **(2 marks)**
        ii) Lead nitrate. **(2 marks)**
        iii) Sodium ethanoate (acetate) **(2 marks)**
    b) Crystals of Zinc Sulphate were prepared using the method described below:
    Excess zinc carbonate was mixed with aqueous sulphuric acid in a beaker. The mixture was warmed until the reaction stopped. The mixture was filtered to remove the unreacted zinc carbonate. The filtrate was evaporated until a small volume remained. The remaining solution was left to cool to form crysta1s.

i) Write a balanced equation for the reaction between zinc carbonate and sulphuric acid. **(2 marks)**

ii) Why was an excess of zinc carbonate used? **(1 mark)**

iii) Why would a similar method not be suitable for preparing lead (II) sulphate (lead sulphate)? **(2 marks)**

iv) The salt zinc sulphate has the formula $ZnSO_4.7H_2O$. How would you show by a simple experiment that it contains water of crystallization? **(2 marks)**

v) Calculate the percentage of water by mass in the formula $ZnSO_4.7H_2O$ (Zn = 65, S = 32, O = 16, H = 1) **(2 marks)**

MARKING SCHEME OF ORDINARY LEVEL CHEMISTRY NATIONAL EXAMINATION 2006

Section A: Answer all questions

1. a) $CuO + H_2 \rightarrow Cu + H_2O$
   b) CuO
   c) Copper (II) sulphate

2. a) NH_3 (aq)
   b) $AgNO_3$ (aq)
   c) H_2SO_4 (aq)
   d) H_2SO_4 (aq)

3. a) A hydrocarbon is a substance which contains carbon and hydrogen only.
   b) $C_{10}H_{16}$
   c) The color would change from reddish brown to colourless.
   d) Double bond.

4. a) Hard water is that water that does not form lather readily with soap.
   b) Permanent hardness is caused by the dissolved compounds i.e. $CaSO_4$, $MgSO_4$ but temporary hardness is caused by dissolved compounds like calcium bicarbonate or magnesium bicarbonate.
   Permanent hardness can be removed by chemical means only but temporary hardness can be removed by physical means i.e. boiling water.
   c) $Ca(HCO_3)_2$ (aq) $\rightarrow$ CaO (s) + CO_2 (g) + H_2O (l)

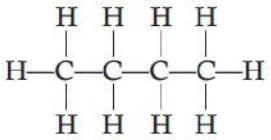
5. a) Mg: 2:8:2
   b) Electrovalent / ionic bond
   c) Mg_3N_2

6. a) In solid state, there are no free ions, but in molten state, there are free ions responsible for electric current flow.
   b) $Na^+ + 1e^- \rightarrow Na$
   $2Cl^- - 2e^- \rightarrow Cl_2$

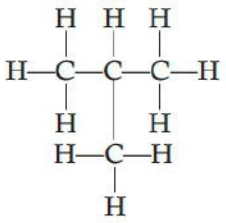
7. a) Zn^{2+}
   b) SO_4^{2-}

c) No Cl^- ion present
d) Amphoteric

8. a) Butane
   b) Structural formulae of 2 isomers

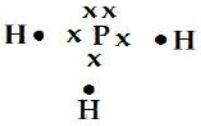


n-Butane



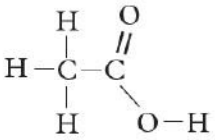
2-Methylpropane

9. a) Covalent bond
   b)



10. a) Fractional distillation.
    b) Chromatography.
    c) Simple distillation
    d) Filtration

11. a)



    b) A gas which turns lime water milky.
    c) An ester.

12. a) Presence of: i) Moisture / water
    ii) Air (O_2)
    b) Both use oxygen to take place.

13. a) A polymer is a large molecule built from hundreds or thousands of small unit molecules called monomers joined together.
    b) Unsaturated hydrocarbon are hydrocarbons which contain less than the maximum amount of hydrogen atoms due to having double or triple bond and react addition reaction.
    c) Poly (ethene) it used in the manufacture of polythene bags.

14.a) From the equation:

2 moles of Al → 2 moles of $AlCl_3$

So 1 mole of Al → 1 mole of $AlCl_3$

Moles of Al $= \frac{m}{Mm} = \frac{0.54\ g}{27\ g/mole} = 0.02\ mole$

Mm of $AlCl_3$ = 27 + 35.5 X 3 = 133.5 g/mole

Mass $AlCl_3$ = 0.02 mole X 133.5 g/mole = 2.67 g

b) 2 moles of Al react with 3 moles of Cl_2

So 1 mole of Al reacts with $\frac{3}{2}$ or 1.5 mole of Cl_2

0.02 mole of aluminium will react with $\frac{0.02\times3}{2} = 0.03\ mole$

Volume of aluminium = 0.03 mole X 24,000 cm^3/mole = 720 cm^3.

15.a) Because it causes suffocation. Or it binds with hemoglobin and prevents it from transporting oxygen, thus causing asphyxia.

b) 2C (s) + O_2 (g) → 2CO

c) To prevent incomplete burning of charcoal which can produce carbon monoxide.

SECTION B: Attempt any THREE questions in this section

16.a) $2NH_4Cl + Ca(OH)_2 \rightarrow CaCl_2 + 2NH_3 + 2\ H_2O$

b) Sublimation is the change of state from solid directly to gas or vice-versa.

% of nitrogen $= \frac{14}{53.5} \times 100 = 26.2\ \%$

c) By fractional distillation of liquid air.

d) 400 - 500°C, catalyst, divided iron.

e) Ammonia is used in the manufacture of artificial fertilizers.

17.a) Allotropy

b) i) Graphite crystals consist of layers of carbon atoms, and each carbon atom is joined to others by covalent bonds.

ii) Graphite contains delocalized (free and mobile) electrons which are responsible for graphite to conduct electric current. Diamond has no delocalized electrons.

iii) Uses of diamond.

- Used for drilling and cutting hard cutter substances e.g used to cut glasses.
- Used for making rings and ear rings.

18.a) $CaO + H_2O$

b) i) Number of moles of nitric acid = n X V = 0.05 mole/dm^3 X 0.0075 dm^3 = 0.000375 mole.

ii) From the equation:

2 moles of HNO_3 react with 1 mole of $Ca(OH)_2$

1 mole of HNO_3 react with $\frac{1}{2}$ or 0.5 mole of $Ca(OH)_2$

0.000375 mole of HNO_3 react with $\frac{1\times0.000375}{2} = 0.0001875$ mole of $Ca(OH)_2 = 1.875 \times 10^{-4} mole$ of $Ca(OH)_2$

iii) Number of moles of $Ca(OH)_2$ is equal to the number of molecules of CaO.

Mm of CaO = 40 + 16 = 56 g/mole

Mass of CaO = n X Mm = 0.0001875 mole X 56 g/mole = 0.0105 g

c) $Ca(OH)_2 + CO_2$ (g) $\rightarrow CaCO_3$ (s) + H_2O (l)

When more CO_2 is passed through, the white precipitate dissolves to give a colourless solution which is calcium bicarbonate.

i.e. $CaCO_3 + H_2O + CO_2 \rightarrow Ca(HCO_3)_2$ (aq)

19.a) To reduce the melting point of Aluminium oxide.

b) i) At cathode: $2Al^{3+} + 6e^- \rightarrow 2Al$

ii) At anode: $3O^{2-} \rightarrow O_2 + 6e^-$

c) Since they are carbon, they react with oxygen produced forming CO_2 gas.

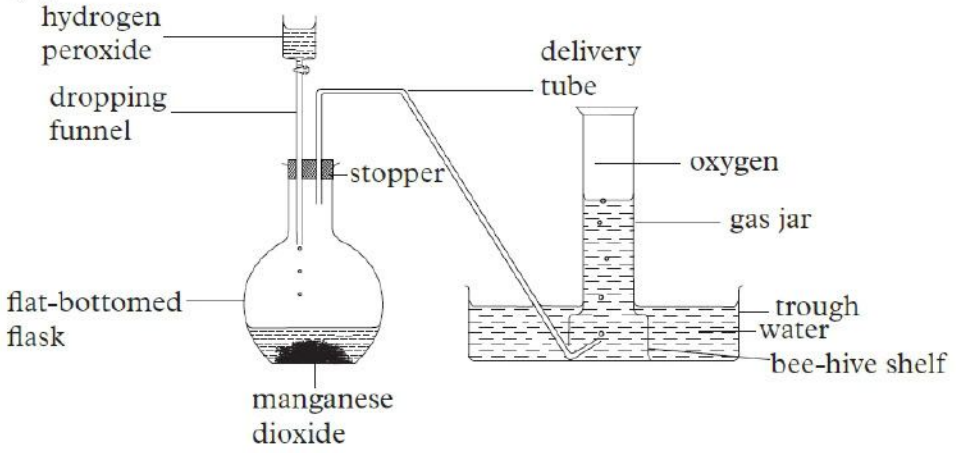
d) - Soil erosion

- Air pollution (CO_2) from oxidation of carbon anode)

e) Used in the manufacture of air craft since it is the lightest metal.

SECTION C: Attempt one question from this section

20.a) i)



ii) It acts as a catalyst.

b) i) Acidic: $SO_2 + H_2O \rightarrow H_2SO_3$

ii) Alkaline: $NaO + H_2O \rightarrow 2NaOH$

iii) Acidic: $CO_2 + H_2O \rightarrow H_2CO_3$

c) Oxygen is used for respiration in living organisms.
Oxygen supports combustion.

d) - Oiling
- Painting

21. a) i) Acid: HCl
Metal: Mg

ii) Acid: HNO_3
Substance: PbO

iii) Acid: CH_3COOH
Substance: NaOH

b) i) $ZnCO_3 + H_2SO_4 \rightarrow ZnSO_4 + CO_2 + H_2O$

ii) To ensure that all the acid was used up.

iii) Lead II sulphate is insoluble.

iv) By heating Zinc crystals first and condense the vapour produced. Add the condensed vapour to anhydrous copper II sulphate. If copper II sulphate turns blue, then the condensed vapour is water.

v) Mm of $ZnSO_4.7H_2O = 65 + 32 + (16 \times 4) + 7(1 \times 2 + 16) = 287$ g/mole

% of water $= \frac{126}{287} \times 100 = 43.9\ \%$

CHEMISTRY III

003

15th Nov. 2007 08.30 – 11.30 am

RWANDA NATIONAL EXAMINATIONS COUNCIL

P.O BOX 3817 KIGALI-TEL/FAX : 586871

ORDINARY LEVEL NATIONAL EXAMINATIONS 2007

SUBJECT: CHEMISTRY III

DURATION: 3 HOURS

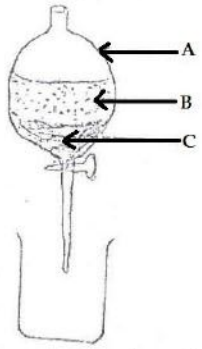
INSTRUCTIONS:

- This paper consists of **three** sections **A**, **B** and **C**
- Answer **ALL** questions in section A. **(55 marks)**
- Answer **THREE** questions in section B. **(30 marks)**
- Answer only **one** question in section C **(15 marks)**
- Calculators may be used.

SECTION A: ANSWER ALL QUESTIONS **(55 MARKS)**

1. A compound contains 40% carbon, 6.67 % hydrogen and the rest is oxygen. If the molecular mass of the compound is 180, calculate the:
   i) Empirical formula **(2 marks)**
   ii) Molecular formula **(1.5 marks)**
   (Relative atomic masses: H = 1, O = 16, C = 12)

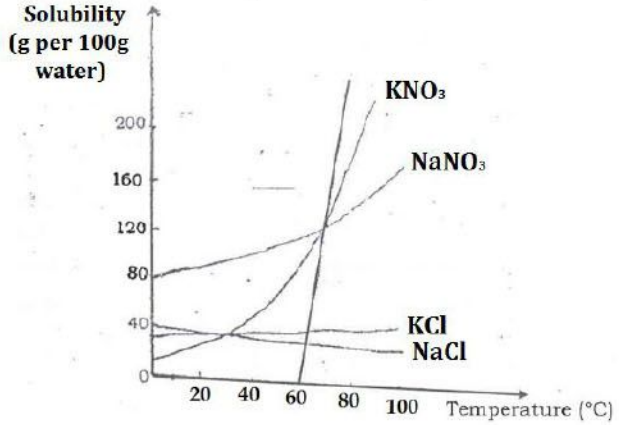
2. Study the diagram below and answer the questions that follow:



   a) What method of separating mixtures does the above diagram represent? **(1 mark)**
   b) Name the parts labelled A, B and C. **(3 marks)**
   c) When are you going to use this method? **(1 mark)**

3. a) Name two ways in which atmospheric nitrogen is fixed in the soil. **(1 mark)**
   b) Name two artificial fertilizers containing nitrogen. **(1 mark)**
   c) Which important nitrogen-containing compound is produced by the Haber process? **(1 mark)**
   d) Name the complex process by means of which plants build up carbohydrates from carbon dioxide. **(1 mark)**

4. The following graph shows the solubility curves for potassium nitrate, sodium nitrate, potassium chloride and sodium chloride.



   Potassium nitrate can be prepared by mixing hot saturated solutions of potassium chloride and sodium nitrate. Use the solubility curves to answer the following questions:

a) Which salt crystallizes first from solution at 80°C? **(1 mark)**
b) Which salt crystallizes first from solution at 10°C? **(1 mark)**
c) At which temperature are the solubilities of potassium nitrate and sodium nitrate the same? **(1 mark)**
d) If a saturated solution of sodium nitrate, at 80°C, containing 150g of sodium nitrate in 100g water was cooled to 0°C, how much sodium nitrate would crystallize? **(1 mark)**

5. Insert the following oxides in their appropriate position in the table below: Zinc oxide (ZnO), carbon monoxide (CO), sodium oxide (Na_2O), carbon dioxide (CO_2).

Classification	**Oxide**
Acidic	
Basic	
Amphoteric	
Neutral	

6. State whether the following are physical or chemical changes: **(3 marks)**
a) Alcohol fermentation
b) Dilation of a solid
c) Sublimation of iodine

7. Aluminium reacts with oxygen to form aluminium oxide.
a) Write a balanced equation for this reaction. **(1 mark)**
b) What mass of aluminium will burn in 1.6g of oxygen? **(2 marks)**
(Atomic masses: Al = 27, O = 16)

8. For each of the following pairs of ions, identify the chemical test to distinguish them, stating clearly the observations.
a) Cl^- (aq) and NO_3^- (aq) **(1 mark)**
b) Fe^{2+} (aq) and Cu^{2+} (aq) **(1 mark)**

9. Give 3 reactions (equations) involved in the contact process. **(3 marks)**

10. Complete the following table: **(3 marks)**

Radical	**Name**	**Valency**
NO_3		
	Hydrogen carbonate	
PO_4		

11. This question refers to the elements of the periodic table with atomic masses from 3 to 18. Some of the elements are shown by letters but the letters don't represent the symbols of the elements:

3 **A**	4	5	6	7	8	9	10
11 **B**	12 **C**	13	14 **D**	15 **E**	18	17 **F**	18

a) Which of the elements lettered A to G: **(3 marks)**

i) Is a noble gas?
ii) Is a halogen gas?
iii) Would react most readily with chlorine?

b) Give i) the formula of the hydride of D. **(1 mark)**
ii) the formula of the oxide of C. **(1 mark)**

c) Indicate whether the bonding in the oxide wil1be ionic or covalent. **(3 marks)**

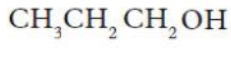
12. Iron nails were placed in test tubes under different conditions. Show that both air and water are necessary for rusting. **(3 marks)**

13. Complete the following table: **(3 marks)**

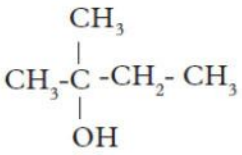
Particle	Mass	Charge
Proton		
		0
	$\frac{1}{1836}$	-1

14. When solutions of potassium chloride (KCl) and silver nitrate ($AgNO_3$), are mixed, together, a precipitate of silver chloride forms.
a) Write down a balanced equation for this reaction. **(1 mark)**
b) Deduce from this the ionic equation. **(1 mark)**

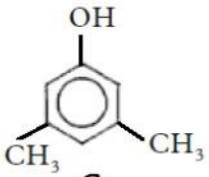
15. The compounds A to E are alcohols, phenols or ethers.



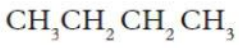
A



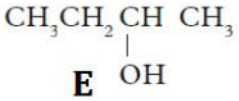
B



C



D



E

a) Which of these is: **(3 marks)**
i) A primary alcohol?
ii) A phenol?
iii) An ether?

b) Name compound A. **(1 mark)**

SECTION B: Attempt any THREE questions in this section. (3O marks)

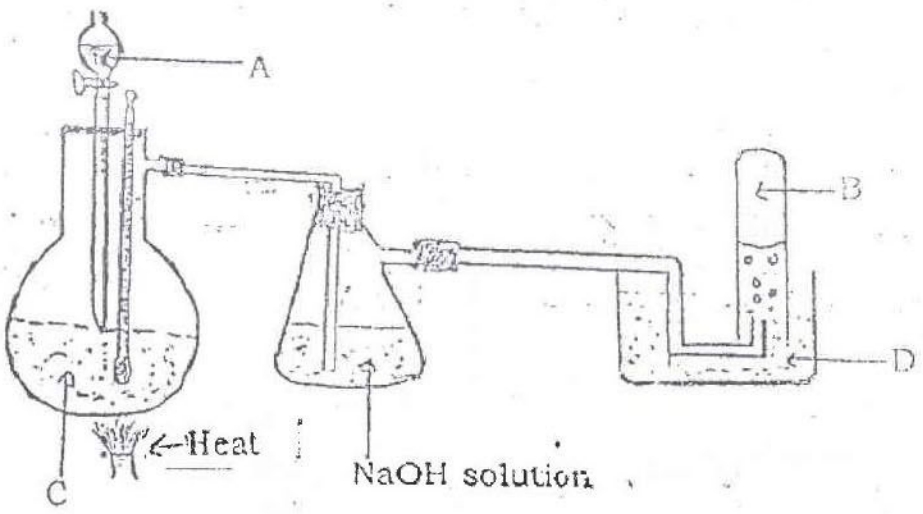
16. a) Write the name and formula of the principal ore of copper. **(2 marks)**
    b) Suggest one method by which the ore you have named may be concentrated. **(1 mark)**
    c) Outline, giving equations, the process by which impure copper is obtained from concentrated ore. **(3 marks)**
    d) Name the method by which impure copper is purified in industries. **(1 mark)**
    e) Give the formula of compounds that are obtained when copper reacts with concentrated $HN0_3$. **(3 marks)**

17. a) Give 3 differences between ionic and covalent bonds. **(3 marks)**
    b) Compare the properties of ionic and covalent compounds. **(4 marks)**
    c) Give two examples of each type of compounds. **(3 marks)**

18. The electronic configuration of an element X is $ls^2 2s^2 2p^6 3s^2$.
    a) Find out the atomic number, the number of protons and the number of electrons for X. **(2 marks)**
    b) How many electrons are in i) K-shell **(1 mark)**
    ii) L-shell **(1 mark)**
    iii) M-shell **(1 mark)**
    iv) N-shell **(1 mark)**
    c) i) To which group does the element belong? **(1 mark)**
    ii) Give one reason for your answer. **(1 mark)**
    d) What is the valence of X?
    e) Give the formula of the compound formed between X and:
    i) Hydrogen **(1 mark)**
    ii) Sulphur **(1 mark)**

19. $20cm^3$ of sodium hydroxide was pipetted into a conical flask and titrated against 0.1M hydrochloric acid using phenolphthalein as an indicator. The indicator changed colour when $15.6cm^3$ of acid has been added.
    a) Define titration. **(1 mark)**
    b) State two basic pieces of apparatus that would be used in this experiment. **(2 marks)**
    c) What is the role of the indicator in this experiment? **(1 mark)**
    d.) i) Write the equation for this neutralization. **(1 mark)**
    ii) Calculate the concentration of sodium hydroxide solution. **(3 marks)**
    e) Calculate the percentage composition of sodium in one mole of sodium hydroxide. **(2 marks)**

20. Study the diagram below and answer the questions that follow.
Dehydration of ethanol (preparation of ethane from ethanol).



a) Name the substances labelled A, B, C and D. **(4 marks)**
b) What is the role of NaOH solution? **(2 marks)**
c) What is the molar volume at room temperature and atmospheric pressure? (r.t.p) **(2 marks)**
d) What is the volume of 2 moles of C_2H_4 gas at r.t.p? **(2 marks)**

SECTION C: Answer only one question in this section. (15 MARKS)

21. a) The following tests were carried out on some unknown organic compounds:
- Compound A was shaken with bromine (in tetrachloromethane). There was an immediate decolourization of the red bromine solution.
- Compound B was shaken with bromine (in tetracholromethane). There was only a very slow decolourization of the red bromine solution and after a white pungent acid fumes could be detected.
- A small piece of freshly cut sodium was added to the non-acidic compound. A gas was liberated which formed an explosive mixture with air.

On warming compound D with ethanol and a few drops of concentrated sulphuric acid, a pleasant fruity smell could be detected which then was poured into water.

i) Assign the following formulas to compounds A, B, C and D: **(4 marks)**

$CH_3CH_2CH_2OH$, $CH_3CH_2CH_3$, $CH_3CH_2CH_2COOH$, $CH_2 = CHCH_2$

ii) Write the equation for each observation. **(2 marks)**

b) i) What are the basic raw materials used in the production of soap? **(2 marks)**

ii) Write the equation for the reaction involved in the production of soap. **(1 mark)**

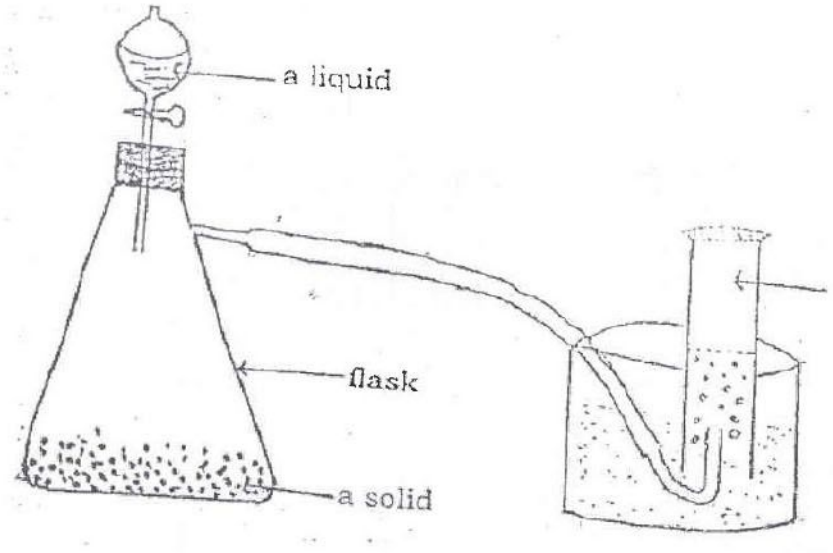
iii) Which type of compound is used to separate soap from the mixture? **(1 mark)**

iv) What other substances are used in the manufacture of soap?

(2 marks)

v) State any use of the by-products of the manufacture of soap.
(3 marks)

22. Gases are always made from the reaction between a solid and a liquid. The volume of gas made is controlled by the amount of liquid run into the flask holding the solid reactant. **(15 marks)**



Complete the table below:

Gas	**Liquid**	**Solid**	**Reaction**
Sulphur dioxide (SO_2)	Dilute hydrochloric acid	Sodium sulphate	$2HCl + Na_2SO_3 \rightarrow SO_2 + 2NaCl + H_2O$
Hydrogen (H_2)			
Oxygen (O_2)			
Carbon dioxide (CO_2)			
Hydrogen chloride (HCl)			
Ammonia (NH_3)			
Chlorine (Cl_2)			
Nitrogen dioxide (NO_2)			

MARKING SCHEME OF ORDINARY LEVEL CHEMISTRY NATIONAL EXAMINATION 2007

Section A: Answer all questions

1. (i) Percentage of oxygen = 100 – (40 + 6.67) = 53.33%
   Empirical formula of the compound:

C		H		O
$\frac{40}{12}$	:	$\frac{6.72}{1}$	:	$\frac{53.28}{16}$
3.33	:	6.77	:	3.33
$\frac{3.33}{3.33}$	:	$\frac{6.77}{3.33}$	:	$\frac{3.33}{3.33}$
1	:	2	:	1

   Empirical formula is CH_2O

   (ii) Molecular formula of the compound:

   $(CH_2O)\ n = 180$

   $(12 + 2 + 16)n = 180$

   $30\ n = 180$

   $n = 6$

   Molecular formula is $C_6H_{12}O_6$

2. a) Decantation
   b) A - Decanting or /separating funnel
      B - Less dense liquid
      C - Denser liquid.
   c) Used to separate a mixture of immiscible Liquids with different densities.

3. a) - Lightning
      - Root nodules of certain plants
      - Nitrogen fixation by nitrogen fixing bacteria
   b) - Ammonium sulphate
      - Ammonium nitrate
      - Ammonia.
      - Urea, Ammonium phosphate
   c) Ammonia

d) Photosynthesis

4. a) Sodium chloride
   b) Potassium nitrate
   c) 70°C
   d) 150 g – 80 g = 70 g

5.

Classification	Oxide
Acidic	CO_2
Basic	Na_2O
Amphoteric	ZnO
Neutral	CO

6. a) Chemical change
   b) Physical change
   c) Physical change

7. a) $4Al + 3O_2 \rightarrow 2Al_2O_3$
   b) Molecular mass of O_2 = 16 X 2 = 32g/mole
   Number of moles of $O_2 = \frac{1.6\ g}{32\ g/mole} = 0.05\ mole$
   From the equation, 3 moles of oxygen react with 4 moles of Aluminium
   1 mole of oxygen will react with $\frac{4}{3}$ moles of Aluminium
   0.05 mole of oxygen will react with $\frac{4\times0.05}{3} = 0.066$ mole of Aluminium
   Mass of aluminium = n X Mm = 0.066 mole X 27 g/mole =1.8 g

8. a) Add silver nitrate solution.
   - For $C1^-$, white precipitate formed.
   - For NO_3, no observable reaction.
   b) Add NaOH solution:
   - For Fe^{2+}, a dirty green precipitate insoluble in excess NaOH.
   - For Cu^{2+}, a blue precipitate insoluble in excess NaOH.

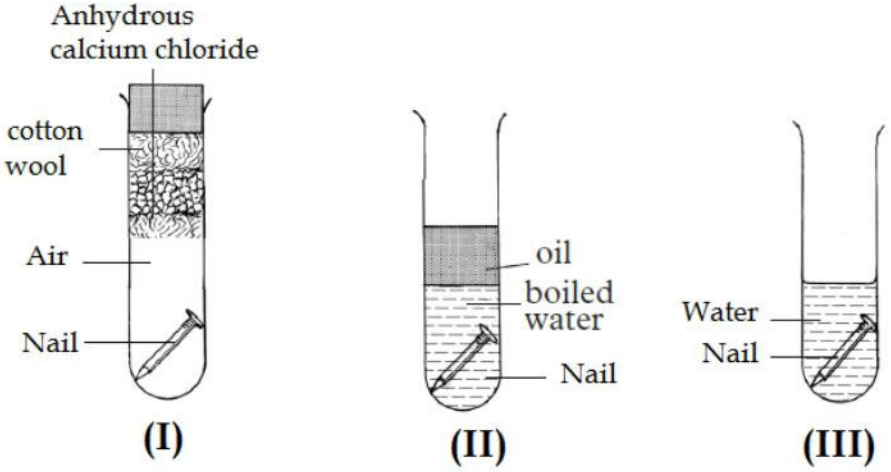
9. i) $S + O_2 \rightarrow SO_2$
   ii) $2SO_2 + O_2 \xrightarrow{V_2O_5} 2SO_3$
   iii) $H_2O + SO_3 \rightarrow H_2SO_4$ or $SO_3 + H_2SO_4 \rightarrow H_2S_2O_7$
   $H_2S_2O_7 + H_2O \rightarrow 2H_2SO_4$

10.

Radical	Name	Valence
NO_3	Nitrate	1
HCO_3	Hydrogen carbonate	1
PO_4	Phosphate	3

11.a) i) G
ii) F/ Fluorine
iii) B / A
b) i) DH_4
ii) CO or MgO
c) Ionic

12.



- In experiment (i), there is no moisture (water) since $CaCl_2$ is used to absorb any moisture that may be present. So, no rusting takes place.
- In experiment (ii), there is no air. Oil is used to prevent the entry of air hence no rusting takes place.
- In experiment (iii) nails will rust since the test-tube is exposed, so there is both moisture and air.

13.

Particle	Mass	Charge
Proton	1	1 or +1
Neutron	1	0
Electron	$\frac{1}{1836}$	-1

14.a) $KCl\ (aq) + AgNO_3\ (aq) \rightarrow KNO_3\ (aq) + AgCl\ (s)$

b) $Ag^{+}(aq) + Cl^{-}(aq) \rightarrow AgCl(s)$

15.a) i) A
ii) C
iii) None of the above
b) 1- Propanol or propan -1-ol

SECTION B: Attempt any THREE questions in this section

16.a) Copper pyrite, $CuFeS_2$ or Cu_2S; $CuCO_3$; $Cu(OH)_2$
b) From floatation method
c) The ore is roasted in limited supply of air which converts it to copper (I) sulphate:
i.e. $2CuFeS_2 + 4H_2O \rightarrow Cu_2S + FeO + 3SO_2$
The silica is added and the mixture is heated to remove FeO as iron II silicate or slag: i.e. $FeO + SiO_2 \rightarrow FeSiO_3$
Cu_2S is heated in controlled air supply which helps reduce Cu2S to impure copper: i.e. $Cu_2S + O_2 \rightarrow Cu + SO_2$
Or $Cu_2S + 2Cu_2O \rightarrow 6Cu + SO_2$
Slag floats on top of molten copper that is washed away.
d) Electrolysis
e) $Cu(NO_3)_2$; NO_2; H_2O

17. a)

Ionic bonds	**Covalent bonds**
Formed by transfer of electrons	Formed by sharing of electrons
Formed by attraction between positive and negative ions.	Formed by the sharing of electrons between atoms.
Formed between a metal and a non-metal	Formed between two non-metals.

b)

Ionic compounds	**Covalent compounds**
Ionic compounds are usually crystalline solids.	Covalent compounds are usually solids, liquids or gases.
Ionic compounds have high	Covalent compounds have

melting points and boiling points. That is, ionic compounds are non-volatile.	usually low melting and boiling points.
Ionic compounds conduct electricity when dissolved in water or melted.	Most covalent compounds do not conduct electricity.
Ionic compounds are usually soluble in water.	Covalent compounds are usually insoluble in water (except, glucose, sugar, urea, etc.).

c) Examples of ionic compounds: NaCl, $MgCl_2$
Examples of covalent compounds: Glucose, water, urea

18. a) Z = 12; Number of electrons = 12; Number of protons = 12.
b) K =2; L = 8; M = 2; N = 0
c) i) Group 2
ii) Because it has 2 electrons in the outer shell.
d) 2
e) i) XH_2
ii) X_5

19. a) Titration is the progressive addition of known/standard volume of solution of acid to an alkali or vice - versa as a technique to determine the concentration of either solution.
b) Burette
Flask (Conical flask)
c) To show the end point for the reaction or to change the colour.
d) i) NaOH + HCl → NaCl + H_2O or H^+ (aq) + OH^- (aq) → H_2O (l)
ii) $\frac{V_b M_b}{M_a V_a} = \frac{n_a}{n_b}$
$n_a V_b M_b = n_b V_b M_b$ but $n_a = 1\ ;\ n_b = 1$
$M_b = \frac{M_a \times V_a}{V_b} = \frac{0.5 \times 15.6}{20} = 0.078\ M$
e) Mm of NaOH = 23 + 1 + 16 = 40 g/mole.
One mole of NaOH is equal to 40 g/mole.
Percentage composition of sodium in one mole = $\frac{23}{40} \times 100 = 57.5\ \%$

20. a) A: concentrated H_2SO_4
B: Ethene
C: Ethanol
D: Water

b) To remove impurities accompanying ethane. E.g: SO_2

c) 24 l or 24 dm^3

d) V = Number of moles X molar volume = 2 moles X 24 dm^3/mole = 48 dm^3

SECTION C: Attempt one question from this section

21.a) i) A : $CH_2 = CH\text{-}CH_2\text{-}CH_3$

B : $CH_3CH_2CH_3$

C : $CH_2CH_2CH_2OH$

D : $CH_3CH_2CH_2COOH$

ii) Equations: $CH_2 = CH\text{-}CH_2\text{-}CH_3 + Br_2 \rightarrow CH_2Br\text{-}CHBr\text{-}CH_2\text{-}CH_3$

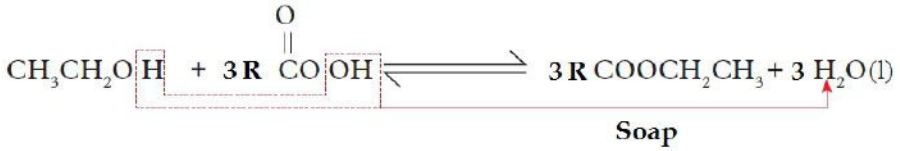
$CH_3CH_2CH_3 + Br_2 \rightarrow CH_3CH_2CH_2Br + HBr.$

$2CH_3CH_2CH_2OH + 2Na \rightarrow 2CH_3CH_2CH_2ONa + H_2$

$2CH_3CH_2CH_2COOH + CH_3CH_2OH \rightarrow CH_3CH_2CH_2COOCH_2CH_3 + H_2O$

b) i)Vegetable oil or animal fat, sodium hydroxide or potassium hydroxide.

ii)



iii) - Salt i.e, NaCl if NaOH is used.

- KCl if KOH used ; water.

iv) Uses: Dyes, Perfumes, sodium silicate.

22.

Gas	Liquid	Solid	Reaction
Sulphur dioxide (SO_2)	Dilute hydrochloric acid	Sodium sulphate	$2HCl + Na_2SO_3 \rightarrow SO_2 + 2NaCl + H_2O$
Hydrogen (H_2)	Dilute H_2SO_4	Mg / Zn	$Mg + H_2SO_4 \rightarrow MgSO_4 + H_2$
Oxygen (O_2)	H_2O_2	MnO_2	$H_2O_2 \xrightarrow{MnO_2} 2H_2O + O_2$
Carbon dioxide (CO_2)	Dilute HCl	$CaCO_3$	$CaCO_3 + 2HCl \rightarrow CaCl_2 + CO_2 + H_2O$
Hydrogen chloride (HCl)	Conc H_2SO_4	NaCl	$NaCl + H_2SO_4 \rightarrow NaHSO_4 + HCl$
Ammonia (NH_3)	$Ca(OH)_2$	NH_4Cl	$Ca(OH)_2 + 2NH_4Cl \rightarrow CaCl_2 + 2NH_3 + H_2O$
Chlorine (Cl_2)	Conc HCl	$KMnO_4$	$2KMnO_4 + 16HCl \rightarrow 2MnCl_2 + 2KCl + 5Cl_2 + 8H_2O$
Nitrogen dioxide (NO_2)	Conc HNO_3	Cu	$Cu + 4HNO_3 \rightarrow Cu(NO_3)_2 + 2NO_2 + 2H_2O$

CHEMISTRY III

003

10th Nov. 2008 08.30 – 11.30 am

RWANDA NATIONAL EXAMINATIONS COUNCIL

P.O BOX 3817 KIGALI-TEL/FAX : 586871

ORDINARY LEVEL NATIONAL EXAMINATIONS 2008

SUBJECT: CHEMISTRY III

DURATION: 3 HOURS

INSTRUCTIONS:

- This paper consists of **three** sections **A**, **B** and **C**
- Answer **ALL** questions in section A. **(55 marks)**
- Answer **THREE** questions in section B. **(30 marks)**
- Answer only **one** question in section C **(15 marks)**
- Calculators may be used.

SECTION A: ANSWER ALL QUESTIONS **(55 MARKS)**

1. a) Name two types of hardness of water. **(2 marks)**
   b) i) Give the causes of hardness of water. **(2 marks)**
   ii) Briefly explain how one of the types of hardness can be removed. **(1 mark)**

2. Methane burns in oxygen to give carbon dioxide and water vapour only.
   a) Write a balanced equation for this reaction. **(1 mark)**
   b) Calculate the volume of oxygen needed for the complete combustion of 100cm^3 of methane. (All volumes of gases were measured at the same temperature and pressure) **(2 marks)**

3. The following techniques are used for the separation of mixtures: evaporation, chromatography, filtration, fractional distillation and sublimation. Which of these is the most suitable technique for obtaining?
   a) Sodium chloride from a solution of sodium chloride? **(1 mark)**
   b) Ammonium chloride from a white powder composed of ammonium chloride and sodium chloride? **(1 mark)**
   c) Small pieces of metal from the engine oil of a car? **(1 mark)**
   d) The different pigments from an extract of flower petals? **(1 mark)**

4. Calculate the number of water molecules in 900g of water (H_2O). (Relative atomic masses: H = 1, O = 16, Avogadro's number = 6.0x 10^{23} per mole). **(2 marks)**

5. Sodium is manufactured by the electrolysis of molten sodium chloride containing calcium chloride in the Downs cell.
   a) Why is calcium chloride added? **(1 mark)**
   b) i) Name the product at the anode. **(1 mark)**
   ii) Write an equation showing the discharge at the anode. **(1 mark)**

6. In an experiment concerning the displacement of one metal from an aqueous solution of salt by another metal, the results were tabulated as follows:

Solution	**Metal A**	**Metal B**	**Metal C**	**Metal D**
Solution of salt A	-	W	Reaction	X
Solution of salt B	Reaction	-	Reaction	Reaction
Solution of salt C	No reaction	No reaction	-	Y
Solution of salt D	Reaction	No reaction	X	-

The table shows whether or not a reaction occurs between a metal and a solution of another metal salt.
   a) Arrange the metals in order of reactivity giving the most reactive one first. **(4 marks)**

b) State whether a reaction will take place in the spaces labelled W, X, Y and Z. **(4 marks)**

7. Classify solutions A, B and C. **(3 marks)**

Solution	PH value
A	7
B	3
C	10

8. a) Which method can be used to separate the compounds of air? **(2 marks)**
   b) What is meant by air pollution? **(1 mark)**
   c) Name two sources of air pollution. **(2 marks)**

9. a) What is the cause of inertness of nitrogen? **(1 mark)**
   b) The following reaction: N_2 (g) + $3H_2$ (g) → $2NH_3$ (g) takes place during Haber process. Give the optimum conditions used in the process (temperatures, pressure, catalyst) for this reaction. **(2 marks)**
   c) What feature of the catalyst in (b) makes it efficient? **(1 mark)**

10. a) Give one example of (i) a reaction which shows effervescence. **(1 mark)**
    (ii) an exothermic reaction. **(1 mark)**
    b) Complete the following equations: **(2 marks)**
    i) $SO_2 + H_2O \rightarrow$
    ii) $Na + H_2O \rightarrow$

11. a) Write an equation for the reaction that takes place when hydrogen reacts with copper (II) oxide. **(1 mark)**
    b) i) State which of the species is a reducing agent. Give a reason for your answer. **(2 marks)**
    ii) Which is an oxidizing agent? **(1 mark)**

12. Give three means of preventing the rusting of iron. **(3 marks)**

13. Write the formula of: **(4 marks)**
    (a) Ammonium phosphate
    (b) Potassium chloride
    (c) Pentanol
    (d) Butane

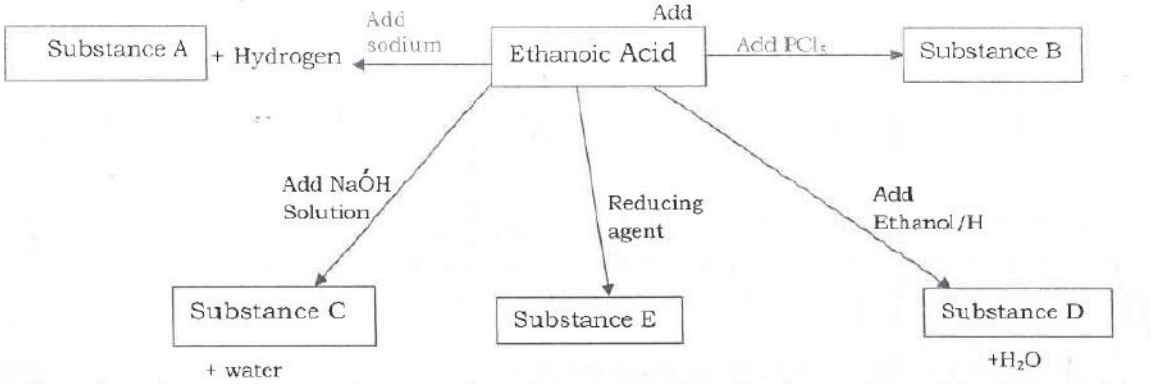
14. An organic compound contains 40% by mass of carbon, 13.3% of hydrogen and 46.7% of nitrogen.
    a) Calculate the empirical formula of the compound. **(2 marks)**
    b) If the relative molecular mass of the compound is 60, determine its molecular formula. (Relative atomic masses: C = 12, H = 1, O = 16) **(1 mark)**

15. Give one example of: **(3 marks)**
    (a) A weak electrolyte

(b) A non-electrolyte
(c) A conductor.

SECTION B: Attempt any THREE questions in this section. (3O marks)

16. a) The following question is about some of the reactions of ethanoic acid, Study the chart below and answer the questions that follow.



i) Write the structural or molecular formula of ethanoic acid. **(1 mark)**
ii) Write al equation to show how ethanoic acid reacts with sodium carbonate. **(1 mark)**
iii) Give the formula of substances A, B, C, D and E. **(5 marks)**
b) Name one natural polymer and give its monomers. **(2 marks)**
c) Write the structural formula of ethane. **(1 mark)**

17. Answer the following questions about the extraction of iron. (no diagrams are required)
a) Give the name and formula of one mineral from which iron is extracted. **(2 marks)**
b) Explain how carbon monoxide is formed in the blast furnace. **(3 marks)**
c) Write the equation for the reaction by which iron is formed in the furnace from its ore. **(1 mark)**
d) Name two impurities likely to be present in the "Pig iron" formed in the blast furnace. **(2 marks)**
e) Explain clearly why limestone (calcium carbonate) is used in the blast furnace. **(2 marks)**

18. Sulphuric acid is manufactured by converting sulphur dioxide to sulphur trioxide and dissolving this in 95-98 per cent sulphuric acid, whilst adding an appropriate amount of water.
a) How is the sulphur dioxide obtained? (2 different methods) **(2 marks)**
b) i) Name one catalyst commonly used in this process. **(1 mark)**
ii) Name another catalyst not commonly used and explain why. **(2 marks)**
c) Why is sulphur trioxide not dissolved in water directly? **(1 mark)**
d) Give two uses of sulphuric acid. **(2 marks)**
e) Complete the following equations: **(2 marks)**
(i) $H_2SO_4 + NaCl \rightarrow$

(ii) $Zn + H_2SO_4$ (aq) →

19. What volume of 0.lM sodium hydroxide solution:
    a) Contains 0.0025 mole of sodium hydroxide? **(3 marks)**
    b) Neutralizes 25cm^3 of O.05M sulphuric acid solution? **(4 marks)**
    c) Reacts exactly with O.5 mol of hydrochloric acid? **(3 marks)**
    (Relative atomic mass: Na = 23, H = 1, O = 16, S = 32, Cl = 35.5)

20. a) Write down the electronic configuration of chlorine. (Atomic number of chlorine = 17) **(1 mark)**
    b) Explain why chlorine forms an ion $C1^-$. **(2 marks)**
    c) Write the symbol for the magnesium ion. **(1 mark)**
    (Atomic number of magnesium = 12)
    d) Write the formula and the name for the compound formed when these two elements combine. **(2 marks)**
    e) Would you expect this compound to have a high or low melting point? Give a reason. **(2 marks)**
    f) Indicate whether the bonding in the compound will be ionic or covalent. Give a reason for your answer. **(2 marks)**
    (Atomic number: Mg = 12, Cl = 17).

SECTION C: Answer only one question in this section. (15 MARKS)

21. In an experiment to determine the volume of hydrogen produced when magnesium powder reacts with dilute hydrochloric acid, the volume of hydrogen produced was measured at different intervals of time. The following results were obtained.

Time (seconds)	0	5	10	20	30	40	50	60
Volume of H_2 (cm^3)	0	32	52	78	93	95	95	95

    a) Write down the equation for the reaction. **(1 mark)**
    b) Suggest three ways of speeding up this reaction. **(3 marks)**
    c) Plot a graph of volume of H_2 produced (on y-axis) versus time (x-axis). **(8 marks)**
    d) Why is the volume of H_2 constant in the last three results? **(1 mark)**
    e) Why is the volume of H_2 = 0 cm^3 when the time = 0 seconds? Suggest one use of hydrogen gas. **(1 mark)**
    f) Suggest one use of hydrogen gas. **(1 mark)**

22. With the help of equations where possible, state the chemical test that would be used to distinguish each pair of the following substances and state the observation in each case.
    (a) Fe^{2+} (aq) and Cu^{2+} (aq) **(5 marks)**
    (b) C_2H_4 (g) and C_2H_6 (g) **(5 marks)**
    (c) C_5H_{12} (l) and C_2H_5OH (l) **(5 marks)**

MARKING SCHEME OF ORDINARY LEVEL CHEMISTRY NATIONAL EXAMINATION 2008

Section A: Answer all questions

1. a) Temporary hardness, Permanent hardness
   b) i) Temporary hardness is caused by the presence of calcium (or magnesium) hydrogen carbonate dissolved in water.
   Permanent hardness is caused by the presence of calcium and magnesium chloride and sulphate (Ca^{2+} and Mg^{2+} ions).
   ii) Temporary hardness: - Boil water
   - Distillation
   - $Ca(OH)_2$
   Or both temporary and permanent hardness: - Add sodium carbonate to precipitate calcium and magnesium carbonate.

2. a) $CH_4\ (g) + 2O_2\ (g) \rightarrow CO_2\ (g) + 2H_2O\ (l)$
   b) 1 Vol of $CH_4 \rightarrow$ 2 Vol of O_2
   $100cm^3$ of $CH_4 \rightarrow 2 \text{ X } 100 = 200cm^3$ of oxygen

3. a) Evaporation
   b) Sublimation
   c) Filtration
   d) Chromatography

4. Mm of $H_2O = (2 \text{ X } 1) + 16 = 18$ g/mole
   Number of moles of water $= \frac{m}{Mm} = \frac{900\ g}{18\ g/mole} = 50\ moles$
   1 mole contains $6.0 \text{ X } 10^{23}$ molecules
   50 moles contain $50 \text{ X } 6.0 \text{ X } 10^{23}$ molecules = $3.0 \text{ X } 10^{25}$ molecules

5. a) To lower the melting point of NaCl.
   b) i) Chlorine
   ii) $2Cl^- - 2e^- \rightarrow Cl_2$

6. a) C > A > D > B
   b) W = no reaction
   X = no reaction
   Y = no reaction
   Z = reaction

7. A – Neutral
   B – Acidic
   B - Basic
8. a) Fractional distillation
   b) Placing / putting harmful substances in the atmosphere / air.
   c) - Incomplete combustion of wood/charcoal or fossil fuels to give carbon monoxide.
      - Burning of coal which contains sulphur or oxides of nitrogen from exhaust fumes of cars.

9. a) Strong triple bond / strong covalent bonds.
   b) Temperature: 400 – 500°C
      Pressure: 200 – 250 atmospheres
      Catalyst: Iron
   c) Finely divided / powder / greater surface area.

10. a) i) Combustion / carbonate with acid
    b) i) $SO_2 + H_2O \rightarrow H_2SO_3$
       ii) $Na + H_2O \rightarrow 2NaOH + H_2$

11. a) $CuO + H_2 \rightarrow Cu + H_2O$
    b) i) Hydrogen is the reducing agent because it removes oxygen it removes oxygen from copper (II) oxide
    ii) Copper (II) oxide.

12. Painting, oiling / greasing, galvanizing.

13. a) $(NH_4)_3PO_4$
    b) KCl
    c) $CH_3\text{-}CH_2\text{-}CH_2\text{-}CH_2\text{-}CH_2OH$
    d) $CH_3\text{-}CH_2\text{-}CH_2\text{-}CH_3$ or C_4H_{10}

14. (a) Empirical formula of the compound X:

C		H		N
$\frac{40}{12}$	:	$\frac{13.3}{1}$	:	$\frac{46.7}{14}$
3.33	:	13.3	:	3.33

$$\frac{3.33}{3.33} : \frac{13.3}{3.33} : \frac{3.33}{3.33}$$

1 : 4 : 1

Empirical formula is CH_4N

(b) Molecular formula of the compound:

$(CH_4N)\ n = 60$

$(12 + 1 \times 4 + 14)n = 60$

$30\ n = 60$

$n = 2$

Molecular formula is $C_2H_8N_2$

15. a) Weak acid / weak base e.g. CH_3COOH (weak acid), NH_3 (aq)(weak base)

b) Petrol/ ethanol/ sugar solution/ water. .

c) Any metal (aluminium, iron...) / graphite.

SECTION B: Attempt any THREE questions in this section

16. a) i) CH_3COOH

ii) $2CH_3COOH + Na_2CO_3 \rightarrow 2CH_3COONa + CO_2 + H_2O$

iii) A: CH_3COONa

B: CH_3-CO-Cl

C: CH_3COONa

D: $CH_3COOC_2H_5$

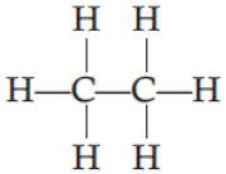
E: CH_3-CH_2-OH

b) Polymer – proteins

Monomer – Amino acid

Or starch (polymer) and glucose (monomer)

c) Structural formula of ethane



17. a) Iron oxide / Haematite

Alternatively: magnetite (Fe_3O_4), $FeCO_3$

b) Coke carbon burns in pre-heated air.

CO_2 reacts with hot coke ($CO_2 + C \rightarrow 2CO$)

c) $Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$

d) Sulphur / phosphorous / Silicon, carbon

e) $CaCO_3$ decomposes at high temperature.

$CaCO_3 \xrightarrow{\Delta} CaO + CO_2$

18.a) - Sulphur sulphur:

$S(s) + O_2(g) \rightarrow SO_2(g)$

- Burning / roasting iron pyrites / any metal sulphate

$4FeS_2 + HO_2 \rightarrow 2FeO_3 + 8SO_2$

b) i) Vanadium pentoxide / V_2O_5 or Vanadium (V) oxide

ii) Platinum is not commonly used. Because it is expensive and easily poisoned.

c) Reaction with water too violent / vigorous.

d) Manufacture of fertilizers.

Used as acid for cars / automobile batteries

Used as catalyst.

e) i) $H_2SO_4 + 2NaCl \rightarrow 2HCl + Na_2SO_4$

$H_2SO_4 + NaCl \rightarrow HCl + NaHSO_4$

ii) $Zn + H_2SO_4(aq) \rightarrow ZnSO_4(aq) + H_2(g)$

19.a) n = M X V

$V = \frac{n}{M} = \frac{0.0025\ mole}{0.1\ mole/dm^3} = 0.025\ dm^3 = 25\ cm^3$

b) $2NaOH + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O$

c) $NaOH + HCl \rightarrow NaCl + H_2O$

Number of moles of H_2SO_4 = n X V = 0.5 mole/dm^3 X 0.025 dm^3 = 0.00125 mole

Number of moles of NaOH = 0.00125 mole X 2 = 0.0025 mole

$V = \frac{n}{M} = \frac{0.0025\ mole}{0.1\ mole/dm^3} = 0.025\ dm^3 = 25\ cm^3$

c) $NaOH + HCl \rightarrow NaCl + H_2O$

0.5 mole of HCl reacts with 0.5 mole of NaOH

$V = \frac{n}{M} = \frac{0.5\ mole}{0.1\ mole/dm^3} = 5\ dm^3 = 5000\ cm^3$

20.a) 2: 8: 7

b) To attain the noble gas structure of argon by gain of an electron so that it is stable. Or to fill the outer shell so that it becomes stable.

c) Mg^{2+}

d) $MgCl_2$ (Magnesium chloride)

e) High melting point. It has a giant ionic structure with strong attraction between ions or strong electrovalent bond.

f) Ionic because metal atoms donate electrons to non-metal atoms or a bond between a metal and a non-metal.

SECTION C: Attempt one question from this section

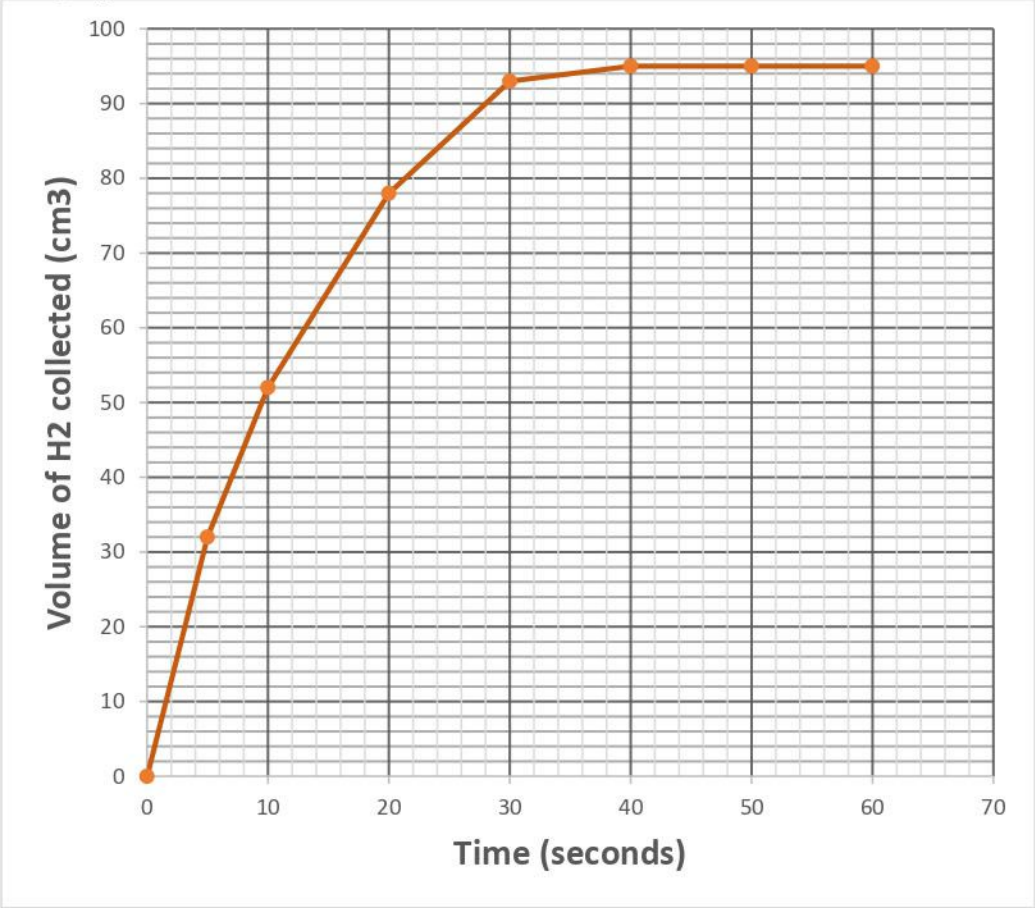
21.a) $Mg\ (s) + 2HCl\ (aq) \rightarrow MgCl_2\ (aq) + H_2\ (g)$

b) By shaking/ stir the mixture

Heat (increasing temperature)

Increasing the concentration of the reactant

c) A graph of volume of H_2 versus time:



d) Because the reaction is over

e) Because the reaction has not yet started.

f) Hydrogen is used: as a fuel; to manufacture fats/Margarine; to fill balloons.

22.a) Add NaOH / NH_3 to each solution up to excess

Fe^{2+}, a green precipitate insoluble in excess.

$Fe^{2+} + 2OH^- \rightarrow Fe(OH)_2$

Cu^{2+}, a blue precipitate insoluble in excess.

$Cu^{2+} + 2OH^{-} \rightarrow Fe(OH)_2$

N.B: If NH_3 (aq) is used

Cu^{2+}, a deep blue solution is observed in excess NH_3 (aq).

b) Mix with bromine water / aqueous bromine in the absence of light.

Mix with $CH_2 = CH_2$, it decolorizes bromine water

With CH_3-CH_3, no observable change

c) Add Na metal

With C_5H_{12}, no change

With C_2H_5OH, effervescence as H_2 is evolved.

$2C_2H_5OH + 2Na \rightarrow 2C_2H_5ONa + H_2$

CHEMISTRY I

003

10th Nov. 2009 08.30 – 11.30 am

RWANDA NATIONAL EXAMINATIONS COUNCIL

P.O BOX 3817 KIGALI-TEL/FAX : 586871

ORDINARY LEVEL NATIONAL EXAMINATIONS 2009

SUBJECT: CHEMISTRY I

DURATION: 3 HOURS

INSTRUCTIONS:

- This paper consists of **three** sections **A**, **B** and **C**
- Answer **ALL** questions in section A. **(55 marks)**
- Answer **THREE** questions in section B. **(30 marks)**
- Answer only **one** question in section C **(15 marks)**
- Calculators may be used.

SECTION A: ANSWER ALL QUESTIONS **(55 MARKS)**

1. Hydrogen gas is prepared by reacting Zinc metal with hydrochloric acid solution. The gas is collected by upward delivery.
   a) Describe a chemical test for hydrogen gas. **(2 marks)**
   b) From its method of collection, what can you conclude about the density of hydrogen compared to that of air? **(1 mark)**
   c) Write a balanced chemical equation for the reaction of Zinc with hydrochloric acid. **(2 marks)**

2. Unpolluted air is a mixture of gases.
   a) State the components of unpolluted air and their approximate percentage. **(2 marks)**
   b) Carbon monoxide is known to be one of the pollutants of air.
      i) What is the main source of carbon monoxide in air?
      ii) Why is carbon monoxide poisonous? **(2 marks)**

3. The following methods may be used to separate mixtures: filtration, distillation, chromatography, evaporation. State which method you would use to separate:
   a) Zinc chloride from sea water.
   b) Pure water from sea water.
   c) The components of chlorophyll. **(3 marks)**

4. The elements of W, X and Y have the following atomic numbers W = 6, X = 8, Y = 19.
   a) Write the electronic configuration of Y. **(1 mark)**
   b) Write down the formula of a compound formed between Y and X. Use Y and X as symbols in the compound. **(1 mark)**
   c) What type of bond is formed when W combines with X? Give a reason. **(2 marks)**

5. Dilute hydrochloric acid was electrolyzed using carbon electrodes.
   a) Give the formulae of all the ions present in a solution of sulphuric acid. **(2 marks)**
   b) Which gas is formed at the anode? **(1 mark)**
   c) As electrolysis continues, does the solution become more or less acidic or the acidity remains unchanged? Give a reason. **(2 marks)**

6. An organic formula C_4H_8 was prepared by heating butanol with concentrated sulphuric acid.
   a) Give the structural formula of butanol (butanol-1) **(2 marks)**
   b) To what class of hydrocarbons does C_4H_8 belong? **(1 mark)**
   c) Give the structural formulae of two isomers of C_4H_8. **(1 mark)**

7. Ammonia gas is prepared by heating calcium hydroxide and ammonium chloride.
   a) Write a balanced chemical equation for the reaction between calcium hydroxide and ammonia chloride. **(2 marks)**

b) Why is ammonia gas not dried by using concentrated sulphuric acid? **(1 mark)**

c) State one large scale use of ammonia. **(1 mark)**

8. Organic compounds are classified according to their functional groups. From the compounds represented by the formulae:
A: CH_3CH_2COOH, B: CH_3CH_2OH, C: $CH_3CH = CH_2$,
D: $CH_3COOCH_2CH_3$, E: $CH_3CH_2CH_2CH_3$.
Select a letter corresponding to the formula of:
a) An ester
b) A carboxylic acid
c) An alkene. **(3 marks)**

9. A scientist suspected that drinking water was contaminated by zinc sulphate.
How would the scientist show by chemical tests that the water contained:
a) Zinc ions? **(2 marks)**
b) Sulphuric ions? **(2 marks)**
In each case describe the reagents {chemicals} used and the expected observation for a positive result.

10. Poly(ethene) is a commonly used plastic polymer.
a) State one advantage of using Poly(ethane) plastic compared to other materials such as metals of glass. **(1 mark)**
b) Why is poly(ethene) plastic considered a pollutant in the environment? **(1 mark)**

11. 5.95g of tin (Sn: relative atomic mass = 119) were burned in oxygen to produce 7.55g of an oxide of tin.
a) Calculate the mass of oxygen in the oxide of tin. **(1 mark)**
b) Determine the empirical formula of the oxide of tin. (O: relative atomic mass = 16) **(2 marks)**

12. Sulphur dioxide is known to be one of the gases which cause acid rain.
a) Write an equation to show the reaction of sulphur dioxide with water. **(1 mark)**
b) In the contact process, sulphur dioxide is converted into sulphuric acid.
Give one large scale use of sulphuric acid. **(1 mark)**

13. a) Arrange the following metals in order of reactivity, starting with the most reactive: Zn, Cu, Mg, Ca, Pb. **(1 mark)**
b) A piece of magnesium was mixed with copper (II) sulphate and the mixture was left to stand for about an hour. What observation would be made after an hour? Explain your reasoning. **(2 marks)**

14. a) Name a process which removes carbon dioxide from the atmosphere. **(1 mark)**

b) Name a process which releases carbon dioxide into the atmosphere. **(1 mark)**

c) In recent years, human activity has caused a large increase of carbon dioxide in the atmosphere. Briefly explain what effect the increase amount of carbon dioxide has on the environment. **(2 marks)**

15. The table below shows some of the methods for the preparation of salts.

Reactants	**Products**
Magnesium oxide + A	Magnesium nitrate + B
C + Sodium sulphate	Barium sulphate + D

Identify the compounds A, B, C and D by writing their names. **(4 marks)**

A = B =

C = D =

SECTION B: Attempt any THREE questions in this section. (3O marks)

16. Iron is extracted from an iron ore called haematite (Fe_2O_3) in blast furnace. Iron ore is mixed with coke (carbon), calcium carbonate (limestone) and and introduced into the furnace. A blast of hot air is blown in from the bottom of the furnace. Coke (carbon) burns to form carbon dioxide which reacts with more carbon to form carbon monoxide.

a) Write two balanced equations to show the formation of the two gases. **(2 marks)**

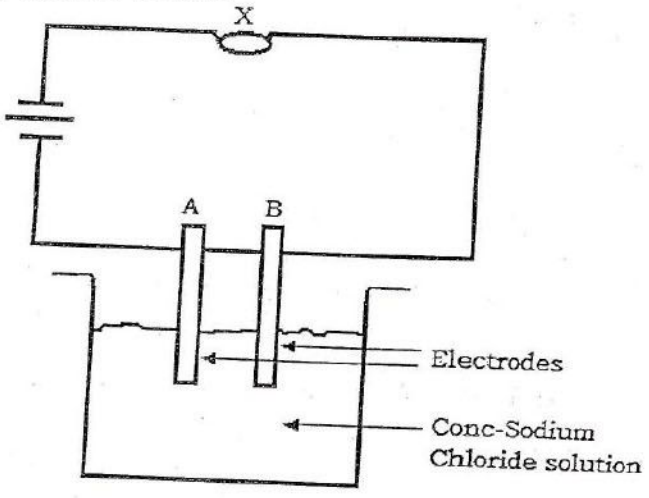
b) Write a balanced equation to show the reaction between Fe_2O_4 and carbon. **(2 marks)**

c) Identify the oxidizing agent and reducing agent in reaction of (b) above. **(2 marks)**

d) What is the function of calcium carbonate? Explain your answer using two equations. **(2 marks)**

e) What is galvanized iron? Why is iron sometimes galvanized? **(2 marks)**

17. A student carried out electrolysis of concentrated chloride solution using the apparatus shown below:



a) What apparatus could be connected at X to show that the solution is an electrolyte? **(1 mark)**

b) Identify the electrodes labelled A and B. **(3 marks)**

c) Which gas is formed at electrode B? Write an equation to show its formation. **(2 marks)**

d) After some time, the solution around one of the electrodes was tested with a red litmus paper. The paper turned blue. Explain in terms of the electrolysis process, why the solution turned red litmus paper blue? **(2 marks)**

e) Suppose the electrodes A and B are graphite and the electrode is a solution of copper (II) sulphate, give two observations that could be made as a result of electrolysis (apart from observing bubbles of gas). **(2 marks)**

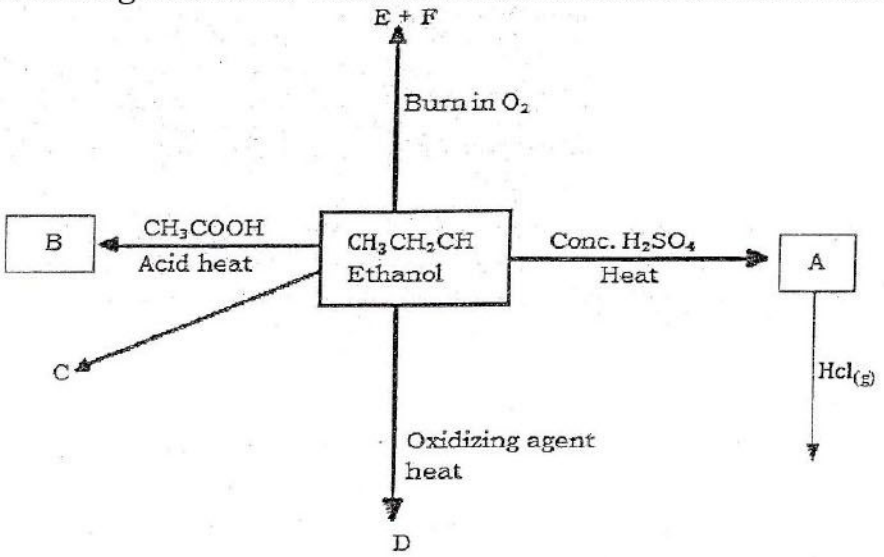
18. Ethanol is a member of a family of organic compounds Alcohols (Alkanols). Ethanol is prepared by mixing a solution of glucose with yeast; leaving the mixture for a day at a temperature of about 37°C and then isolating ethanol from the mixture.

a) Name the process in which ethanol is formed from a solution of glucose. **(1 mark)**

b) What is the role of yeast? **(1 mark)**

c) What functional group is present in all alcohols? **(1 mark)**

d) The diagram below shows reactions of ethanol and other compounds.



i) Identify the organic compounds (by name or formula) A, B, C and D? **(4 marks)**

ii) The formation of E and F is an exothermic reaction. What is an exothermic reaction? **(1 mark)**

c) Compound A reacts with hydrogen chloride. Write a chemical equation for the reaction. **(2 marks)**

19. An experiment was carried out to find the concentration of sulphuric acid solution and to prepare sodium sulphate crystals from the solution. In that experiment, it was found that 25 cm^3 of 2 $mol.dm^{-3}$ sodium

carbonate solution neutralized 27cm^3 of sulphuric acid. After neutralization the solution was used to obtain crystals of salt.

a) Write a balanced equation for the reaction of sodium carbonate and sulphuric acid. **(2 marks)**

b) How many moles of Na_2CO_3 were in 25 cm^3 of 2 mole.dm^{-3} solution? **(1 mark)**

c) Calculate the concentration of sulphuric acid in moldm^{-3} (to 2 decimal places). **(2 marks)**

d) State the name of one indicator you could use in the neutralization process. **(1 mark)**

e) Briefly explain how crystals of sodium sulphate could be obtained from the solution after neutralization. **(2 marks)**

f) Calculate the mass of sodium sulphate crystals which could be obtained from the solution. (Na = 23, S = 32, O = 16). **(2 marks)**

20. Magnesium is in group 2 of the periodic table and is represented by the symbol $^{24}_{12}Mg$, it combines with oxygen to form magnesium oxide. The symbol for oxygen is $^{16}_{8}O$.

a) What do the numbers 24 and 12 in the symbol of Mg represent? **(1 mark)**

b) Another type of magnesium is represented by $^{26}_{12}Mg$. State the name given to the different types of magnesium atoms? **(2 marks)**

c) Give the electronic configuration of magnesium and predict in which period of the periodic table it is. **(2 marks)**

d) Magnesium combines with oxygen. State the type of bond which is formed and give two properties such a compound shows. **(3 marks)**

e) Calcium is below magnesium in the same group of the periodic table. Compare the reactivities of the two metals with water. Write an equation to show how one of the two metals react with water. **(2 marks)**

SECTION C: Attempt one question from this section. (15 MARKS)

21. Chlorine gas is prepared by heating Manganese (IV) Oxide (Manganese dioxide) with concentrated hydrochloric acid. The gas is collected by downward delivery. It is highly reactive and a strong oxidizing agent.

a) Describe a chemical test for chlorine gas. **(1 mark)**

b) Chlorine is a member of halogens of group 7 in the periodic table. How does the reactivity of halogens change down the group and why? **(2 marks)**

c) Using balanced equations, show the products formed when chlorine reacts with:

i) Sodium iodide **(2 marks)**

ii) Sodium hydroxide solution at room temperature. **(2 marks)**

iii) Iron (II) chloride **(3 marks)**

d) Aluminium chloride is prepared from chlorine by passing dry chlorine over hot aluminium. Aluminium chloride sublimes and is collected in the cooler part of the apparatus.

i) What is sublimation? **(1 mark)**

ii) Write a balanced a balanced equation for the reaction of chlorine with aluminium. **(2 marks)**

iii) What mass of aluminium chloride is produced from 0.54 g of aluminium? (Cl = 35.5, Al = 27) **(2 marks)**

22. A student found a piece of rock which contained copper (II) carbonate. He carried out the following reactions in order to extract copper metal from the rock. Sulphuric acid was added to crush rock. When the reaction is over, the mixture was filtered. To precipitate containing copper (II) sulphate, sodium hydroxide solution was added. The precipitate obtained was filtered and the residue obtained was heated strongly to obtain copper (II) oxide which was reduced by heating with hydrogen gas.

a) Write a balanced equation for the reaction (II) carbonate with sulphuric acid. **(2 marks)**

b) How could the student tell if the reaction was complete? **(1 mark)**

c) What products were formed when copper (II) sulphate was reacted with sodium hydroxide? **(2 marks)**

d) Describe the colour of the mixture in (c) above. **(1 mark)**

e) Write a balanced equation for the reaction which involves heating to give copper (II) oxide. **(2 marks)**

f) Write down a balanced equation for the reaction between copper (II) oxide and hydrogen and identify the oxidizing agent. **(3 marks)**

g) If 5.0g of copper (II) oxide was used, calculate:

i) The mass of hydrogen gas which reacted with copper (II) oxide. **(2 marks)**

ii) The mass of copper metal which was produced. **(2 marks)**

MARKING SCHEME OF ORDINARY LEVEL CHEMISTRY NATIONAL EXAMINATION 2009

Section A: Answer all questions

1. a) Apply a burning splint (wooden). The gas burns with a pop sound or a pop sound is heard.
   b) The gas is lighter than air or the gas is less dense than air.
   c) $Zn\ (s) + 2\ HCl\ (aq) \rightarrow ZnCl_2\ (aq) + H_2\ (g)$
2. a)

Compound	Percentage
Nitrogen	78 %
Oxygen	21 %
Carbon dioxide	0.03 %
Noble gases	1 %

   b) i) Incomplete combustion/burning containing carbon.
   ii) Forms a stable compound with haemoglobin. (caboxyhaemoglobin) which prevents circulation of oxygen in blood, thus causing death. Or it interferes with circulation of oxygen in blood, hence causing death.

3. a) Evaporation
   b) Distillation
   c) Chromatography

4. a) Y: 2, 8, 8, 1
   b) X: 2, 6 hence the formula is Y_2X
   c) Covalent bond. **Reason:** Both W and X are non-metals. Or W and X bond by sharing electrons.

5. a) H^+, OH^-, SO_4^{2-}
   b) Oxygen
   c) Acidity remains unchanged. Reason: Equal amounts of H^+ and OH^- ions are removed during electrolysis.

6. a) $CH_3\text{-}CH_2\text{-}CH_2\text{-}CH_2OH$
   b) Alkenes
   c) $CH_2 = CH\text{-}CH_2\text{-}CH_3$
   $CH_3\text{-}CH = CH\text{-}CH_3$

7. a) $Ca(OH)_2 + 2NH_4Cl \rightarrow CaCl_2 + 2NH_3 + 2H_2O$
   b) Since NH_3 is alkaline / basic, it would react with H_2SO_4.
   c) Manufacture of nitric acid, fertilizers etc.
8. a) D
   b) A
   c) C
9. a) Add aq. Ammonia and aq. Sodium hydroxide until in excess.
   Observation: A white precipitate which dissolves in excess to give a colourless solution.
   b) Add dilute HCl, then $BaCl_2$ (aq) or dilute HNO_3 then $Ba(NO_3)_2$ (aq)
   Observation: a white precipitate insoluble in HNO_3 / HCl.
10. a) Advantages:
   Less expensive
   Not breakable
   Not attacked by chemicals.
   b) Do not decay or not broken down by microorganisms.

11. a) The mass of oxygen is 7.55 – 5.95 = 1.6 g
   b) Number of moles of Sn = 5.95 / 119 = 0.05 mol
   Number of mol of O = 1.6 / 16 = 0.1 mol
   Mole ratio of Sn / O = 0.05 : 0.1 = 1 : 2
   Empirical formula = SnO_2
12. a) H_2O (l) + SO_2 (g) $\rightarrow$ H_2SO_3 (aq)
   b) To manufacture fertilizers or in car / vehicle batteries.

13. a) Ca, Mg, Zn, Pb, Cu
   b) A brown deposit of copper or a blue colour fades / turns colourless
   Explanation: Mg displaces Cu from the solution since it is more reactive than Cu.
   Or Mg (s) + $CuSO_4$ (aq) $\rightarrow$ $MgSO_4$ (aq) + Cu (s)

14. a) Photosynthesis
   b) Respiration / combustion of fuels containing carbon
   c) CO_2 acts as a greenhouse gas or CO_2 traps heat radiated from the earth hence causes global warming.

15. A = Nitric acid
   B = Water
   C = Barium nitrate or barium chloride.
   D = Sodium nitrate or sodium chloride

SECTION B: Attempt any THREE questions in this section

16.a) $C(s) + O_2(g) \rightarrow CO_2(g)$

$CO_2(g) + C(s) \rightarrow 2CO(g)$

b) $Fe_2O_3(s) + 2CO(g) \rightarrow 2Fe(s) + 2CO_2(g)$

c) Oxidizing agent is Fe_2O_3

Reducing agent is CO.

d) To remove the impurity of silicon dioxide (SiO_2)

$CaCO_3(s) + SiO_2(g) \rightarrow CaO(s) + CO_2(g)$

17.a) Ammeter / bulb

b) A: cathode (negative electrode)

B: cathode (positive electrode)

c) Oxygen / Cl_2.

d) The solution was alkaline / basic.

Electrolysis continued, H^+ ions were converted into H_2 gas, leaving excess of OH^- in the solution around that electrode; hence causing the solution to be alkaline.

e) A brown solid deposited on the cathode (negative electrode)

The blue colour fades of the solution becomes less blue as Cu^{2+} ions are removed.

18.a) Fermentation

b) It provides a catalyst to increase the rate of fermentation / reaction.

c) OH group.

d) i) A: $CH_2 = CH_2$ or C_2H_4 or ethane

B: $CH_3COOC_2H_5$ or ethyl ethanoate

C: CH_3CH_2ONa or sodium ethanoate

D: CH_3COOH or ethanoic acid

ii) Exothermic reaction is a reaction which gives out / produces heat.

e) $CH_2 = CH_2 + HCl \rightarrow CH_3CH_2Cl$

19.a) $Na_2CO_3(aq) + H_2SO_4(aq) \rightarrow Na_2SO_4(aq) + H_2O(l) + CO_2(g)$

b) Number of mole: 2 X 25 / 1000 = 0.050 moles

c) Number of moles of H_2SO_4 = 0.050 moles

(since mole ratio of $Na_2CO_3 = H_2SO_4$)

d) Methyl orange or phenolphthalein

e) Evaporate the solution to saturation, then leave to cool → crystals will form or evaporate to dryness.

f) Number of moles of Na_2CO_3 = number of moles of Na_2SO_4 = 0.050 mole

Molar mass of Na_2SO_4 = (2 X 23) + 32 + (16 X 4) = 142 g/mol.

Mass of Na_2SO_4 = 0.050 mole X 142 g/mole = 7.1 g

20. a) 24 = mass number (number of protons + number of neutrons)

12 = atomic number or number of protons or number of electrons.

b) Isotopes

c) Mg: 2: 8: 2. Period 3

d) Ionic bond or electrovalent bond

Properties: High melting point and high boiling point.

Conducts electricity in molten state

e) Ca is more reactive than Mg.

$Ca (s) + 2H_2O (l) \rightarrow Ca(OH)_2 (l) + H_2 (g)$

Or $Mg (s) + H_2O (g) \rightarrow MgO (s) + H_2 (g)$

SECTION C: Attempt one question from this section.

21. a) Apply wet red litmus Paper.

The litmus paper is bleached / loses colour to become white

(or blue litmus paper → red → bleached)

b) Reactivity decreases down the group. They become weaker oxidizing agents.

Or as the size of atoms increases, they accept electrons less easily.

c) i) $Cl_2 (g) + 2NaI (g) \rightarrow NaCl (aq) + I_2 (g)$

ii) $2NaOH (aq) + Cl_2 (g) \rightarrow NaCl (aq) + NaOCl + H_2O (l)$

iii) $2FeCl_2 + Cl_2 \rightarrow 2FeCl_3$

d) i) Sublimation: change from solid to gas directly.

ii) $2 Al (s) + 3Cl_2 (g) \rightarrow 2AlCl_3 (s)$

Number of mole of Al = number of moles of $AlCl_3$.

Number of moles of Al = 0.54g / 27 $g.mole^{-1}$ = 0.02 mole

Number of mole of $AlCl_3$ = 0.02 mole

Mm of $AlCl_3$ = 27 + (35.5 X 3) = 133.5 $g.mol^{-1}$.

Mass of $AlCl_3$ = 0.02 mole X 133.5 $g.mole^{-1}$ = 2.67 g

22. a) $CuCO_3 (s) + H_2SO_4 (aq) \rightarrow CuSO_4 (aq) + CO_2 (g) + H_2O (l)$

b) If no more bubble / fizzying / effervescence

c) Copper (II) hydroxide + sodium sulphate

Oxidizing agent is CuO.

d) Blue solution

e) $Cu(OH)_2$ (s) → CuO (s) + H_2O (l)

f) CuO (s) + H_2 (g) → Cu (s) + H_2O (l)

Oxidizing agent is CuO.

g) i) Mole ratio of CuO : H_2 : Cu = 1: 1: 1

Mm of CuO = 64 + 16 = 80 g/mole.

Number of moles of CuO = 5 / 80 = 0.0625 mole

Number of moles of H_2 = 0.0625 mole

Mass of H_2 = 0.0625 g X 2g/mole = 0.125 g.

ii) Number of moles of Cu = 0.0625 mole

Mass of Cu = 0.0625 mole X 64 g/mole = 4g

CHEMISTRY I

003

08th Nov. 2010 08.30 – 11.30 am

RWANDA NATIONAL EXAMINATIONS COUNCIL

P.O BOX 3817 KIGALI-TEL/FAX : 586871

ORDINARY LEVEL NATIONAL EXAMINATIONS 2010

SUBJECT: CHEMISTRY I

DURATION: 3 HOURS

INSTRUCTIONS:

- This paper consists of **three** sections **A**, **B** and **C**
- Answer **ALL** questions in section A. **(55 marks)**
- Answer **THREE** questions in section B. **(30 marks)**
- Answer only **one** question in section C **(15 marks)**
- Calculators may be used.
- You do not need the periodic table.

SECTION A: ANSWER ALL QUESTIONS (55 MARKS)

1. The stomach secrets gastric juice, which contains hydrochloric acid. The gastric juice helps with digestion. Sometimes there is an overproduction of acid, leading to indigestion. Antacids such as milk of magnesia, can be taken to neutralize the excess acid. Milk of magnesia is only slightly soluble in water and has the chemical formula $Mg(OH)_2$.
   a) Write a balanced chemical equation to show how the antacid reacts with the acid. **(1 mark)**
   b) The directions on the bottle recommended that children under the age of 12 years take one teaspoon of milk of magnesia, whereas adults can take two teaspoons of the antacid. Briefly explain why the dosages are different. **(1 mark)**
   c) Why is it not advisable to take an overdose of the antacid in the stomach? Refer to the hydrochloric acid concentration in the stomach in your answer. **(1 mark)**

2. An unknown substance has a molar mass of 62.2 $g.mol^{-1}$ and consists of the following elements: 74.07% carbon, 17.28% nitrogen and 8.65% hydrogen.
   a) Determine the empirical formula of the substance. **(2.5 marks)**
   b) What is the molecular formula of the substance? **(1.5 marks)**
   (Atomic mass: H = 1, C = 12, N = 14)

3. Two test tubes, A and B, both contain HCl at a concentration of 1M. One gram of calcium carbonate powder is added to test tube A. In test B, one gram of calcium carbonate chunks is added. The reaction that takes place in the two test tubes is:
   $CaCO_3 + 2HCl \rightarrow CaCl_2 + H_2O + CO_2$ (g)
   a) i) In which test tube (A or B) will the formation of CO_2 take place at a. higher rate? **(0.5 mark)**
   ii) Give a reason for your answer. **(1 mark)**
   b) Will the rate at which CO_2 (g) is formed in test tube A be influenced (yes of no) if more of the HCl solution of the same concentration is poured into the test tube. **(0.5 mark)**
   c) Name two ways in which the rate of CO_2 (g) formation in both test tubes can be increased, excluding the option of adding more $CaCO_3$. **(1 mark)**

4. 0.72 g of O_3 reacts with 0.66 g NO according to the following equation:
   O_3 (g) + NO (g) $\rightarrow$ O_2 (g) + NO_2 (g)
   a) Calculate the number of moles of O_3 and NO present at the start of the reaction. **(2 marks)**
   b) Identify the limiting reagent (reactant) in the reaction and justify your answer. (Atomic mass: C = 16, N = 14) **(2 marks)**

5. Research has shown that the temperature on Earth is gradually rising.
   a) What term has been given to this phenomenon? **(1 mark)**
   b) What is the likely cause of this phenomenon? **(1 mark)**

c) What are the consequences of this phenomenon? **(1 mark)**
d) What can be done about it? **(1 mark)**

6. Study the formula of the compound: crystalline magnesium, sulphate: ($MgSO_4.7H_2O$)
   a) Determine the percentage of sulphur present in the compound. **(2 marks)**
   b) If we have 5g of this substance available, what mass will comprise of water? (Atomic mass: H = 1, O = 16, S = 32, Mg = 24) **(2 marks)**

7. Write only the word / term for each of the following descriptions:
   a) The distance between two atoms in a molecule. **(0.5 mark)**
   b) A chemical reaction during which electrons are transferred. **(0.5 mark)**
   c) A measure of how much solute is dissolved in a solvent. **(0.5 mark)**
   d) An ionic solution that conducts electricity. **(0.5 mark)**

8. a) Hydrogen is not a metal, but it is classified in 1A group (alkali metals), why? **(1 mark)**
   b) 15 cm^3 N_2 reacts with 30 cm^3 of H_2 to produce ammonia gas (NH_3 (g)). Determine the total volume of gas left in the container if the reaction runs to completion and if the volumes are measured at the same temperature and pressure before and after the reaction. **(3 marks)**

9. Read the following statements and then choose the best answer(s) from the column marked possible answers. There could be more than one correct answer and the possible answers may be used more than once. **(6 marks)**

Statement	**Possible answers**
1. The extent to which a salt dissolves in water is known as the ..... of salt.	A. Element
2. Sand and water is an example of a	B. Compound
3. In the case of a cup of black coffee, the coffee is the	C. Solution
4. A homozygous mixture can also called a	D. Homogeneous mixture
5. Salt dissolved in water is an example of a	E. Heterogeneous mixture
6. When $AgNO_3$ and NaCl are mixed, a ..... is formed.	F. Solvent
	G. Precipitate
	H. Solubility
	I. Solute
	J. Mixture

10. a) Name the following compounds:
    i) $NaHCO_3$ **(1 mark)**
    ii) CS_2 **(1 mark)**
    b) Write down the chemical formulae for the following compounds:

i) Ammonium sulphate **(1 mark)**
ii) Aluminium hydroxide **(1 mark)**

11. a) What an element? **(1 mark)**
b) Write down the name of seven elements on the periodic table which always occur as diatomic molecules in nature. **(3 marks)**

12. a) Define dilution. **(1 mark)**
b) What volume of 15M of sulphuric acid must be used to prepare 1.5 L of a 0.1M H_2SO_4 solution? **(1 mark)**

13. a) Name the type of chemical bond that occurs between the atoms in a water molecule. **(1 mark)**
b) Comment on the following table: Boiling points of the hydrides of VIA group elements against molecular weights. **(3 marks)**

Compound	**H_20**	**H_2S**	**H_2Se**	**H_2Te**
Molecular weight				
Boiling point (K)				

14. Sketch a diagram showing a water cycle. **(4 marks)**

15. a) The atomic number of phosphorous is 15. What does this mean? **(1 mark)**
b) Phosphorus is also classified as a non-metal: Name four physical properties phosphorus should have because of its non-metallic status. **(2 marks)**
c) Phosphorus has only one naturally occurring isotope. The isotope has 16 neutrons. The two radioactive isotopes of phosphorus have 17 and 18 neutrons respectively. Represent the two radioactive isotopes of phosphorus according to the notation $^{A}_{Z}X$. **(2 marks)**

Section B: Answer only THREE questions (30 marks)

16. Study the following reaction: Fe_2O_3 (s) + 3CO (g) → 2Fe (s) + $3CO_2$ (g)
Carbon monoxide is added to 500kg of iron (III) oxide at STD. Determine:
a) The mass of iron formed. **(4 marks)**
b) The volume of carbon dioxide released. **(2 marks)**
c) The number of iron atoms formed. **(2 marks)**
d) The number of atoms present in 500kg of Fe_2O_3 **(2 marks)**
(Atomic mass: Fe = 56, O = 16, C = 12, Number of Avogadro,
NA = 6.023 x 10^{23}; molar volume = 22.4 $l.mol^{-1}$)

17. A student wants to test sea water for the presence of chloride ions.
a) Make a list of the chemicals and apparatus that will be needed to conduct his test. **(2 marks)**
b) Suggest a method (procedure) to test sea water for the presence of chloride ions. **(4 marks)**
c) Write balanced equations for all reactions that take place. **(2 marks)**

d) If chloride ions are present, a precipitate forms. What is the colour of the precipitate? **(1 mark)**

e) Do you think the precipitate will contain other ions as well? Give a reason for your answer. **(1 mark)**

18. Bauxite is the principal ore of aluminium.

a) Describe briefly how bauxite is purified. **(2 marks)**

b) Explain why cryolite is added to the purified ore before it is electrolyzed. **(1 mark)**

c) Write equations to show the reactions that take place at the electrodes during the electrolysis of the purified ore (Al_2O_3). **(2 marks)**

d) Explain why the anode is replaced from time to time. **(2 marks)**

e) State two reasons why aluminium is not obtained from bauxite by heating the purified ore with carbon. **(2 marks)**

f) What is the reason why certain metals (such as gold) are more expensive than others (such as aluminium and copper etc)? **(2 marks)**

19. Because the world population is increasing so rapidly, the demand for food is increasingly high. The largest percentage of the world's soil is used for cultivation of crops, but large shortages of nutrients and minerals to allow good growth exist. The solution is the use of fertilizers.

a) Where do plants get the elements carbon, hydrogen and oxygen from? **(1 mark)**

b) The fertilizer: NPK is sold as NPK 14-26-16. What does this mean? **(2 marks)**

c) Why are liquid fertilizers used more and more in agriculture? **(3 marks)**

d) Write two paragraphs in which you address the impact of fertilizers on the environment. **(4 marks)**

20. a) Hydrocarbons are obtained from crude oil through fractional distillation.

i) Which physical property is used to separate the various hydrocarbons from crude oil? **(1 mark)**

ii) Which if the hydrocarbons, ethane or butane, will be removed first during distillation? Give a reason for your answer. **(1.5 marks)**

b) Consider the following organic compound: CH_3-CO-O-CH_3

i) Write down the name of this compound. **(1 mark)**

ii) Write down the names of two organic compounds that were used to prepare this compound. **(2 marks)**

iii) Write down the structural formula and name of one isomer of this compound. **(2 marks)**

c) Write the functional group of an amine, a ketone. **(1 mark)**

d) Is butane a saturated or unsaturated hydrocarbon? Give a reason for your answer) **(1.5 mark)**

Section C: Answer only ONE question. (15 marks)

21. A chemist conducts an investigation and makes use of the following:

– 0.1 mol.dm^{-3} NaOH

- Unknown concentration HCl
- Bromothymol blue indicator
- Burette
- Stand
- Erlenmeyer

20 cm^3 of HCl and a few drops of the indicator are placed in the Erlenmeyer flask. The burette is filled with NaOH. The latter is added to an acid solution until a permanent colour change occurs. The reaction mixture heats up slightly. The whole process is repeated three times. Results:

Volume acid	20	20	20
Volume base	15.3	15.5	15.2

a) Supply a possible hypothesis for the investigation. **(1 mark)**

b) Name the dependent and independent variables in this investigation. **(2 marks)**

c) i) Write the ionic equation for the unknown value. **(2 marks)**

ii) Use a calculation to determine the unknown value. **(3 marks)**

iii) Give the common name of salt formed. **(2 marks)**

d) What will happen to the pH of the acid during this reaction? **(1 mark)**

e) Is the reaction endothermic or exothermic? Explain. **(2 marks)**

f) Give the name of the method used for neutralizing the reaction. **(1 mark)**

g) Define acid-base indicator. **(1 mark)**

22. A group of learners was asked to investigate the reactivity of alkanes and alkenes. They chose ethane and ethane as examples. They then carried out the following experiments.

Experiment A: the learners poured a few drops of ethane and ethene onto two separate watch glasses and lit the liquids in a fume cupboard. Their observations are indicated in the table below:

Compound	**Colour of flame**	**Sootiness**
Ethane	Orange and blue flame	No soot observed
Ethene	Orange and blue flame	Slightly sooty

Experiment B: The learners perform the reaction of ethane and ethane firstly in a darkened room. They poured 2 cm^3 of ethane and 2 cm^3 of ethane into two separate test tubes and then added a few drops of bromine to the contents of each test tube. They then repeated the experiment in sunlight. Their observations are indicated in the table below:

Compound	Action of liquid bromine in the dark	Action of liquid bromine in the sunlight
Ethane	No visible reaction	Liquids mix and decolorize after a long time. A gas evolves.
Ethene	Bromine decolorizes slowly	Liquids mix and decolorize rapidly. No gas evolves.

a) Write down for safety precautions that the learners took during the experiment. **(2 marks)**

b) Write down a possible hypothesis for the investigation. **(2 marks)**

c) What conclusion should the learners reach about the reactivity of the compounds as a result of:

i) The experiment A? **(1 mark)**

ii) The experiment B? **(1 mark)**

d) i) Write down the balanced equations for the combustion reactions involved in the experiment A. **(2 marks)**

ii) Write down the balanced equations for the combustion reactions involved in the experiment A. **(2 marks)**

e) Ethene molecules bond with one another to form long polymer chains. What are these units known as? **(1 mark)**

f) Give the general molecular formula of the alkenes? **(1 mark)**

g) Calculate the mass of gas evolved in experiment B. **(3 marks)**
(Atomic mass: H = 1; C = 12; Br = 80, density of ethane = 1.212 g/L).

MARKING SCHEME OF ORDINARY LEVEL CHEMISTRY NATIONAL EXAMINATION 2010

Section A: Answer all questions

1. a) $Mg(OH)_2$ (s) + 2HCl (aq) → $MgCl_2$ (aq) + $2H_2O$ (l)
   b) Adults have a bigger mass and generally produce more acid than children. Adults will therefore need more antacid to neutralize the excess acid.

2. a)
   $Moles\ of\ C = \frac{74.07}{12} = 6.17$
   $Moles\ of\ N = \frac{17.28}{14} = 1.23$
   $Moles\ of\ H = \frac{8.65}{1} = 8.65$
   Ratio of elements
   $C = \frac{6.17}{1.23} = 5$

   $N = \frac{1.23}{1.23} = 1$

   $H = \frac{8.65}{1.23} = 7$

   The empirical formula is C_5NH_7
   b) Molar mass of C_5NH_7 = (5 X 12) + 14 + (7 X 12) = 81 g/mole
   But it should be 162.2 g/mole
   $\frac{162.2}{81} = 2$
   Thus molecular formula is $C_{10}N_2H_{14}$
   c) A low acid concentration, the stomach may slow down food digestion or may cause further stomach upset.

3. a) i) Test tube A
   ii) Powdered has greater reaction surface than the pieces of $CaCO_3$
   b) No
   c) Add more concentrated HCl to each test tube.
   Heat the test tube

4. a) Mm of O_3 = 48 g/mole
   Mm NO = 30 g/mole
   n of O_3 = 0.74 / 48 = 0.0154 mole
   n of NO = 0.67 / 30 = 0.0223 mole

b) From the equation: 1 mole of O_3 combines with 1 mole of NO
Hence 0.015 mole of O_3 will react with 0.0154 mole of NO
The O_3 yields the smaller product hence it is the limiting agent
Or needed ratio = 1/1

O_3 is thus the limiting reagent.

5. a) Global warming
   b) The rise in carbon dioxide levels in the atmosphere as a result of the growing of the growing population and technological progress.
   c) Rise in sea level; floods; droughts; Melting of icebergs
   d) Limited use of fossil fuels
   Delay damage to the ozone layer by reducing CFC_S

6. a) Total molar mass of $MgSO_4.7H_2O$
   = 24 + 32 + (14 X 4) + 7 X {(2 X 1) + (16 X 1)} = 120 + 126 = 246 g/mole
   % of sulphur $= \frac{32}{246} \times 100 = 13.01\ \%$
   b) $\%\ H_2O = \frac{126}{246} \times 100 = 51.22\ \%$
   $Thus\ \frac{51.22}{100} \times 5\ g = 2.56\ g$

7. a) Bond length
   b) Redox reaction or oxido-reduction reaction
   c) Concentration
   d) Electrolyte

8. a) Because hydrogen has one electron in the outer shell like alkali metals it can lose it and form monovalent ion like alkali.
   b)

N_2 needed	H_2 needed	To form NH_3
1 cm^3	3 cm^3	2 cm^3
15 cm^3	45 cm^3 (impossible)	
10 cm^3	30 cm^3	20 cm^3

   Thus, (15 – 10) = 5 cm^3 of N_2 remains; and 20 cm^3 of ammonia is formed.
   Final volume of gas = 5 + 20 = 25 cm^3 gas.

9. 1. H
   2. E, J
   3. I

4. C
5. C, D
6. G

10. a) i) Sodium bicarbonate
Sodium hydrogen carbonate
ii) Carbonate sulphite
b) i) $(NH_4)_2SO_4$
ii) $Al(OH)_3$

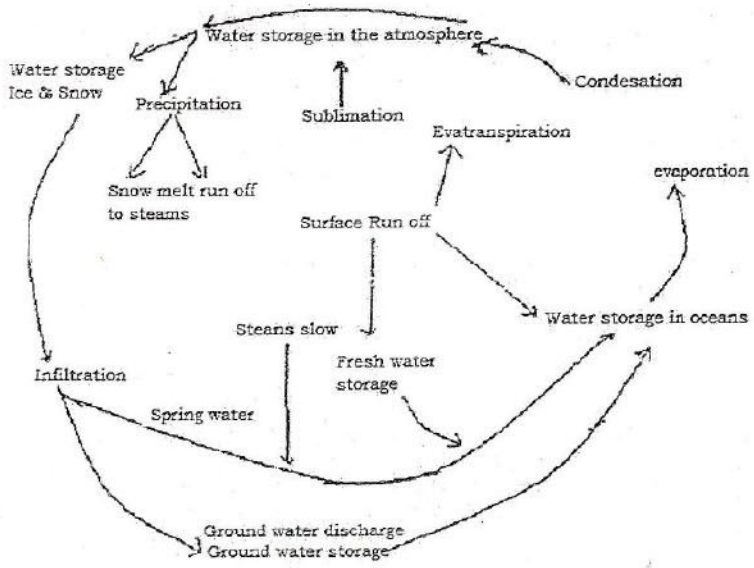
11. a) Elements are the basic units of matter; they are pure substances that cannot be broken down into simpler substances by chemical methods.
b) Hydrogen – Gas
Nitrogen – Gas
Oxygen – Gas
Fluorine – Gas
Chlorine – Gas
Bromine – Gas
Iodine - Gas

12. a) Dilution is a technique used to diminish the concentration of a substance by adding water.
b) Ci = 15 M
Vi = ?
Cf = 0.1 M
Vf = 1.5 L
Ci Vi = CfVf

$$V_i = \frac{C_f V_f}{C_i} = \frac{0.1M \times 1.5\ L}{15\ M} = 0.01\ l = 10\ cm^3$$

13. a) Covalent bond
b) There is a trend of decrease of boiling points with decrease of molecular weight from H_2Te to H_2S. But there is a sharp increase in case of H2O, although it has the smallest molecular weight. The reason is that the molecules of water are associated by hydrogen bonds between them, while H_2Te, H_2Se and H_2S exist as single molecules since they are incapable of forming hydrogen bonds. Therefore, more energy is required to separate the molecules of water as they enter the gaseous state or the liquid.

14.



15. a) Number of protons

b) Brittle

i. Dull

ii. Does not conduct electricity

c) $^{32}_{15}X$ and $^{33}_{15}X$

SECTION B: ANSWER ONLY THREE QUESTIONS

16. $Fe_2O_3 + 3\,CO \rightarrow 2Fe + 3CO_2$

1mole 3 moles 2moles

a) Fe_2O_3 = 500 kg = 500,000 g

Mm of Fe_2O_3 = (56 X 2) + (16 X 3) = 160 g/mole

n of $Fe_2O_3 = \frac{m}{Mm} = \frac{500\,000\ g}{160\ g/mole} = 3125\ moles$

Fe = 56 g/mole

For one mole of $Fe_2O_3 \rightarrow$ 2 moles of Fe

3125 moles mole of $Fe_2O_3 \rightarrow$ 6250 moles of Fe

Mass of iron = n X Mm = 6250 moles X 56 g/mole = 3,350,000 g = 3,350 tones

b) For 1 mole of one mole of $Fe_2O_3 \rightarrow$ 3 moles of CO_2

1325 moles of $Fe_2O_3 \rightarrow$ 9375 moles of CO_2

Volume of CO_2 = n X Vm = 9,375 moles X 22.4 L/mole = 210,000 L

c) n of Fe = 6250 moles

Number of atoms = n X A_N = 6,250 X 6.023 X 10^{23} = 3.76 X 10^{27} Fe atoms

d) n of Fe_2O_3 = 3125 moles

Number of atoms = n X A_N X 5 = 3,125 X 6.023X10^{23} X 5

= 9.41 X10^{27} atoms

17. a) Test tube, $AgNO_3$, sea water, concentrated HNO_3.
b) Method:
Pour a small amount of sea water into the test tube.
Add $AgNO_3$ (aq) to the test tube and observe if a white precipitate forms.
If a precipitate forms, add a few drops of concentrated HNO_3.
If the precipitate does not reach with the acid, it is possibly AgCl, and the sea water contained chloride ions.
c) Cl^- (aq) + $AgNO_3$ (aq) → AgCl (l) + NO_3^- (aq)
AgCl (l) + HNO_3 (aq) → No reaction
d) The precipitate is white
e) Yes, because sea water contains dissolved ions and it is possible that the sample will contain some bromide and iodide ions as well. AgBr and AgI are both insoluble in HNO_3.

18. The ore is dissolved in concentrated sodium hydroxide solution to form aluminate
Al_2O_3 (l) + $2Na(OH)_4$ (aq) + $3H_2O$ (l) → $2NaAl(OH)_4$
The solution is filtered and the filtrate is diluted then carbon dioxide is blown through it, Aluminium hydroxide is the precipitate as a result. The aluminium hydroxide is then heated to produce Aluminium oxide.
$Al(OH)_3$ (l) → Al_2O_3 (l) + $3H_2O$ (g)
b) To lower the melting point of aluminium oxide.
c) Cathode: Al^{3+} (aq) + 3e → Al (s)
Anode: $2O^{2-}$ (aq) → O_2 (g) + 4e
d) Because it is burnt to carbon dioxide in the oxygen produced.
e) Because aluminium is a stronger reducing agent than carbon, hence Al_2O_3 cannot be reduced. (i.e. Al is above C in the electrochemical series) Because Al reacts with carbon to form aluminium carbide (Al_4C_3).
f) The cost of the mining and processing, as well as the availability of the metal play an important role.

19. a) From the CO_2 and H_2O absorbed through their leaves and roots from the soil and air.
b) N: nitrogen, P: phosphorous, K: Potassium
c) They cause least environmental problems
Substances are wasted minimally
Insecticides can be added
Nutrients are spread evenly

d) The leaching of too many nitrates and phosphates (in fertilizers) into natural water resources may lead to eutrophication. This can take place during heavy rains or when too much fertilizers are administered. When there is an excess of nutrients in the water, blue-green algae thrive. The algae contain waste products, which taint the water and make it unsuitable for drinking.
When the algae die, the excessive decomposing matter uses up oxygen in the water. The lack of oxygen then leads to the death of animals living in the water.

20. a) i) Different boiling points
ii) Ethane, because ethane has a lower boiling point than butane or ethane's mass is smaller than that of butane.
b) i) Methylethanoate
ii) Methanol, Ethanoic acid
iii) CH_3-CH_2-COOH (Propanoic acid)
c) Amine: CN Ketone: -C-CO-C-
d) Saturated hydrocarbon due to lack of double or triple bonds.

SECTION C: ANSWER ONLY ONE QUESTION

21. a) The concentration of an acid solution can be determined by means of a titration process. By knowing the quantity of a base required to neutralize a certain quantity of acid.
b) Independent = volume of acid
Dependent = volume of base
c) i) $HCl + NaOH \rightarrow H_2O + NaCl$
$H^+ + Cl^- + Na^+ + OH^- \rightarrow H_2O + Na^+ + Cl^-$
$H^+ + OH^- \rightarrow H_2O$
ii) CaVa = CbVb
$Vb = \frac{15.3+15.15+15.2}{3} = 15.22\ cm^3$
$Ca = \frac{CbVb}{Va} = \frac{0.1M \times 15.22cm^3}{20\ cm^3} = 0.076M$
iii) Caustic soda
d) The pH will rise to approximately seven
e) Exothermic (the energy of the products is lower than the energy of the reagents). Or it is a reaction that releases energy.
f) Titration

g) An indicator is a substance which changes colour in aqueous solution when the pH is changed colour in aqueous solution when the PH is changed.

22. a) Wear gloves, Wear goggles, Wear a gas mask; Perform the experiment in fume cupboard or outside the lab or in a well-ventilated room.

b) Alkenes are more reactive than alkanes under identical conditions.

c) i) Under the same conditions alkenes are more reactive than alkanes.

ii) Alkenes react more readily in bromine than alkanes.

d) i) $CH_3CH_3 + 7/2\ O_2 \xrightarrow{\Delta} 2CO_2 + 3H_2O$

$CH_2 = CH_2 + 3\ O_2 \rightarrow 2\ CO_2 + 2\ H_2O$

ii) $CH_3\ CH_3 + Br_2 \rightarrow CH_3CH_2Br + HBr$

$CH_2 = CH_2 + Br_2 \rightarrow CH_2Br - CH_2Br$

e) Monomers

f) C_nH_{2n}

g) $CH_3\ CH_3 + Br_2 \rightarrow CH_3CH_2Br + HBr$

1 mole of $CH_3\ CH_3 \rightarrow$ one mole of HBr (g)

Mm of Hbr = 1 + 80 = 81 g/mole

Volume of $CH_3CH_3 = 2\ cm^3 = 2 \times 10^{-3}$ L

Mass = volume X density = $1.212 \times 2 \times 10^{-3} = 2.42 \times 10^{-3}$ g

$CH_3CH_3 = 0.00242$ g

Mm of CH_3CH_3 = 30 g/mole.

Number of moles of $CH_3CH_3 = \frac{2.424 \times 10^{-3}}{30} = 8.08 \times 10^{-5} mole$

mHBr = n X HBr = $8.08 \times 10^{-5} \times 81$ g = 6.5448×10^{-3} g

CHEMISTRY I

002

08 Nov. 2011 08.30 am – 11.30 am

REPUBLIC OF RWANDA

RWANDA EDUCATION BOARD (REB)
P .O.BOX 3817 KIGALI. TEL/FAX: 586871

ORDINARY LEVEL NATIONAL EXAMINATIONS 2011

SUBJECT: CHEMISTRY I

DURATION: 3 HOURS

INSTRUCTIONS:

This paper consists of **three** sections **A**, **B** and **C**

Answer **ALL** questions in section A. **(55 marks)**

Answer **THREE** questions in section B. **(30 marks)**

Answer only **one** question in section C **(15 marks)**

You do not need the periodic table.

Calculators may be used.

SECTION A: Attempt all questions from this section. (55 marks)

1. Some oxides of period 3 of the periodic table are: Na_2O, Al_2O_3 and SO_3.
   (a) From the list choose and write down the formula of an oxide which is:
   (i) Acidic **(1 mark)**
   (ii) Basic **(1 mark)**
   (iii) Amphoteric **(1 mark)**
   (b) Write a balanced equation to show the reaction between the basic oxide and water. **(2 marks)**

2. The following list shows the chemical formulae of some ions: Na^+, Al^{3+}, Zn^{2+}, Br^-, PO_4^{3-} and O^{2-}. Use the list to write down the chemical formula of:
   Use the list to write down the chemical formula of:
   (a) Sodium phosphate **(1 mark)**
   (b) Aluminium oxide **(1 mark)**
   (c) Zinc bromide. **(1 mark)**

3. Silicon (atomic number 14) combines with chlorine (atomic number 17) to form compound A.
   (a) Write the electronic arrangement of silicon. **(1 mark)**
   (b) Using a 'dot and cross' diagram and the symbols Si (silicon) and Cl (chlorine), draw a diagram to show the bonding in the compound formed between Si and Cl. Use electrons in the outer shell only. **(2 marks)**
   (c) Would you expect the compound formed in (b) to conduct electricity when in molten state? Explain your answer. **(2 marks)**

4. C_5H_{12} is an organic compound which is a member of the homologous series of alkanes.
   (a) What is the name of C_5H_{12}? **(1 mark)**
   (b) Give the formula of an alkane with 7 C atoms. **(1 mark)**
   (c) Alkanes are examples of fossil fuels. Explain one environmental problem caused by the burning of alkanes. **(2 marks)**

5. Magnesium sulphate crystals ($MgSO_4.7H_2O$) were prepared by reacting excess magnesium oxide and sulphuric acid.
   (a) Write an equation for the reaction of magnesium oxide with sulphuric acid to form a solution of magnesium sulphate. **(2 marks)**
   (b) Why was excess magnesium oxide used? **(1 mark)**
   (c) Calculate the percentage of oxygen by mass in the compound ($MgSO_4.7H_2O$ (Mg = 24, S = 32, O = 16, H = 1) **(2 marks)**

6. 11.0g of manganese were reacted with oxygen to produce 17.4g of an oxide of manganese.
   (a) Calculate the mass of oxygen in the oxide of manganese. **(1 mark)**
   (b) Calculate the number of moles of:
   (i) Manganese (Mn) atoms **(1 mark)**
   (ii) Oxygen (O) atoms, and then **(1 mark)**
   (c) Determine the empirical formula of the oxide of manganese. **(1 mark)**

7. An alcohol has molecular formula C_3H_8O.
   (a) Write down the formula of the functional group in alcohols. **(1 mark)**
   (b) Write down the structural formulae of two possible isomers which are alcohols with molecular formula C_3H_8O. **(1 mark)**
   (c) Give the name of one of the isomers in (b). **(2 marks)**

8. A concentrated solution of sodium chloride was electrolyzed, using carbon (graphite) electrodes.
   (a) List all the ions present in aqueous sodium chloride by giving their formulae or names. **(2 marks)**
   (b) What is produced at the cathode? **(1 mark)**
   (c) After electrolysis, the remaining solution was tested with red and blue litmus papers. State and explain the expected observations. **(2 marks)**

9. Chlorine gas was prepared by heating concentrated hydrochloric acid and manganese (IV) oxide (MnO_2). After drying, it was collected by downward delivery.
   (a) Write a balanced equation for the reaction of hydrochloric acid with manganese (IV) oxide to produce chlorine, manganese (II) chloride and water. **(2 marks)**
   (b) How would you test for chlorine gas? Give the expected observation. **(2 marks)**
   (c) How is chlorine gas dried? **(1 mark)**
   (d) Suggest one precaution that would be taken while preparing chlorine gas in the laboratory? **(1 mark)**

10. The structures of some organic compounds are given below:
    A: $CH_3 - CH_2 - CH = CH_2$ **B:** $CH_3 - CH_2 - CH_2 - OH$
    C: CH_3 -CH_2-COOH **D:** CH_3 - CH_2 –CH_3.
    (a) Which of these compounds is:
    (i) An alkane **(1 mark)**
    (ii) A carboxylic acid? **(1 mark)**
    (iii) An alcohol? **(1 mark)**
    (b) Which of the compounds would react with sodium carbonate? **(1 mark)**
    (c) **B** and **C** were reacted together. What class of organic compounds is produced by reacting **B** and **C**? **(1 mark)**

11. Separation of mixtures can be below: Fractional distillation, simple distillation, filtration, chromatography.
    Select a method which would be used to separate:
    (a) Components of chlorophyll. **(1 mark)**
    (b) Kerosene and petrol (gasoline). **(1 mark)**
    (c) Copper (II) hydroxide from a precipitate of copper (II) hydroxide and water. **(1 mark)**
    (d) Pure water from sea water. **(1 mark)**

12. Ammonia (NH_3) is an important chemical used to manufacture other products such as fertilizers and nitric acid.

(a) Write a balanced equation to show the formation of ammonium nitrate from ammonia and nitric acid. **(2 marks)**

(b) State one pollution problem associated with nitrate fertilizers. **(1 mark)**

(c) Ammonium salts usually sublime when heated:

(i) What is meant by sublimation? **(1 mark)**

(ii) Write an equation to show the products of heating ammonium chloride. **(1 mark)**

SECTION B: Attempt any THREE questions only. (30 marks)

13. Hydrogen peroxide was mixed with manganese (IV) oxide to produce oxygen gas. The gas was collected in several gas jars so that some experiments could be carried out with it.

(a) What is the role of manganese (IV) oxide (MnO_2) in this experiment? **(1 mark)**

(b) How is oxygen gas tested? Describe the test and the expected observation. **(2 marks)**

(c) The elements sodium and sulphur were burned separately in gas jars containing oxygen. The product in each gas jar was mixed with water and the mixture shaken. The resulting solution was tested with litmus paper.

Write a balanced equation to show:

(i) How each element reacts with oxygen? **(2 marks)**

(ii) How each product in (i) reacts with water. **(4 marks)**

(d) State the observation made when the product of burning sulphur in oxygen was shaken with water and tested with blue litmus paper. **(1 mark)**

14. Drinking water was suspected to have been contaminated by some salts. It was tested to identify some ions which were suspected to be present. The following tests were carried out: One sample was acidified with nitric acid and then barium nitrate was added. A white precipitate was observed. Another sample was mixed with nitric acid and then silver nitrate was added. A white precipitate was observed. A third sample was mixed with sodium hydroxide and there was no observable change.

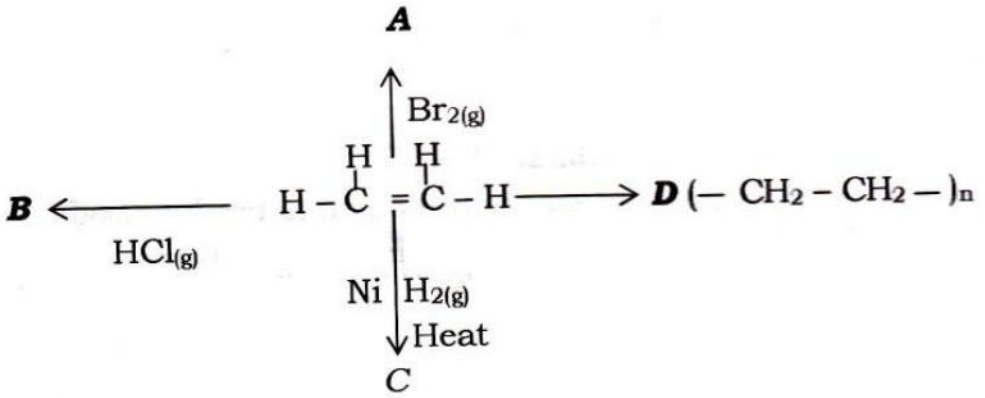
(a) Which ion was identified by the test with barium nitrate? Write an ionic equation to show the formation of the white precipitate. **(3 marks)**

(b)Which ion was identified by the test with silver nitrate? Write an ionic equation to show the formation of the white precipitate. **(3 marks)**

(c) Suggest two possible cations which could have been present as shown by the test using sodium hydroxide. **(2 marks)**

(d) Suppose the water contained some ammonium would confirm the presence of NH_4^+ ions? **(2 marks)**

15. The chart below shows some reactions starting with ethane.



(a) Give the structure and name of each of the compounds **A**, **B** and **C**. **(6 marks)**

(b) What name is given to the type of reaction that produces compound **D**? **(1 mark)**

(c) Give the name and the structural formula of the compound C_3H_6. **(2 marks)**

(d) Bromine is used to test for organic compounds which contain C=C. What is observed in this test? **(1 mark)**

16. Sulphuric acid is manufactured in the contact process according to the steps shown below.

I: Sulphur is burned in air (oxygen)

II: The product is reacted with more air (oxygen) in the presence of a catalyst to form sulphur trioxide.

III: Sulphur trioxide is absorbed in concentrated sulphuric acid and then diluted with water.

(a) Give a balanced' equation for the reaction in step I. **(2 marks)**

(b) Give a balanced equation for the reaction in step II. **(2 marks)**

(c) Name the catalyst used in step II. **(1 mark)**

(d) Briefly explain why sulphur trioxide is not directly reacted with water. **(2 marks)**

(d) Some sulphur dioxide may escape into the atmosphere. Explain an environmental problem this may cause. **(2 marks)**

(f) Give one large scale use of sulphuric acid. **(1 mark)**

17. A sample of carbon dioxide was prepared and collected for further experiments. The gas was produced by mixing calcium carbonate with hydrochloric acid. It was collected over water.

(a) Write a balanced equation to show the reaction of calcium carbonate with hydrochloric acid. **(2 marks)**

(b) Describe a chemical test for carbon dioxide, by stating the reagents and the expected observation for a positive result. **(2 marks)**

(c) Carbon dioxide can be prepared by burning charcoal in air (oxygen).

(i) Write a balanced equation for the reaction. **(1 mark)**

(ii) What might be formed if the charcoal burns in insufficient air (oxygen)? **(1 mark)**

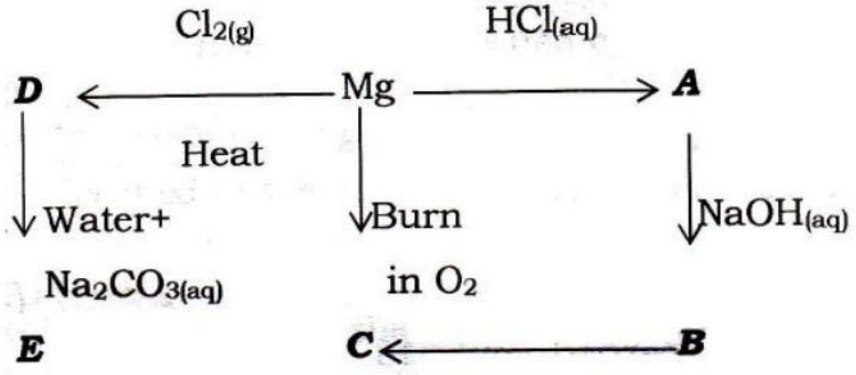
(d) State one environmental problem caused by too much carbon dioxide in the atmosphere. **(2 marks)**

(e) Carbon dioxide is used in some fire extinguishers. Give two properties of carbon dioxide which enable it to be used as a fire extinguisher. **(2 marks)**

SECTION C: Attempt only ONE question. (15 marks)

18. A titration experiment was carried out to determine the concentration of potassium hydroxide (KOH) and prepare crystals of potassium sulphate. In this experiment, 25cm^3 of KOH were neutralised by 24.50cm^3 of 0.1 mole/dm^3 sulphuric acid, using a suitable indicator.
(a) Write a balanced equation for the reaction of KOH and H_2SO_4. **(2 marks)**
(b) Calculate the number of moles of H_2SO_4. **(2 marks)**
(c) Calculate the number of moles of KOH in 25cm^3. **(2 marks)**
(d) Calculate the concentration of KOH in mole/dm^3. **(2 marks)**
(e) Calculate the mass of KOH that was dissolved in 1dm^3 of solution. (K = 39, O = 16, H =1) **(2 marks)**
(f) In order to prepare a sample of crystals of potassium sulphate, 25cm^3 of KOH were mixed with 24.50cm^3 of 0.1 mole/dm^3 sulphuric acid without the indicator. Describe in details how a sample of crystals of the salt would be obtained from the solution. **(3 marks)**
(g) Rubidium (Rb) is below potassium (K) in group I of the periodic table. How would you compare the reactivity of Rb with K? Explain your reason. **(2 marks)**

19. The chart below shows some reaction of magnesium and its compounds.



(a) Identify the compounds **A, B, C, D** and **E** either by names or by the chemical formula. **(10 marks)**
(b) In the reaction which produces compound **A**, a gas is produced also.
(i) Name the gas produced. **(1 mark)**
(ii) Describe a chemical test for the gas. **(2 marks)**
(c) Write a balanced equation for the reaction of compound A with NaOH (aq). **(2 marks)**

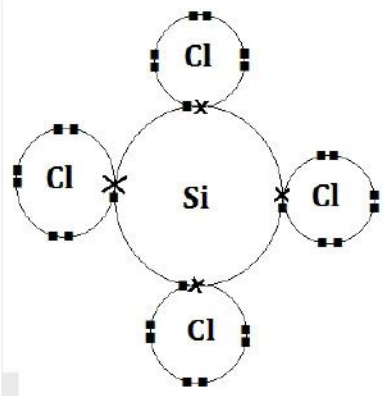
MARKING SCHEME OF ORDINARY LEVEL CHEMISTRY NATIONAL EXAMINATION 2011

Section A: Answer all questions

1. a) i) Acidic: SO_3
   ii) Basic: Na_2O
   iii) Amphoteric: Al_2O_3
   b) $Na_2O\ (s) + H_2O\ (l) \rightarrow 2NaOH\ (aq)$

2. a) Na_3PO_4
   b) Al_2O_3
   c) $ZnBr_2$

3. a) 2: 8:4 or $K^2\ L^8\ M^4$
   b)



   c) $SiCl_4$ cannot conduct electricity because it's a covalent, it's a non-electrolyte and it doesn't ionize to set free ions.

4. a) C_5H_{12} is pentane
   b) C_7H_{16} or $CH_3CH_2CH_2CH_2CH_2CH_2CH_3$
   c) Air pollution, pollutant gases, global warming, green hour effects, floods, releases CO_2 and CO.

5. a) $MgO + H_2SO_4 \rightarrow MgSO_4 + H_2O$
   b) Excess MgO was used to ensure that the neutralization reaction is complete and also the acid is finished or used up.
   c) Molar mass of $MgSO_4.7H_2O$ = 24 + 32 + 16 X 4 + 7(2 + 16) = 246 g/mole
   Mass of oxygen = (16 X 4 + 16 X 7) = 176 g

% of oxygen is $= \frac{176}{246} \times 100 = 71.5\ \%$

6. a) $Mn\ (s) + O_2\ (g) \rightarrow MnO\ (s)$

   11g 17.4g

   Mass of oxygen = 17.4 g – 11 g = 6.4 g

   b) i) n of Mn $= \frac{m}{Mm} = \frac{119\ g}{559\ g/mole} = 0.2\ mole$

   ii) n of oxygen $= \frac{m}{Mm} = \frac{6.4\ g}{169\ g/mole} = 0.4\ mole$

   c) Empirical formula:

	Mn	O
n	0.2	0.4
Ratio	0.2/0.2	0.4/0.2
	1	2

   Empirical formula is MnO_2

7. a) The functional group of alcohols is R-OH

   b) i) $CH_3 – CH_2 – CH_2 – OH$

   ii) $CH_3 – CHOH – CH_3$

   c) 2-Propanol

8. a) Na^+, Cl^-, H^+ and OH^-

   b) Hydrogen gas or H_2

   c) The red litmus paper turns blue. The blue litmus paper is not affected or changed. **Reason:** presence of NaOH which is an alkaline solution.

9. a) $4HCl + MnO_2 \rightarrow Cl_2 + MnCl_2 + 2H_2O$

   b) Test for chlorine:

   Turns moist blue litmus paper red and bleaches it.

   It changes acidified $K_2Cr_2O_7$ from orange to green.

   It changes acidified $KMnO_4$ purple to colourless.

   c) Chlorine gas is dried using concentrated sulphuric acid or anhydrous chloride.

   d) The preparation of chlorine in the laboratory should be done in a fume cupboard because it is poisonous.

10. a) i) D or $CH_3CH_2CH_3$

    ii) C or $CH_3 – CH_2 – COOH$

iii) B or $CH_3 – CH_2 – CH_2 – OH$

b) C

c) Ester or $CH_3 – CH_2 – COO– CH_2 – CH_3$

11. a) Chromatography

b) Fractional distillation

c) Filtration

d) Simple distillation

12. a) $NH_3 + HNO_3 \rightarrow NH_4NO_3$

b) Water pollution, it acidifies soil and causes eutrophication.

c) i) Sublimation as a direct change from solid to gas or from gas to solid without passing through the liquid state.

ii) $NH_4Cl \overset{\Delta}{\Longleftrightarrow} NH_3 + HCl$

SECTION B: ANSWER ONLY THREE QUESTIONS

13. a) MnO_2 is a catalyst (it speeds up the reaction), it increases the rate of a chemical reaction.

b) Test: it relights a glowing splint

c) i) $4Na\ (s) + O_2\ (g) \rightarrow 2Na_2O$

$S + O_2 \rightarrow SO_2$

ii) $Na_2O + H_2O \rightarrow 2\ NaOH$ or

$2Na_2O_2 + 2H_2O \rightarrow 4NaOH + O\ (g)$

$SO_2 + H_2O \rightarrow H_2SO_3$

14. a) SO_4^{2-}

Equation: $Ba^{2+}\ (aq) + SO_4^{2-} \rightarrow BaSO_4\ (s)$

(White precipitate)

b) Cl^-

Equation: $Ag^+\ (aq) + Cl^- \rightarrow AgCl$

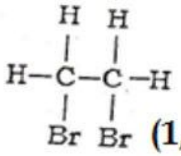
(White precipitate)

c) Na^+, K^+ or NH_4^+, Li^+, Ca^{2+}

d) After addition of NaOH to NH_4^+, there is a smell of ammonia (which turns red litmus paper blue or with HCl gas, it forms dense white fumes.

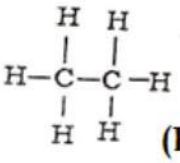
15.

a) A



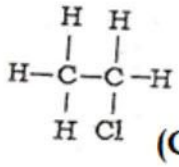
(1,2-dibromoethane)

C



(Ethane)

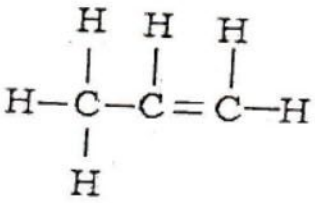
B



(Chloroethane)

b) Polymerization

c)



d) These compounds decolorize bromine water or red bromine loses colour (becomes colourless).

16.a) $S + O_2 (g) \rightarrow SO_2$

b) $2SO_2 + O_2 \rightarrow 2SO_3$

c) The catalyst is V_2O_5 (vanadium pentoxide or Vanadium (V) oxide)

d) The reaction is exothermic / produces mist fumes or the reaction is violent / produces a lot of heat.

e) Acid rain which infects water and fish, causes greenhouse effect, global warming, respiratory diseases etc.

f) Used in car batteries, manufacture of fertilizers, detergents, chemicals, it is used as a drying agent, covering metals, used as a dehydrating agent, used as a catalyst etc.

17.a) $CaCO_3 + 2HCl \rightarrow CaCl_2 + CO_2 + H_2O$

b) Use of lime water (calcium hydroxide solution)

Observation: Lime water turns milky or white precipitate in excess carbon dioxide i.e forms a clear solution.

c) i) $C (s) + O_2 \rightarrow CO_2 (g)$

ii) Carbon monoxide

d) It causes greenhouse effect and global warming, causes air pollution, floods etc...

e) It is denser than air

It does not support combustion / burning

It is poisonous.

SECTION C: ANSWER ONLY ONE QUESTION

18.a) $2KOH + H_2SO_4 \rightarrow K_2SO_4 + 2H_2O$

b) Number of moles contained in 24.5 cm^3 of H2SO4 0.1 M

n = M X V = 0.1 mole/dm^3 X 0.0245 dm^3 = 0.00245 mole

c) From the equation

1 mole of H_2SO_4 reacts with 2 moles of KOH

Hence 0.00245 mole of H_2SO_4 will react with 0.0049 mole of KOH

d) Concentration of KOH

In 25 cm^3, there is 0.0049 mole

$Molarity\ of\ KOH = \frac{n}{V} = \frac{0.0049\ mole}{0.025\ dm^3} = 0.196\ mole/dm^3$

e) Mm of KOH = 39 + 16 + 1 = 56 g/mole

Mass of KOH = n X Mm = 0.196 mole/dm^3 X 56 g/mole = 10.976 g/dm^3

f) Evaporation then followed by crystallization or evaporate a bit to remove the excess water and leave it covered with pieces paper to crystallize.

g) Rubidium is more reactive than potassium because reactivity of group I metals increases down the group Or Rubidium is more electro positive than potassium. Or Atomic radius of Rd is greater than atomic radius of K. Number of shells of Rb is greater than number shells of K.

19.a) A = $MgCl_2$ or Magnesium chloride

B = $Mg(OH)_2$ or Magnesium hydroxide

C = MgO or Magnesium oxide

D = $MgCl_2$ or Magnesium chloride

E = $MgCO_3$ or Magnesium chloride

b) i) Hydrogen gas

ii) Hydrogen gas is burnt in air and it produces a pop sound.

c) $MgCl_2 + 2NaOH \rightarrow Mg(OH)_2 + 2NaCl$

CHEMISTRY I

002

20th Nov. 2012 08.30 am – 11.30 am

REPUBLIC OF RWANDA

RWANDA EDUCATION BOARD (REB)
P.O.BOX 3817 KIGALI

ORDINARY LEVEL NATIONAL EXAMINATIONS 2012

SUBJECT: CHEMISTRY I

DURATION: 3 HOURS

INSTRUCTIONS:

This paper consists of **three** sections **A**, **B** and **C**

- Answer **ALL** questions in section A. **(55 marks)**
- Answer **THREE** questions in section B. **(30 marks)**
- Answer only **one** question in section C **(15 marks)**
- Silent non-programmable calculators may be used.
- **You do not need the periodic table.**

SECTION A: Attempt all questions from this section. (55 marks)

1. The atomic number of potassium is 19 and that of oxygen is 8.
   (a) Write the electronic configuration (arrangement) of an atom of potassium. **(1 mark)**
   (b) Write the electronic configuration of an atom of oxygen. **(1 mark)**
   (c) Write a balanced chemical equation for the reaction between potassium and oxygen. **(2 marks)**

2. Carbon monoxide was passed over a hot oxide of iron to reduce it to iron. 1.60 g of the oxide produced 1.12 g of iron. (Fe = 56, O = 16)
   (a) Calculate the number of moles of Fe. **(1 mark)**
   (b) Calculate the mass of oxygen and the number of moles of oxygen atoms. **(2 marks)**
   (c) Determine the empirical formula of the oxide of iron. **(1 mark)**

3. An organic compound has a molecular formula $C_2H_4O_2$. Its aqueous solution produces carbon dioxide when mixed with sodium carbonate.
   (a) Give the empirical formula of the compound. **(1 mark)**
   (b) State the name of the functional group present in the compound. **(1 mark)**
   (c) Give the full structural formula of the compound, showing all the covalent bonds. **(1 mark)**

4. Write one term or word to describe each of the following reactions or processes.
   (a) A reaction between an acid and a base. **(1 mark)**
   (b) A reaction between an alcohol and a carboxylic acid. **(1 mark)**
   (c) A method used to separate different dyes present in ink. **(1 mark)**
   (d) A method used to obtain pure water from sea water. **(1 mark)**

5. Calcium metal can be extracted by electrolysis of molten calcium chloride.
   (a) Give the chemical formula of calcium chloride. **(1 mark)**
   (b) Give a balanced ionic equation to show the reaction which occurs at the anode. **(2 marks)**
   (c) Why is it necessary to have the calcium chloride molten before electrolysis? **(1 mark)**

6. Propane is a compound of carbon and hydrogen. It can be used as a fuel.
   (a) Write the chemical formula of propane. **(1 mark)**
   (b) To which homologous series does propane belong? **(1 mark)**
   (c) Briefly explain how the combustion of propane might affect the environment. **(2 marks)**

7. A student prepared ammonia gas by heating an aqueous mixture of two compounds.
   (a) State any two compounds that can be heated together to produce ammonia gas. **(1 mark)**

(b) What type of bonding is present in ammonia gas? **(1 mark)**
(c) Ammonia gas dissolves easily in water, what is the approximate pH of the resulting solution? **(1 mark)**

8. A student prepared zinc sulphate crystals by reacting excess zinc with sulphuric acid. The mixture was filtered to remove excess zinc.
   (a) Why was excess zinc used? **(1 mark)**
   (b) Briefly explain how the student obtained crystals of zinc sulphate from the mixture. **(2 marks)**

9. Ethene is one of the major chemicals used to prepare plastics.
   (a) How is ethene obtained from ethanol? State the reagents and conditions used. **(2 marks)**
   (b) State the name of a plastic obtained from ethane. **(1 mark)**
   (c) State the name of the chemical process for changing ethene into the plastic named in (b) above. **(1 mark)**

10. Carbon dioxide gas was prepared by reacting excess hydrochloric acid with zinc carbonate. 0.125 g of Zinc carbonate was used.
    (Zn = 65, C = 12, H = 1)
    (a)Write a balanced equation for the reaction. **(2 marks)**
    (b) Calculate the number of moles of zinc carbonate used. **(1 mark)**
    (c) State one use of carbon dioxide. **(1 mark)**

11. From the following list of compounds: $MgSO_4$, $CaCl_2$, HNO_3, C_2H_4, C_2H_6. Select the compound (write the formula) which:
    (a) Produces a white precipitate when mixed with acidified silver nitrate solution. **(1 mark)**
    (b) Decolorizes bromine easily. **(1 mark)**
    (c) Is manufactured from ammonia gas. **(1 mark)**
    (d) Produces a white precipitate when mixed with acidified barium nitrate solution. **(1 mark)**

12. Iodine vapour was reacted with hydrogen gas in the presence or a suitable catalyst to form hydrogen iodide gas.
    (a) What is meant by the term "catalyst"? **(1 mark)**
    (b) Write a balanced equation for the reaction. **(1 mark)**
    (c) What volume of hydrogen iodide is produced by reacting 60 cm^3 of iodine vapour with 60 cm^3 of hydrogen? (Assume that all volumes are measured at the same temperature and pressure). **(2 marks)**

13. Three metals X, Y and z were investigated in order to place them in order of reactivity. Metal X did not react with a sulphate of Z reacted with a sulphate of Z as well as a sulphate of X.
    (a) Place the three metals in order of their reactivity, starting with the most reactive explain your reasoning. **(2 marks)**
    (b) Metal Z is heated with an oxide of X. State if there would be a reaction and give a reason for your answer. **(2 marks)**

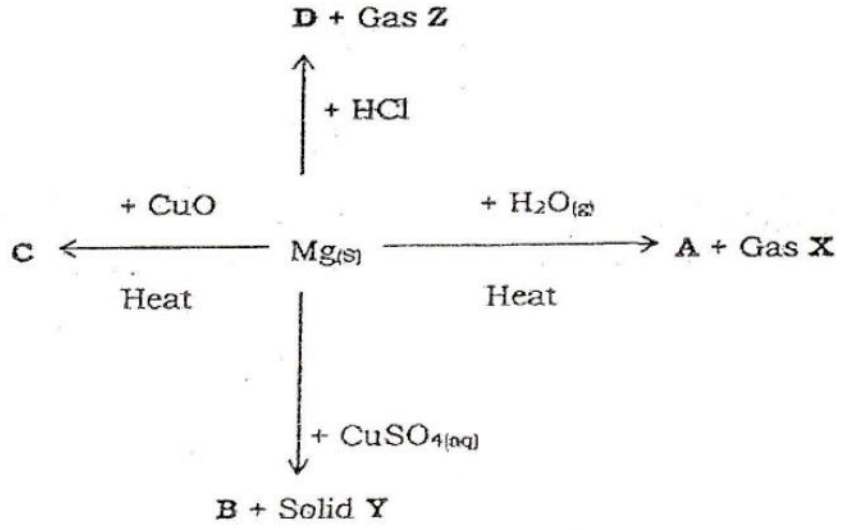
14. Sodium (atomic number 11) combines with sulphur (atomic number 16).
    (a) State what type of bond is present in the compound formed? **(1 mark)**
    (b) Give the chemical formula of the compound formed. **(1 mark)**
    (c) Would the compound formed conduct electricity when it is in molten form? Give a reason for your answer. **(2 marks)**

15. Air is an important raw material for the manufacture of some important chemicals.
    (a) Name a process that is used to separate the major components of air. **(1 mark)**
    (b) Name an important chemical manufactured from the most abundant component of air. **(1 mark)**

SECTION B: Attempt any THREE questions. (30 marks)

16. Hydrogen gas was prepared by reacting magnesium with dilute sulphuric acid. The gas was dried and burnt in air in a controlled wav. The gaseous product was cooled to obtain a colourless liquid.
    (a) How would you show by a chemical test that the gas is hydrogen? **(2 marks)**
    (b) How would you show that the colourless liquid is pure water? **(2 marks)**
    (c) Hydrogen gas can be used as a fuel. State:
        (i) One advantage of using hydrogen gas as a fuel. **(1 mark)**
        (ii) One disadvantage of using hydrogen as a fuel. **(1 mark)**
    (d) Give the name of the product formed when hydrogen is reacted with propene. **(1 mark)**
    (e) Hydrogen gas was passed over hot copper (II) oxide. Write a balanced equation for the reaction. **(2 marks)**
    (f) Identify the oxidizing agent in the reaction (e) above. **(1 mark)**

17. The scheme below shows some reactions starting with magnesium.



    (a) State the name of compound **A** and the name of gas **X**. **(2 marks)**
    (b) Give the name of solution **E** and the name of solid **Y**. **(2 marks)**

(c) **C** is a mixture of two solids. Identify the two solids. **(2 marks)**
(d) State the name of solution **D** and the name of gas **Z**. **(2 marks)**
(e) Give two different ways of increasing the rate of reaction between magnesium and hydrochloric acid. **(2 marks)**

18. One of the uses of electrolysis is electroplating. A student used the set up below to electroplate a copper coin with silver.
(a) Name a suitable electrolyte that could have been used. **(1 mark)**
(b) What name is given to the negative electrode? **(1 mark)**
(c) Give an ionic equation for the reaction which occurred on the surface of the copper coin. **(2 marks)**
(d) What happened s to the mass of the silver electrode? Explain your answer? **(2 marks)**
(e) State the name of particles responsible for conduction of electricity in:
(i) The electrolyte
(ii) The external wire connecting the electrodes. **(2 marks)**
(f) The original mass of the copper coin used was 12.8 g. Calculate the number of moles of copper in the coin (Cu = 64) **(2 marks)**

19. Sulphur dioxide gas was prepared in the laboratory by heating sodium sulphite (Na_2SO_3) with hydrochloric acid. The gas was dried and collected by downward delivery.
(a) Write a balanced chemical equation for the reaction between sodium sulphite and hydrochloric acid. **(2 marks)**
(b) Name one reagent that is used to dry sulphur dioxide. Why is such a reagent unsuitable for drying ammonia gas? **(2 marks)**
(c) State the name of the solution produced by dissolving sulphur dioxide in water and give the approximate pH of that solution. **(2 marks)**
(d) Calculate the percentage by mass of sulphur in the compound sodium sulphite (Na_2SO_3) (Na = 23, S = 32, O = 16) **(2 marks)**
(e) Explain one undesirable effect of sulphur dioxide on the environment. **(2 marks)**

SECTION C: ATTEMPT ONLY ONE QUESTION. (15 MARKS)

20. A sample of rock was analysed to determine if it contained the following ions: Fe^{2+}, NH_4^+, Cl^- and CO_3^{2-}. First it was crushed into a fine powder and then nitric acid was added. A vigorous reaction occurred. The mixture filtered and the filtrate was analysed.
(a) Why was the sample of rock crushed into a fine powder? **(2 marks)**
(b) Define the term "filtrate". **(1 mark)**
(c) Name the gas produced when nitric acid was added. How would you test the gas? Give the reagents you would use and the expected observation. **(3 marks)**
(d) Describe a chemical test you would carry out to confirm the presence of the following ions. In each case state the reagent and the expected observation for a positive result.
(i) Fe^{2+} **(2 marks)**
(ii) NH_4^+ **(2 marks)**

(iii) Cl^- **(2 marks)**

(d) Suppose a piece of magnesium metal is added to the filtrate. Which of the ions stated will react with magnesium? Write a balanced equation for the reaction. **(3 marks)**

21. Precipitation is one of the methods for preparing salts. Lead sulphate ($PbSO_4$) was prepared by mixing $25cm^3$ of $O.2mole.dm^{-3}$ lead nitrate $\{Pb(NO_3)_2\}$ solution with 25 cm^3 of 0.2 $mole.dm^{-3}$ magnesium sulphate ($MgSO_4$) solution. The mixture was filtered to separate the products.

(a) State which salt was in the residue and which salt was in the filtrate. **(2 marks)**

(b) Write a balanced equation for the reaction. **(2 marks)**

(c) Calculate the number of moles of lead nitrate in 25 cm^3 of the solution. **(2 marks)**

(d) Calculate the number of moles of magnesium sulphate in 25 cm^3 of the solution. **(2 marks)**

(e) State the number of moles of lead sulphate formed. Calculate the molar mass of lead sulphate. Hence calculate the mass of lead sulphate produced. (Pb = 207, S = 32, O = 16) **(4 marks)**

(f) Write a balanced equation to represent the thermal decomposition of lead nitrate. **(2 marks)**

(g) State one observation you would make if sodium hydroxide solution is added to aqueous lead ions (Pb^{2+}). **(1 mark)**

MARKING OF ORDINARY LEVEL CHEMISTRY NATIONAL EXAMINATION 2012

Section A: Answer all questions

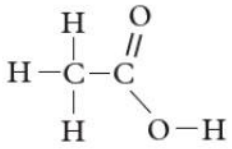
1. a) 2: 8: 8: 1
   b) 2: 6
   c) $4K\ (s) + O_2\ (g) \rightarrow 2K_2O\ (s)$

2. a) Number of moles of Fe $= \frac{Mass}{Molar\ mass} = \frac{1.12\ g}{56\ g/mole} = 0.02\ mole$
   b) Mass of oxygen = 1.60 g – 1.12 g = 0.48 g
   Number of moles of oxygen atoms:
   $= \frac{Mass}{Molar\ mass} = \frac{0.48\ g}{16\ g/mole} = 0.03\ mole$
   c) Empirical formula of the oxide of iron:

Fe	:	O
0.02	:	0.03 (multiply by 100)
2	:	3

   Empirical formula: Fe_2O_3

3. a) CH_2O
   b) Carboxylic acid group
   c)



4. a) Neutralization
   b) Esterification
   c) Chromatography
   d) Simple distillation

5. a) $CaCl_2$
   b) $2Cl^- \rightarrow Cl_2 + 2e^-$
   c) So that irons are free to move or to make ions mobile.

6. a) C_3H_8
   b) Alkanes / saturated hydrocarbon

c) It produces CO_2 which causes global warming / greenhouse effects, acid rain.

7. a) Any ammonium salt and any base / hydroxide e.g. NH_4Cl and $Ca(OH)_2$
   b) Covalent
   c) PH > 1 or 8 – 12

8. (a) To ensure that all the acid reacts completely.
   (b) Heat the filtrate to leave a small volume then leave to cool to crystallize or evaporate the solution to dryness.

9. a) Heat ethanol with concentrated H_2SO_4
   b) Poly(ethene)
   c) Polymerization

10. a) $ZnCO_3$ (s) + 2HCl (aq) → $ZnCl_2$ (aq) + CO_2 (g) + H_2O (l)
    b) Number of moles of Fe $= \frac{Mass}{Molar\ mass} = \frac{0.125\ g}{125\ g/mole} = 0.001\ mole$
    Molar mass of $ZnCO_3$ = 65 + 12 + 48 = 125 g/mole
    c) Used in fire extinguishers, in refrigeration, photosynthesis, in fizzy drinks, baking bread.

11. a) $CaCl_2$
    b) C_2H_4
    c) HNO_3
    d) $MgSO_4$

12. a) A catalyst is a substance which alters (changes) the rate of a chemical reaction but remains chemically unchanged at the end of the reaction. Or it's a substance which speeds up / increase the rate of a reaction but is not used up.
    b) I_2 (g) + H_2 (g) → 3HI (g)
    c) 1 vol + 1 vol = 2 vol
    Total volume of HI = 2 X 60 cm^3 = 120 cm^3

13. (a) J, Z and X. Y is the most reactive and X is the least. Reason: Y displaces metals Z and X. X doesn't displace any metal.
    b) Yes there is a reaction. Since Z is more reactive than X, it will become an oxide of Z.

14.a) Ionic / covalent bonds

b) Na_2S

c) Yes, **Reason:** because it contains free ions / mobile ions.

15.a) Fractional distillation

b) Ammonia, Fertilizers (NPK)

SECTION B: ANSWER ONLY THREE QUESTIONS

16. a) Apply a burning (wooden splint), a pop sound is heard.

b) Determine its boiling point, if it is 100°C at room temperature and pressure, then it is pure water, melting point should be 0°C.

c) i) It is cheap, gives no pollution and it is light.

ii) It explodes in air.

d) Propane / C_3H_8

e) $CuO\ (s) + H_2\ (g) \rightarrow Cu\ (s) + H_2O\ (l)$

f) CuO is the oxidizing agent.

17.a) Compound **A** = Magnesium oxide (MgO)

Gas **X** = Hydrogen (H_2)

b) Solution **B** = Magnesium sulphate ($MgSO_4$)

Solid **Y** = Copper (Cu)

c) Magnesium oxide (MgO) and Copper (Cu)

d) Solution **D** = Magnesium chloride ($MgCl_2$)

Gas **Z** = Hydrogen (H_2)

e) - Heating the mixture

- Use more concentrated acid
- Use of magnesium powder
- Shaking / stirring.

18.a) Silver nitrate or Silver Cyanide

b) Cathode

c) $Ag^+ + e^- \rightarrow Ag\ (s)$

d) It decreases.

Reason: The anode dissolves in solution (oxidation)

e) i) Ions

ii) Electrons

f) $Number\ of\ moles\ of\ Cu = \frac{Mass}{Molar\ mass} = \frac{12.8\ g}{64 g/mole} = 0.2\ mole$

19.a) Na_2SO_3 (s) + 2HCl (aq) → 2 NaCl (aq) + SO_2 (g) + H_2O

b) Concentrated H_2SO_4

Reason: it would react with ammonia

c) Sulphurous acid or SO_2 (g) + H_2O (l) → H_2SO_3 (aq)

PH: 1 – 3 or < 7.

d) Molar mass of Na_2SO_3 = (2 X 23) + 32 + (3 X 16) = 126 g

$$\% \, of \; S = \frac{32}{126} \times 100 = 25.4 \, \%$$

e) SO_2 contributes to acid rain which destroys crops, buildings / concrete, corrodes metals and harms fish.

20.a) Ionic / electrovalent compound, because it's a metal and a non-metal or metal atom (Ca) donates electrons to a non-metal.

b) Ca^{2+}: 2: 8: 8

F^-:2: 8

c) High melting point due to strong ionic / strong attraction between ions.

d) i) Group 2 or II or Alkali earth metals

Reason: Each atom has 2 electrons in its outer most shell.

ii) Calcium is more reactive because it is below Magnesium in the same group and reactivity increases down the group.

SECTION C: ATTEMPT ONLY ONE QUESTION.

21.a) To increase the surface area so that the reaction is faster.

b) A filtrate is a liquid that passes through a filter paper.

c) **Gas:** Carbon dioxide.

Test: Pass the gas through limewater / calcium hydroxide solution ($Ca(OH)_2$) (aq)

Observation: The mixture (lime water) turns milky or forms a white precipitate.

d) i) Fe^{2+} = Add aqueous NaOH or aqueous NH_3

Observation: A green precipitate is observed.

iii) NH_4^+ = Heat a sample of the filtrate with aqueous NaOH or aqueous KOH or aqueous $Ca(OH)_2$

Observation: Test the gas given off with wet red litmus paper. The red litmus paper turns blue.

iii) Cl^- = Acidify with dilute HNO_3 then add $AgNO_3$ (aq). A white precipitate is observed.

e) Fe^{2+} reacts with Magnesium

$Mg\ (s) + Fe^{2+} \rightarrow Mg^{2+}\ (aq) + Fe\ (s)$

22. a) Residue – Lead sulphate ($PbSO_4$)

Filtrate – Magnesium nitrate $Mg(NO_3)_2$

b) $Pb(NO_3)_2\ (aq) + MgSO_4\ (aq) \rightarrow Mg(NO_3)_2\ (aq) + PbSO_4\ (s)$

c) Number of moles of $Pb(NO_3)_2$ = n X V = 0.2 mole.dm^3 X 0.025 dm^3 = 0.005 mole

d) Number of mole of MgSO4 = n X V = 0.2 mole.dm^3 X 0.025 dm^3 = 0.005 mole.

e) 0.005 mole of $PbSO_4$

Molar mass of $PbSO_4$ = (207 X 1) + (32 X 1) + (4 X 16) = 303 g/mole

Molar mass of $PbSO_4$ = Mm X n = 0.005 mole X 303 g/mole = 1.515 g

f) $2Pb(NO_3)_2\ (s) \rightarrow 2PbO\ (s) + 4NO_2\ (g) + O_2\ (g)$

g) A white precipitate in excess NaOH.

CHEMISTRY I

002

05th Nov. 2013 08.30 am – 11.30 am

REPUBLIC OF RWANDA

RWANDA EDUCATION BOARD (REB)
P.O.BOX 3817 KIGALI

ORDINARY LEVEL NATIONAL EXAMINATIONS 2013

SUBJECT: CHEMISTRY I

DURATION: 3 HOURS

INSTRUCTIONS:

1) Don't open this question paper until you are told to do so.
2) This paper consists of **three** sections: **A**, **B** and **C**
   - **Section A:** Attempt all questions **(55 marks)**
   - **Section B**: Attempt any **THREE** questions. **(30 marks)**
   - **Section C:** Attempt **only one** question **(15 marks)**
3) Silent non-programmable calculators may be used.
4) **You do not need the periodic table.**

SECTION A: Attempt all questions from this section. (55 marks)

1. The atomic number of carbon (C) is 6 and that of chlorine (Cl) is 17.
   (a) What type of bond is formed between carbon and chlorine? **(1 mark)**
   (b) Draw a diagram to show bonding in the compound between carbon and chlorine. Use dots (.) and crosses (x) to represent electrons in the outer shells. **(3 marks)**

2. Chlorine gas is prepared by heating a mixture of manganese (IV) oxide (manganese dioxide) and concentrated hydrochloric acid.
   a) Write a balanced equation for the reaction. **(2 marks)**
   b) Describe a chemical test to show that the gas is chlorine. State the reagents and the expected observation for a positive result. **(2 marks)**

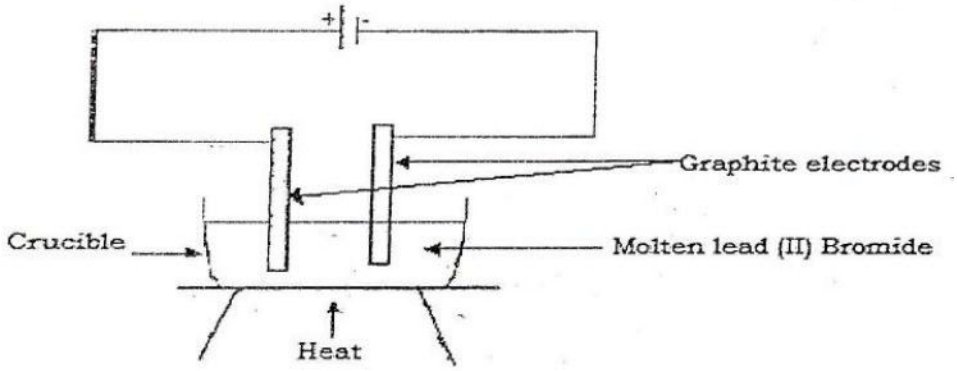
3. Iron is extracted from haematite (Fe_2O_3) by heating it with coke (carbon). Carbon reacts with oxygen to form carbon monoxide which then reacts with Fe_2O_3.
   a) Write a balanced equation between haematite and carbon monoxide. **(2 marks)**
   b) Identify the oxidizing agent in your equation (a) above. **(1 mark)**
   c) What harm might the extraction of iron have on the environment? Explain your answer. **(2 marks)**

4. Ethene belongs to a family of organic compounds known as alkenes.
   a) State the general formula of alkenes. **(1 mark)**
   b) Give the name and formula of alkene with five carbon atoms. **(2 marks)**
   c) Ethene reacts with hydrogen bromide to form another organic compound. Give the formula and name of the organic compound formed. **(2 marks)**

5. Ethanol can be prepared from a mixture of a solution of sugar and yeast kept warm conditions.
   a) What is the role of yeast? **(2 marks)**
   b) What is the name given to the process of preparing ethanol from sugar? **(1 mark)**
   c) What name is given to the organic compounds formed by reacting alcohols with carboxylic acids? **(1 mark)**
   d) State one use of compound identified in (c) above. **(1 mark)**

6. Sulphur and potassium were separately burned inside gas jars. The products were separately shaken with water in gas jars.
   a) Write a balanced chemical equation to show the reaction that occurs when the product from potassium reacts with water. State the approximate pH of the solution. **(3 marks)**
   b) The product from sulphur reacted with water and the solution formed was reacted with sodium hydroxide. Write a balanced equation for the reaction with sodium hydroxide. **(2 marks)**

7. The set-up below was used to electrolyse molten lead (II) bromide.



a) Why was it necessary to melt lead (II) bromide before electrolysis? **(1 mark)**

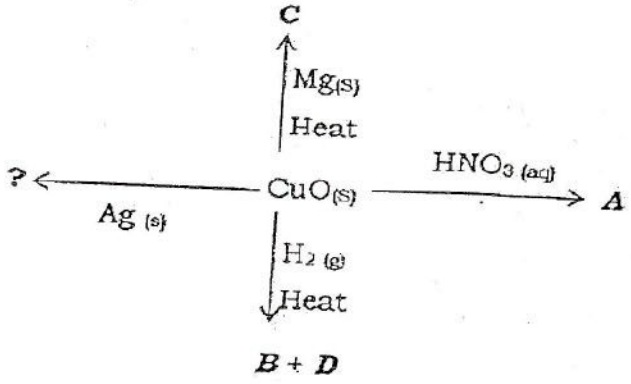
b) Give an ionic equation to show the reaction at the cathode. **(2 marks)**

c) Is the reaction at the anode oxidation or reduction? Give a reason for your answer. **(2 marks)**

8. Draw structural formulae of the following organic compounds.
   a) Propene **(1 mark)**
   b) Butanoic acid **(1 mark)**
   c) Ethylethanoate **(1 mark)**
   d) Butane **(1 mark)**

9. A sample of lead (II) iodide (a) insoluble salt was prepared by reacting $20cm^3$ of $0.2mole.dm^{-3}$ lead (II) nitrate with 40 cm^3 of 0.2 $mole.dm^{-3}$ potassium iodide.
   a) What type of reaction occurs between lead (II) nitrate and potassium iodide solutions? **(1 mark)**
   b) Calculate the number of moles of lead (II) nitrate in $20cm^3$ of the solution. **(1 mark)**
   c) Write a balanced equation for the reaction between lead (II) nitrate and potassium iodide solutions. **(2 marks)**
   d) Calculate the mass in grams of read (II) iodide formed. **(2 marks)**
   (Pb = 207, I = 127).

10. The scheme below shows some reactions of copper (II) oxide to form different products.



a) Give the name of compound A which contains copper. **(1 mark)**
b) What name is given to the reaction between CuO and HNO_3? **(1 mark)**
c) Give the names of products B and D. **(2 marks)**
d) Give a reason whether you would expect a reaction between CuO and Ag. **(1 mark)**

11. a) Using specific examples, distinguish between a strong acid and a weak acid. **(2 marks)**
b) Describe a simple laboratory test you could use to distinguish between a strong acid and a weak acid. State the reagent and the expected observation. **(2 marks)**

12. Compounds of P, N and K are often used as inorganic fertilizers.
a) Explain what is meant by a fertilizer. **(1 mark)**
b) Why is it necessary to apply fertilizers to soil? **(1 mark)**
c) Give two compounds that could be used to prepare potassium nitrate fertilizer. **(1 mark)**

SECTION B: ATTEMPT ANY THREE QUESTIONS. (3O MARKS)

13. The grid below shows part of the Periodic Table for the first 20 elements. The letters are not the actual symbols of the elements. The atomic number of A is 1.

A							**B**
W			**D**		**M**	**E**	
X			**G**		**Q**	**H**	
Y	**J**						

Use the grid above to answer the questions below. Use the given letters to represent elements in your answers.
a) Give the formula of the compound formed between J and E. What type of bond is present in the compound? Give a reason for your answer. **(3 marks)**
b) How many shells of electrons are present in G? **(1 mark)**
c) Element H exists as two isotopes. What is meant by the term isotopes? **(1 mark)**
d) Give two letters of elements which have high melting points. **(2 marks)**
e) Which element forms a divalent anion? **(1 mark)**
f) State two observations you would make when a small piece of element X is added to cold water. **(2 marks)**

14. A student tried to obtain a sample of hydrated crystals of copper (II) sulphate ($CuSO_4.5H_2O$) from a rock containing copper (II) carbonate. He used the method described below:
The rock was crushed into a fine powder. Excess of the powder was reacted with dilute sulphuric acid until no more bubbles were observed. The mixture was filtered. The filtrate was evaporated to dryness.
    a) Why was the rock crushed into a powder? **(2 marks)**
    b) Why was excess of the powder used? **(1 mark)**
    c) Why was the mixture filtered? **(1 mark)**
    d) Write a balanced equation for the reaction between copper (II) carbonate and sulphuric acid. **(2 marks)**
    e) The method used did not yield hydrated crystals of copper (II) sulphate. Explain why. **(1 mark)**
    f) What change would you make in the method in order to obtain hydrated crystals? **(2 marks)**
    g) State one use of copper metal. **(1 mark)**

15. Sulphur is a raw material for the manufacture of sulphuric acid in the "contact" process.
    a) Describe the steps involved in the manufacture of sulphuric acid by the contact process. In each step, write a balanced chemical equation for the reaction that occurs. **(6 marks)**
    b) State two large scale uses of sulphuric acid. **(2 marks)**
    c) How is the manufacture of sulphuric acid likely to harm the environment? **(2 marks)**

16. a) Explain the difference between hard water and soft water. **(2 marks)**
    b) Temporary hardness of water is caused by the presence of calcium hydrogen carbonate. Briefly explain how calcium hydrogen carbonate gets into water and how this type of hardness can be removed from water. **(4 marks)**
    c) What causes permanent hardness? How is permanent hardness removed? **(2 marks)**
    d) When carbon dioxide is bubbled through lime water, the litmus turns milky. Briefly explain why lime water turns milky. **(2 marks)**

17. A compound contains 85.7% by mass of carbon and 14.3% by mass of hydrogen. Its molar mass is 56 g/mol. (C = 12, H = 1)
    a) Calculate its empirical formula. **(2 marks)**
    b) Determine its molecular formula. **(2 marks)**
    c) Draw a possible structural formula of the compound. **(1 mark)**
    d) Write a balanced equation for its combustion in oxygen. **(1 mark)**
    e) $40cm^3$ of hydrogen gas were reacted with $70cm^3$ of chlorine gas to form hydrogen chloride gas.
        i) Write a balanced equation for the reaction. **(2 marks)**
        ii) Calculate the volume of hydrogen chloride gas formed. (Assume that all volumes if gases are measured at the same temperature and pressure). **(2 marks)**

SECTION C: ATTEMPT ONLY ONE QUESTION. (15 MARKS)

18. A sample of dry hydrogen gas was prepared as follows:
Concentrated sulphuric acid was added to sodium chloride crystals in a flat-bottomed flask at room temperature. The gas was dried and collected by downward delivery in a gas jar.
    a) State a suitable reagent to dry hydrogen chloride gas. **(1 mark)**
    b) Which one has a higher density: air or hydrogen chloride? Explain your answer. **(2 marks)**
    c) What is observed when hydrogen chloride reacts with ammonia gas? Write an equation for the reaction. **(2 marks)**
    d) A solution of hydrogen chloride in water was mixed with silver nitrate solution. State what is observed and write an equation for a reaction that occurs. **(3 marks)**
    e) Hydrogen chloride gas was dissolved in pure water to form hydrochloric acid. The acid was titrated with sodium carbonate solution. $25cm^3$ of $0.2mole.dm^{-3}$ sodium carbonate reacted with $24cm^3$ of the hydrochloric acid.
        i. Write a balanced equation for the reaction of hydrochloric acid and sodium carbonate. **(2 marks)**
        ii. Calculate the number of moles of sodium carbonate in $25cm^3$ of the solution. **(1 mark)**
        iii. Calculate the number of moles of hydrochloric acid needed to react with sodium carbonate. **(1 mark)**
        iv. Calculate the concentration of hydrochloric acid in $mole.dm^{-3}$. **(2 marks)**

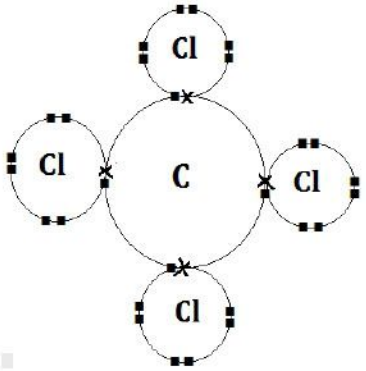
19. Drinking water was suspected to be contaminated with the following ions:
Cu^{2+}, Fe^{3+}, SO_4^{2-} and CO_3^{2-} . A sample of the water was divided into several portions and tested for the presence of the above ions.
    a) The first portion was mixed with nitric acid and there was no observable change. What conclusion can be made from this observation and explain your answer. **(2 marks)**
    b) A second portion was tested using aqueous ammonia solution. A few drops of ammonia solution were added, followed by excess ammonia. Describe what would be observed if Cu^{2+} ions were present. **(3 marks)**
    c) How would you test for the presence of SO_4^{2-}? State the reagent and the expected observation for a positive result. **(2 marks)**
    d) Another portion was mixed with a reagent which removed Cu^{2+}. If the remaining solution contained Fe^{3+}, what test would confirm the presence of Fe^{3+}? State the reagent and observation. **(2 marks)**
    e) Rust contains a compound of iron (III)
        i. State the conditions necessary for rusting to take place. **(2 marks)**
        ii. Give two methods of prevention of rusting. **(2 marks)**
        iii. Give one similarity and one difference between rusting and combustion. **(2 marks)**

MARKING SCHEME OF ORDINARY LEVEL CHEMISTRY
NATIONAL EXAMINATION 2013

Section A: Answer all questions

1. a) Covalent bond

   b)



2. a) MnO_2 (s) + 4HCl (aq) → $MnCl_2$ (aq) + Cl_2 (g) + $2H_2O$ (l)

   b) Reagent: Pass the gas over a wet red / blue litmus paper, the litmus paper is bleached / loses colour.

3. a) Fe_2O_3 (s) + 3CO (g) → 2Fe (s) + $3CO_2$ (g)

   b) Oxidizing agent = Fe_2O_3 / haematite iron (III) oxide

   c) It increases the level of carbon dioxide which causes global warming.

4. a) C_nH_{2n}

   b) Pent-1-ene (C_5H_{10})

   c) Bromoethane

   d) C_2H_5Br

5. a) Yeast contains an enzyme which speeds up c the breakdown of ethanol speeds up the reaction.

   b) Fermentation

   c) Esters

   d) Manufacture of perfumes, soap or solvents.

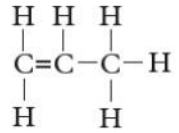
6. a) K_2O (s) + H_2O (l) → 2 KOH (aq)

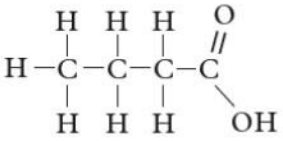
   PH = 13 – 14

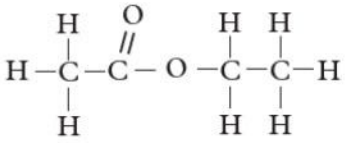
   b) H_2SO_3 (aq) + 2NaOH (aq) → Na_2SO_3 (aq) + $2H_2O$ (l)

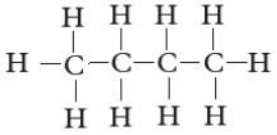
7. a) To make irons free to move or because in solid, irons are not free to move.
   b) $2Br^- \rightarrow Br_2 + 2e^-$
   e) Oxidation: There is loss of electrons.

8.

a) 

b) 

c) 

d) 

9. a) Precipitation
   b) Moles of $Pb(NO_3)_2$ = 0.2 moles.dm^{-3} X 0.02 dm^{-3} = 0.004 mole
   c) $Pb(NO_3)_2 + 2KI\ (aq) \rightarrow PbI_2\ (s) + 2KNO_3\ (aq)$
   d) Molar mass PbI_2 = 207 + (2 X 127) = 462 g/mole.
   Number of moles of PbI_2 = 0.004 mole
   Mass of PbI_2 = 0.004 mole X 461 g/mole = 1.84 g

10. a) Copper (II) nitrate
    b) Neutralization
    c) B = Copper; D = Water.
    d) No reaction because Ag is less reactive than water, hence cannot reduce CuO to Cu.

11. a) A strong acid is fully ionized / completely immersed in aqueous solution e.g HCl or HNO_3 or H_2SO_4.
    A weak acid is partially ionized / not completely immersed in aqueous solution e.g CH_3COOH (ethanoic cid) or any other suitable example.

b) Test both solutions with universal indicator solution PH paper /PH meter.

Weak acid = higher PH = 4 – 6

Strong acid = lower PH = 1 - 3

12. a) An organic fertilizer is a substance added to soil to help grow better crops or it is a substance added to soil to improve growth of crops / plants.

b) Because plant nutrients get used up in the soil.

c) Potassium hydroxide (oxide) and nitric acid

Potassium carbonate + nitric acid

Potassium chloride + Nitric acid

Lead nitrate + Potassium iodide

Potassium + Nitric acid

SECTION B: ANSWER ONLY THREE QUESTIONS

13. a) JE_2, ionic / electrovalent bond. A metal combining with a non-metal.

b) 3 shells of Es

c) Isotopes are atoms of the same element that have the same number of protons but with different number of neutrons. Or atoms of the same element that have the same atomic number with different atomic masses.

d) D and G.

e) M or G.

f) Moves quickly of the surface

Gives out a gas

Melts as it reacts with water.

14. a) To increase the surface area so that it can react faster.

b) To ensure that all the acid reacts.

c) To separate the unreacted solid from the mixture.

d) $CuCO_3$ (s) + H_2SO_4 (aq) $\rightarrow$ $CuSO_4$ (aq)

e) Heating caused all the water to evaporate.

f) Heat the solution until a small amount remains / to saturation point.

Leave the solution to cool after some heating.

g) Used in electric wires, money coins, ornaments, as brass for musical instruments.

15.a) **Step 1:** Burning sulphur

$S\ (s) + O_2 \rightarrow SO_2\ (g)$

Step 2: Oxidation of SO_2

$$2SO_2\ (g) + O_2\ (g) \xrightarrow{Vanadium\ pentoxide} 2SO_3\ (g)$$

Catalyst = Vanadium (V) oxide (V_2O_5)

Step 3: Absorption of SO_3 into concentrated H_2SO_4

$SO_3\ (g) + H_2S)_4\ (g) \rightarrow H_2S_2O_7\ (l)$

Step 4: Dilution of oleum

$H_2S_2O_7\ (l) + H_2O\ (l) \rightarrow 2H_2SO_4$

b) Manufacture of fertilizers, manufacture of detergents, used in car batteries, dehydrating agent, drying agent etc.

c) SO_2 may escape to the atmosphere and cause acid which is harmful to buildings, vegetation and fish.

16.a) Hard water does not form lather with soap easily. Soft water forms lather with soap easily.

b) Rain water containing dissolved CO_2 (or carbonic acid) dissolves limestone rock ($CaCO_3$) to form insoluble calcium hydrogen carbonate.

$CaCO_3\ (s) + H_2O\ (l) + CO_2\ (g) \rightarrow Ca(HCO_3)_2\ (aq)$

c) Permanent hardness is caused by the presence of dissolved $CaSO_4$ (calcium sulphate). It is removed by adding sodium carbonate solution to precipitate $CaCO_3$ (s).

d) CO_2 turns milky due to the formation of white precipitate of calcium carbonate.

$CO_2 + Ca(OH)_2 \rightarrow CaCO_3\ (s) + H_2O$

17.a)

	C	H
Moles	$\frac{85.7}{12}$	$\frac{14.3}{1}$
	= 7.14	= 14.3
Ratio	$\frac{7.14}{7.14}$	$\frac{14.3}{7.14}$

1 : 2

Empirical formula: CH_2

b) $(CH_2)n = 56$

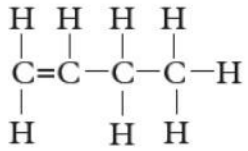
$(12 + 2)\ n = 56$

$14\ n = 56$

$n = \frac{56}{14} = 4$

Molecular formula = $(CH_2)_4 = C_4H_8$

c)



d) $C_4H_8 + 6O_2 \rightarrow 4CO_2 + 4H_2O$

e) i) $H_2\ (g) + Cl_2\ (g) \rightarrow 2HCl\ (g)$

ii) Volume ratio = 1: 1: 2

Volume of HCl formed = 2 X 40 cm^3 = 80 cm^3

SECTION C: THIS QUESTION IS COMPULSORY

18. a) Concentrated sulphuric acid (concentrated H_2SO_4)

b) Hydrogen gas has a higher density because it is able to displace air from the gas jar. Or it sinks into the gas jar as lighter air rises.

c) White fumes

$NH_3 + HCl \rightarrow NH_4Cl\ (s)$

d) White precipitate

$AgNO_3\ (aq) + HCl\ (aq) \rightarrow AgCl\ (s) + HNO_3\ (aq)$

e) i) $2HCl + Na_2CO_3 \rightarrow 2NaCl + H_2O + CO_2$

Number of moles of Na_2CO_3 = 0.2 $mole.dm^{-3}$ X 0.025 dm^{-3} = 0.005 mole

Number of moles of HCl = 2 X 0.005 mole = 0.01 mole

$Concentration\ of\ HCl = \frac{number\ of\ mole}{Volume} = \frac{0.01 mole}{0.024\ dm^3} = 0.42\ mole.dm^{-3}$

19. a) Absence of CO_3^{2-} because there was no effervescence (bubble, fizzing)

b) A blue precipitate (mixed with green precipitate) followed by a dark blue solution in excess ammonia. (Some green precipitate remains).

c) Acidity with nitric acid, then add $Ba(NO_3)_2$ (aq) or acidity with HCl, then add $BaCl_2$ (aq).

d) Add aq. NaOH (or aq NH_3)

Observation: a brown precipitate

e) i) Oxygen / air.

Water / moisture

ii) Painting, oiling, greasing, galvanization, painting, alloying (stainless steel)

CHEMISTRY I

002

04/ 11/ 2014 08.30 am – 11.30 am

Rwanda Education Board

ORDINARY LEVEL NATIONAL EXAMINATIONS, 2014

SUBJECT: CHEMISTRY I

DURATION: 3 HOURS

INSTRUCTIONS:

1) Don't open this question paper until you are told to do so.
2) This paper consists of **three** sections: **A**, **B** and **C**
   - **Section A:** Attempt all questions **(55 marks)**
   - **Section B**: Attempt any **THREE** questions. **(30 marks)**
   - **Section C:** Attempt **only one** question **(15 marks)**
3) Silent non-programmable calculators may be used.
4) **You do not need the periodic table.**

SECTION A: Attempt all questions from this section. (55 marks)

1. One of the types of bonding is "metallic".
   a) Draw a labelled diagram to illustrate "metallic bonding". **(2 marks)**
   b) By using ideas about the structure of metals, state 2 physical properties of metals. **(2 marks)**

2. Give a brief description of the following terms: **(4 marks)**
   a) Melting point b) Fluid.

3. The equation for the reaction between aqueous lead II nitrate and aqueous potassium iodide is shown below:
   $Pb(NO_3)_2$ (aq) + 2KI (aq) → PbI_2 (s) + $2KNO_3$ (aq)
   Lead II iodide is a yellow precipitate. Briefly describe a method that could be used to separate the precipitate from the mixture. **(2 marks)**

4. Bromine is an element of group VII. It has two naturally occurring isotopes.
   a) Describe the term "isotopes". **(2 marks)**
   b) One isotope of bromine has the symbol below:
   $$^{81}_{35}Br$$
   State the number of protons and neutrons in this isotope of bromine. **(2 marks)**

5. When sodium (Na) reacts with cold water (H_2O), hydrogen gas H_2 is given off and an alkaline solution is formed.
   a) Mention one observation that can be made when sodium reacts with cold water. **(1 mark)**
   b) Write a balanced equation for the reaction of sodium with water. **(2 marks)**
   c) State the colour of phenolphthalein indicator in the alkaline sodium mentioned above. **(1 mark)**

6. Nitrogen gas makes up 78% of atmospheric air.
   a) State one importance of nitrogen gas air. **(1 mark)**
   b) Most substances burn in air by reaction with oxygen and not with nitrogen. Give a brief explanation of these occurrences. **(2 marks)**

7. When 8g of metal oxide were reduced using hydrogen gas; 6.4g of metal M were obtained.
   a) Given that the relative atomic mass of the metal is 64, and that of oxygen is 16, determine the empirical formula of the metal oxide. **(3 marks)**
   b) Write an equation for the reaction which occurred between the metal oxide and hydrogen gas. **(2 marks)**

8. Limestone consists mainly of calcium carbonate compound.

a) Write the names or chemical formula of the compounds obtained when calcium carbonate decomposes on heating. **(2 marks)**

b) Write a balanced equation of reaction between sodium oxide (Na_2O) and water (H_2O). **(2 marks)**

9. Draw the conventional representation according to Bohr (show circumferences which represent the shells with electrons on them) of the following elements:
   a) Sodium. **(1 mark)**
   b) Oxygen. (Atomic number: Na = 11, O = 8) **(1 mark)**

10. a) Solid sulphur in crystalline state consists of rings of sulphur molecules of formula S_8. State names of 2 allotropes of sulphur that exists in crystalline form. **(2 marks)**
    b) Sulphur is a non-metal; indicate 2 properties of non-metals. **(2 marks)**

11. a) Write the chemical equation that represents the reaction between iron sulphide (FeS) and dilute hydrochloric acid (HCl). **(2 marks)**
    b) Write a chemical equation or give names of 2 substances that can react in a displacement reaction. **(1 mark)**

12. Write chemical symbols of ions or formula of radicals which migrate to each of the following electrodes during electrolysis of dilute sulphuric acid. (H_2SO_4)
    a) Anode **(2 marks)**
    b) Cathode **(1 mark)**

13. Ammonia is manufactured by the Haber-Bosch process.
    a) Write a balanced equation of reaction for the formation of ammonia from nitrogen gases in the Haber-Bosch process. **(2 marks)**
    b) State the name of the catalyst used to speed up the reaction between nitrogen and hydrogen gases in this process. **(1 mark)**

14. a) A salt solution contains 12g of NaCl per $100cm^3$ of solution. Calculate the molarity (molar concentration) of the solution. (Atomic mass: Na = 23, Cl = 35.5) **(3 marks)**
    b) Calculate the number of moles of HCl in $20cm^3$ 0f 2M HCl. (2moles per litre) **(3 marks)**

15. Calculate the volume of nitrogen dioxide gas (NO_2) produced when 42g of copper nitrate completely decomposes at room temperature and pressure.
    $2Cu(NO_3)_2\ (g) \rightarrow 2CuO\ (s) + 4NO_2\ (g) + O_2\ (g)$
    (1 mole of a gas occupies $24dm^3$ at room temperature and pressure;
    Atomic mass: Cu = 63.5, N = 14, O =16). **(2 marks)**

SECTION B: ATTEMPT ANY THREE QUESTIONS. (3O marks)

16. A student pours (titrates) 30 mL of a 0.1 M aqueous sodium hydroxide from a burette into a beaker containing 25 cm^3 of a 0.1 M sulphuric acid solution. The student measures the pH of the mixture in the beaker using a pH meter during the addition of sodium hydroxide.
    a) Describe how pH values change in the mixture of the beaker during addition of the base. **(2 marks)**
    b) Establish an ionic equation to represent the neutralization reaction between sodium hydroxide (NaOH) and sulphuric acid H_2SO_4. **(2 marks)**
    c) Sulphuric acid is a strong acid.
    (i) What is meant by the term "acid"? **(2 marks)**
    (ii) Explain the difference between a strong acid and a weak acid. **(2 marks)**
    d) Sulphuric acid reacts with magnesium (Mg) to give off hydrogen gas. Write an equation for the reaction between Mg and H_2SO_4. **(2 marks)**

17. a) Draw a labelled diagram for the preparation of ammonia gas in the 1aboratory. **(2 marks)**
    b) Write a balanced equation of reaction between ammonium chloride and calcium hydroxide. **(2 marks)**
    c) By giving appropriate equation of reaction, explain how temporary hardness of water is treated to get soft water. **(2 marks)**
    d) Briefly explain how permanent hard water containing $MgSO_4$ is treated to get soft water. **(2 marks)**

18. a) Methane is a member of the homologous series of hydrocarbons called alkanes. Describe the meaning of the term:
    (i) Homologous series **(2 marks)**
    (ii) Alkane. **(2 marks)**
    b) Write a balanced equation of reaction that takes place when butane burns in oxygen gas. **(2 marks)**
    c) Ethene reacts with hydrogen chloride.
    i) Write the equation of reaction that takes place between ethene and hydrogen chloride. **(2 marks)**
    ii) State the type of reaction taking place in c) (i) above and draw the structural formula of the organic product obtained. **(2 marks)**

19. a) A compound constituted of carbon, hydrogen and oxygen. It contains 40% carbon, 6.67% hydrogen and 53.33% oxygen by mass. The molar mass of the compound is 60 g. $mole^{-1}$. Determine:
    i) The empirical formula of the compound. **(2 marks)**
    ii) The molecular formula of the compound. **(2 marks)**
    b) When very hot carbon reacts with steam, they form carbon monoxide and hydrogen gas according to the equation:
    $C\ (s) + H_2O\ (g) \rightarrow CO\ (g) + H_2\ (g)$

i) Calculate the mass of steam required to react completely with 40g of carbon. **(2 marks)**

ii) What volume of carbon monoxide, measured at room temperature and pressure will be produced? **(2 marks)**

(Atomic mass: C= 12, H = 1, O = 16; 1 mole of a gas occupies 24dm^3 at room temperature and pressure.)

c) Hydrogen gas is used as a fuel; write an equation of reaction between hydrogen gas and oxygen. **(2 marks)**

20. (a) Samples of iron were placed in aqueous solutions having different pH values. The table below shows how the speed of corrosion of iron varies with the pH of the solution.

Speed of corrosion / cm per year	0.043	0.029	0.012	0.010	0.010	0.010	0.009	0.006
pH	2	3	4	5	6	8	10	12

Describe how pH affects the speed of corrosion of iron. **(2 marks)**

b) Mention a material that can be coated on iron metal or mixed with it so that you avoid it being degraded by corrosion. **(1 mark)**

c) Two gases are unlabelled. It is known that one is chlorine and the other is hydrogen chloride. Mention a reagent that can be used to test one gas so as to distinguish it from another. State the observable change for each gas.

(i) Chlorine gas. **(2 marks)**

(ii) Hydrogen chloride gas. **(2 marks)**

d) (i) Write an equation of the reaction observed when chlorine gas (Cl_2) is passed in a solution of potassium iodide (KI). **(2 marks)**

(ii) State the type of reaction that has taken place when chlorine gas (Cl_2) is passed in a solution of potassium iodide (KI). **(1 mark)**

SECTION C: ATTEMPT ONLY ONE QUESTION. (15 marks)

21. 25 cm^3 of a 0.12M sodium hydroxide solution was neutralised by 30 cm^3 of a solution of a dibasic acid H_2X, containing 6.3 g of acid per litre. Calculate:

(i) The number of moles of NaOH that was used in the reaction. **(2 marks)**

(ii) The morality of the acid. **(2 marks)**

(iii) The relative molecular mass of the acid. **(2 marks)**

Equation:

$$H_2X + 2NaOH \rightarrow Na_2X + 2H_2O$$

b) Mention 2 uses of sulphur. **(2 marks)**

c) Write an equation of reaction between chlorine gas and phosphorous. Briefly explain the reason why a mixture or chlorine and hydrogen gas explodes once it is exposed to bright light. **(1 mark)**

e) Chlorine is a powerful bleaching agent in the presence of water. Briefly, describe how chlorine bleaches materials. **(2 marks)**

f) Chlorine gas (Cl_2) was passed over heated iron powder (Fe) in a combustion tube. Write down the observable changes and the equation of reaction that took place. **(2 marks)**

22. a) Petroleum is a complex mixture of hydrocarbons and is also a source of many useful fuels.

i) Describe the meaning of the term "functional group" and give two examples of substances with different functional groups. **(3 marks)**

ii) Name 3 fractions (products) obtained from petroleum. **(3 marks)**

iii) Write the structural formula of an unstable hydrocarbon that contains 4 carbon atoms. **(1 mark)**

b) Magnesium reacts with oxygen in air to form magnesium oxide.

$2Mg + O_2 \rightarrow 2MgO$

If the yield (MgO produced) of the reaction is 100%, calculate the mass of magnesium oxide formed when 6 g of magnesium burns in excess oxygen. (Atomic mass: Mg = 24, O = 16) **(3 marks)**

c) Using pentane as an example,

(i) Write the molecular formula and structural formula of pentane.

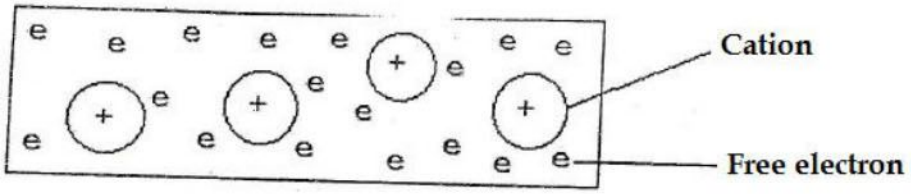
(ii) Mention two uses of pentane on a large scale. **(2 marks)**

d) Write the name of a hydrocarbon derivative that can cause an environment hazard in the atmospheric ozone layer. **(2 marks)**

MARKING SCHEME OF ORDINARY LEVEL CHEMISTRY NATIONAL EXAMINATION 2014

Section A: Answer all questions

1. a) Metallic bond



b) Metals are solid at room temperature except mercury and gallium which are liquid at room temperature.
Metals are hard
Metals are malleable
Metals form alloys
Metals are ductile
Metals are shiny
Metals are good conductors of heat and electricity.
Metals have high density

2. a) Melting point is the temperature at which a solid changes its state to liquid form.
   b) A fluid is a substance that continually deforms (flows) under an applied shear stress. Or It is a substance that takes the shape of the container.

3. A method used separate the precipitate from the mixture can be filtration using a filter paper on a funnel and a beaker.

4. a) Isotopes are variants of a particular chemical element having an equal number of protons but with different neutron numbers.
   b) Number of protons = 35, number of neutrons = 81 - 35 = 46

5. a) The container of the mixture becomes solid and hot.
   The solid sodium metal dashes on the upper surface of water, dissolves, react completely.

Bubbles / effervescence / pop sound / hissing sound etc.

b) $2Na + 2H_2O \rightarrow 2NaOH\ (aq) + H_2\ (g)$

c) Pink

6. a) It is absorbed by plant nodules (roots) for the synthesis of proteins.
It dilutes in oxygen and makes combustion, respiration and rusting slower.
It is used in making fertilizers, ammonia and HNO_3.
b) Oxygen is more reactive than nitrogen so breaking the bonds in an oxygen molecule requires less energy. Or nitrogen is less reactive than oxygen which is more reactive and supports combustion.

7. a) Mass of metal m = 6.4 g
Mass of oxygen = 8 g – 6.4 g = 1.6 g

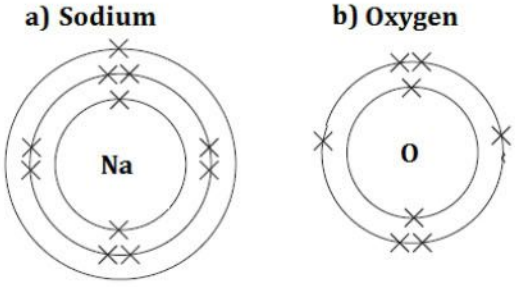
M	:	O
$\frac{6.4}{64}$	:	$\frac{1.6}{16}$
0.1		0.1
$\frac{0.1}{0.1}$	:	$\frac{0.1}{0.1}$
1	:	1

Empirical formula of the metal oxide is MO.

c) $MO\ (s) + H_2\ (g) \rightarrow M\ (s) + H_2O\ (l)$

8. a) Name: Calcium oxide (quick lime), carbon dioxide (carbonic gas)
Or chemical formula: CaO, CO_2
Or $CaCO_3\ (s) \rightarrow CaO + CO_2$
b) $NaO\ (s) + H_2O\ (l) \rightarrow NaOH\ (aq)$

9.



10.a) Names of two allotropes of sulphur:
- Rhombic
- Monoclinic

b) Properties of non-metals:
May be solids, liquids or gases at room - temperature
Non-ductile solids (brittle solids)
Poor conductors of heat and electricity
Have low melting point and low boiling point
Not lustrous (not shiny)
They have a low density
They do not ring when hit
Not attracted by magnets

11.a) $FeS + 2HCl \rightarrow H_2S + FeCl_2$

b) Displacement reaction:
$Zn\ (s) + ZnSO_4\ (aq) \rightarrow 2NH_3$

12.a) Ions at anode: SO_4^{2-} , OH^-

b) Ions at cathode: H^+

13.a) $3H_2\ (g) + N_2\ (g) \rightarrow 2NH_3$

b) Iron (Fe)

14.a) Number of moles = $\frac{Mass}{Molar\ mass}$

Molar mass of NaCl = 23 + 35.5 = 58.5 g/mole

Number of moles = $\frac{12\ g}{58.5\ g/mole} = 0.205\ mole$

Concentration = $\frac{number\ of\ moles}{volume\ (l)}$

Molarity of NaCl = $\frac{0.205\ mole}{0.1\ L} = 2.05\ mole/L$

b) $Molarity = \frac{Number\ of\ moles}{Volume}$

Number of moles = M X V = $2mole.dm^{-3}$ X $0.02dm^3$ = 0.02 mole

15.$2Cu(NO_3)_2\ (g) \rightarrow 2CuO\ (s) + 4NO_2\ (g) + O_2\ (g)$

Molar mass of $Cu(NO_3)_2$ = 63.5 + 2(14 +13X 16) = 187.5 g/mole

Number of moles in 42 g = $\frac{m}{Mm} = \frac{42\ g}{187.5\ g/mole} = 0.224\ mole$

According to the equation:

1 mole of $Cu(NO_3)_2$ produces 2 moles of NO_2

So, 0.224 mole of $Cu(NO_3)_2$ produces 2 X 0.224 mole = 0.448 mole of NO_2

Volume = n X Mv = 0.448 mole X 24 dm^3/mole = 10.752 dm^3

SECTION B: ANSWER ONLY THREE QUESTIONS

16. a) PH increases from 1 to 7 when 25ml of NaOH is added. The PH increases from 7 upwards when more than 25ml of NaOH is added.

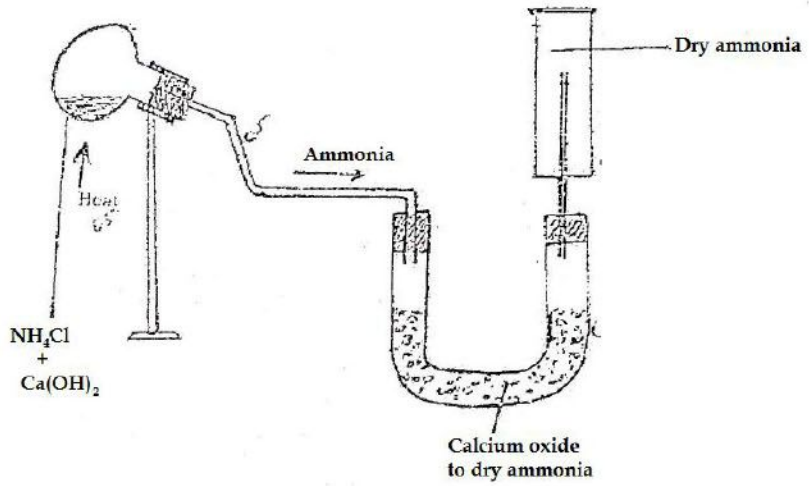
b) $H^+ + OH^- \rightarrow H_2O$ or $H_3O^+ + OH^- \rightarrow 2H_2O$

c) i) An acid is a substance that liberates H^+ ions Or it is a substance that accepts electron.

ii) A strong acid is that which dissociates completely to give H^+ ions while a weak acid dissociates partially to give few H^+ ions.

Or a strong acid turns a universal indicator red while a weak acid turns a universal indicator orange or yellow. Or a strong acid turns blue litmus paper red while a weak acid turns blue litmus paper pale red.

17. a)



b) $Ca(OH)_2$ (s) + $2NH_4Cl$ (s) $\rightarrow$ $CaCl_2$ (s) + $2H_2O$ (l) + $2NH_3$ (g)

c) $Ca(HCO_3)_2 \rightarrow CaCO_3$ (s) + H_2O (l) + CO_2 (g)

Temporary hard water is heated so that $Ca(HCO_3)_2$ decomposes to get the precipitate. $CaCO_3$ settles on the bottom of the container and clear water is collected for use.

d) Permanent hard water containing $MgSO_4$ can be made to pass through an ion exchange equipment to absorb the charged particles of $MgSO_4$.

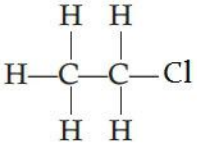
18.a) i) Homologous series is a series of compounds with the same general formula but varying by the length of the carbon chain.

ii) Alkane is a compound that is saturated constituting of carbon and hydrogen atoms only.

b) $C_4H_{10} + 13/2\ O_2 \rightarrow 4CO_2 + 5H_2O$ or $2C_4H_{10} + 13\ O_2 \rightarrow 8CO_2 + 10H_2O$

c) i) $C_2H_4 + HCl \rightarrow CH_3CH_2Cl$

ii) Addition reaction



19.

a) i) Empirical formula of the compound:

C	:	H	:	O
$\frac{40}{12}$	:	$\frac{6.67}{1}$	:	$\frac{53.33}{16}$
3.33	:	6.67	:	3.33
$\frac{3.33}{3.33}$	:	$\frac{6.67}{3.33}$	:	$\frac{3.33}{3.33}$
1	:	2	:	1

Empirical formula is CH_2O

ii) Molecular formula of the compound:

$(CH_2O)\ n = 60$

$(12 + 2 + 16)n = 60$

$30\ n = 60$

$n = 2$

Molecular formula is $C_2H_4O_2$

b) i) $C\ (s) + H_2O\ (g) \rightarrow CO\ (g) + H_2\ (g)$

12g of C reacts with 18 g of water

40 g of C will react with $\frac{18 \times 40}{12} g = 60\ g\ of\ water$

ii) Number of moles of CO (g) = number of moles of C = $\frac{40}{12} = 3.33\ moles$

Volume of carbon monoxide = 3.33 mole X 24 dm^3/mole = 80 dm^3

c) $2H_2\ (g) + O_2\ (g) \rightarrow 2H_2O\ (g)$

20. a) At low PH, the speed of corrosion is high, so the more acid the solution is, the more rate of corrosion.

b) Carbon, nickel, manganese, aluminium, paint, oil, silver, chromium, zinc, tin

c) **Reagent:** KI solution

i) **Chlorine gas:** the KI solution turns red, blue litmus paper turns red then bleaches.

ii) Hydrogen chloride gas: the KI solution does not change its colour, blue litmus paper turns red.

d) i) $2KI\ (aq) + Cl_2\ (g) \rightarrow I_2\ (s) + 2KCl\ (aq)$

ii) Displacement or oxidation or redox, substitution or reduction reaction.

SECTION C: ATTEMPT ONLY ONE QUESTION

21. a) i) Number of moles = M X V = 0.12 $mole.dm^{-3}$ X 0.25 dm^3 = 0.003 mole

ii) Equation: $H_2X + 2NaOH \rightarrow Na_2X + 2H_2O$

Number of mole of the dibasic acid = 0.003 mole : 2 = 0.0015 mole

Morality of the acid $H_2X = \frac{Number\ of\ moles}{Volume} = \frac{0.0015\ mole}{0.003 dm^3} = 0.05\ mole/dm^3$

iii) Molar mass = $\frac{Mass}{Number\ of\ moles} = \frac{6.3\ g/dm^3}{0.05\ mole/dm^3} = 126\ g/mole$

b) Uses of sulphur: To make tyres, to manufacture sulphuric acid, used in fertilizers, used in creation of steel and rubber, used in sugar industries to refine and decolorize sugar, used for refining kerosene and other petroleum products, used as a preservative for fruits, used for bleaching delicate articles e.g paper. Etc.

c) $2P\ (s) + 5Cl_2\ (g) \rightarrow 2PCl_5\ (g)$

OR: $2P + 3Cl_2 \rightarrow 2PCl_5$

$P_4 + 10\ Cl_2 \rightarrow 4PCl_5$

$P_4 + 6Cl_2 \rightarrow 4PCl_3$

d) The reaction between chlorine and hydrogen gas is very exothermic, so it releases a lot of energy to cause explosion.

e) Chorine reacts with materials to remove the colouring matter so that materials are not coloured later (changes the colour of a material).

f) A brown solid of $FeCl_3$ is observed

$2Fe + 3Cl_2 \rightarrow 2FeCl_3$

22. a) i) Functional group is a specific group of atoms or bonds within a molecule that is responsible for characteristic chemical reactions of the molecule.

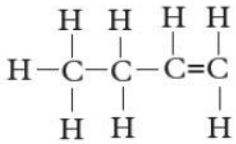
Examples include: CH_3CH_2OH (group OH)

CH_3COOH (group COOH)

$CH_2 = CH_2$ (double bond)

ii) Ethene, pentane, decane, methane, propane, butane, kerosene (paraffin), lubricating oil, greases, bitumen, diesel etc.

iii)

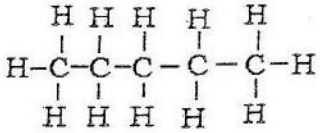


b) Molar mass of MgO = 24 + 16 = 40 g/mole

24 g of Mg produces 40 g of MgO

6 g of Mg produces $\frac{40\times6}{24} = 10\ g\ of\ MgO$

c) i) Molecular formula of pentane: C_5H_{12} and the structural formula of pentane is:



ii) **Two uses of pentane:** Combustion in domestic cookers, to produce hydrogen gas when cracked, Use as fuel, Used as a solvent.

d) Trichlorofluoromethane

Chemistry I

002

18/11/2015 08.30 AM – 11.30 AM

Rwanda Education Board

ORDINARY LEVEL NATIONAL EXAMINATIONS, 2015

SUBJECT: CHEMISTRY I

DURATION: 3 HOURS

INSTRUCTIONS:

1. Write your names and index number on the answer booklet as they appear on your registration form, and **DO NOT** write your names and index number on additional answer sheets of paper if provided.
2. Do not open this paper until you are told to do so.
3. This paper consists of **three** sections **A**, **B** and **C**

   - Answer **ALL** questions in section A. **(55 marks)**
   - Answer **THREE** questions in section B. **(30 marks)**
   - Answer only **one** question in section C **(15 marks)**

4. Use only a **blue** or **black** pen.
5. You do not need the periodic Table.
6. Silent non-programmable calculators may be used.

SECTION A: Attempt all questions from this section. (55 marks)

1. An atom of an element has the structure ${}^{A}_{Z}X$. This atom belongs to group VI and period III, of the periodic table.
   (a) Give the electronic configuration of atom X. **(1 mark)**
   (b) Find Z. **(1 mark)**
   (c) How many protons does this atom have? **(1 mark)**
   (d) How many electrons does the ion X^{2-} have? **(1 mark)**

2. Some elements of the periodic table are called noble or inert gases.
   (a) In which group are these gases in the periodic table? **(1 mark)**
   (b) What is meant by the term inert? **(1 mark)**
   (c) Explain in terms of electronic structure why these gases are inert. **(1 mark)**

3. Name the process by which the components of the following mixtures can be separated:
   (a) Water and ethanol **(0.5 mark)**
   (b) Pigments and leaves. **(0.5 mark)**
   (c) Sand and water **(0.5 mark)**
   (d) Ammonium chloride and sodium chloride. **(0.5 mark)**

4. (a) A solution containing calcium ions was added to a solution of potassium carbonate.
   (i) State what was observed. **(0.5 mark)**
   (ii) Write the equation for the reaction that took place. **(1 mark)**
   (b) To the mixture prepared in (a) above, dilute hydrochloric acid was added.
   (i) State what was observed. **(0.5 mark)**
   (ii) Write the equation for the reaction. **(1 mark)**

5. Hydrochloric acid reacts with magnesium according to the equation:
   $Mg\ (s) + 2HCl \rightarrow MgCl_2\ (aq) + H_2\ (g)$
   (a) Calculate the number of moles of magnesium that will react with excess hydrochloric acid to produce 720 cm^3 of hydrogen at room temperature and pressure. (1 mole of gas occupies 24dm^3 at room temperature and pressure. (Mg = 24, Cl = 35.5, H = 1) **(3 marks)**
   (b) Why is it necessary to use excess hydrochloric acid? **(1 mark)**

6. (a) Calculate the molar mass of Fe_2O_3? (Atomic mass of Fe = 56, 0 = 16) **(1 mark)**
   (b) How many atoms of oxygen are contained in 4.8 g Fe_2O_3?
   (1 mole contains 6.O2 x 10^{23} atoms) **(2 marks)**

7. State one reagent that can be used to distinguish between each of the following pairs of ions and in each case state what would be observed if each ion is treated with the reagent.
   (a) SO_4^{2-} (aq) and CO_3^{2-} (aq) **(2.5 marks)**
   (b) Fe^{2+} (aq) and Fe^{3+} (aq) **(2.5 marks)**

8. The boiling and the melting points of substances W, X, Y and Z are given in the table below:

Substance	Melting point (°C)	Boiling point (°C)
W	+ 29	+ 40
X	- 5	+ 20
Y	0	100
Z	15	85

(a) Give the physical state (gas, solid or liquid) of the substances W, X, Y and Z at room temperature. **(2 marks)**

(b) Which of these substances is water? **(1 mark)**

9. (a) The oxides of some elements are listed below: Sulphur dioxide, Aluminium oxide, Sodium oxide.
State the oxide which reacts with:

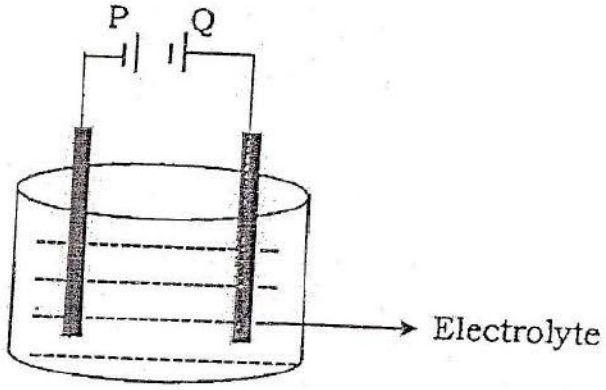
(i) Acids only **(0.5 mark)**

(ii) Alkalis only **(0.5 mark)**

(iii) Both acids and alkalis. **(0.5 mark)**

(b) When excess oxygen was passed over 6.20g of a strongly heated metal W, 14.20g of oxide was formed. Find the empirical formula of the oxide W. (Atomic mass: W = 31, O = 16) **(4 marks)**

10. The diagram below shows the arrangement of apparatuses used for the purification of copper.



(a) Indicate which part is the anode and which part is the cathode on the diagram above. **(1 mark)**

(b) Name the substance used as the:

(i) Anode **(0.5 mark)**

(ii) Cathode **(0.5 mark)**

(c) Name the electrolyte **(0.5 mark)**

(d) Write the equation of the reaction that takes place at:

(i) Anode **(0.5 mark)**

(ii) Cathode **(0.5 mark)**

11. The molecular formula of an organic compound $C_4H_{10}O$. This compound is an alcohol. Give the structural formula and names of all possible isomers (alcohols) of $C_4H_{10}O$. **(4 marks)**

12. Using the table below that shows the pH or different aqueous solutions, answer the questions that follow:

Solution	A	B	C	D	E
pH	12	5.5	3	7	9

Which of the solutions is:

(a) Most acidic? **(0.5 mark)**

(b) Most alkaline? **(0.5 mark)**

(c) Distilled water? **(0.5 mark)**

(d) Likely to be rain water? **(0.5 mark)**

(e) Which two solutions above would give a neutral solution when mixed?

(i) A+E; (ii) C+D; (iii) B+C; (iv) B+E **(0.5 mark)**

13. When 74.2g of hydrated sodium carbonate, $Na_2CO_3.nH_2O$ was heated, the mass of the residue was 10.6 g.

(a) Complete this equation: $Na_2CO_3.nH_2O \xrightarrow{heat}$ ..... + ... **(0.5 mark)**

(b) Calculate the number of moles of water of crystallization (n). **(4.5 marks)**

(c) Write the molecular formula of hydrated sodium carbonate. **(0.5 mark)**

14. Complete and balance the equations below: **(3 marks)**

(a) $CH_3COOH + CH_3CH_2OH \rightarrow$

(b) $CH_3CH = CH_2 + Br_2 \rightarrow$

(c) $CH_2 = CH_2 + HCl \rightarrow$

15. (a) Describe how you would prepare pure crystals of lead (II) nitrate in the laboratory starting from lead (II) oxide. **(1 mark)**

(b) Write the equation for the reaction that takes place. **(1 mark)**

SECTION B: ATTEMPT ANY THREE QUESTIONS. (3O MARKS)

16. (a) Copper (II) carbonate was heated strongly until there was no further observable change. During the reaction, a colourless gas was given off and a black solid was observed.

(i) Give the name of the black solid. **(1 mark)**

(ii) Write the equation for the reaction. **(2 marks)**

(iii) State the name of one reagent which can be used to identify the gaseous product and write an equation for the reaction. **(2 marks)**

(b) Excess dilute sulphuric acid was added to the residue in 16 (a) (ii) and the mixture warmed.

(i) State what was observed. **(1 mark)**

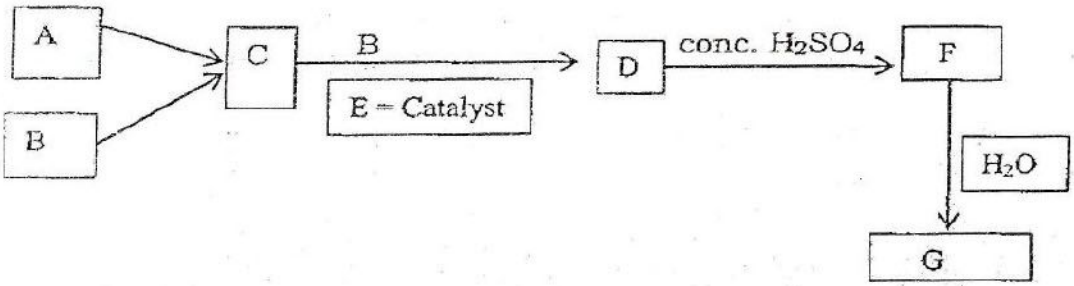
(ii) Write the equation for the reaction. **(1 mark)**

(c) To the product in (b) dilute sodium hydroxide solution was added drop wise until in excess.

(i) State what was observed. **(1 mark)**

(ii) Write an ionic equation for the reaction. **(2 marks)**

17. The diagram below represents the flow chart for the manufacture of sulphuric acid by the contact process.



(a) Write the molecular formula of the substance: A, B, C, D, E and F. **(3 marks)**

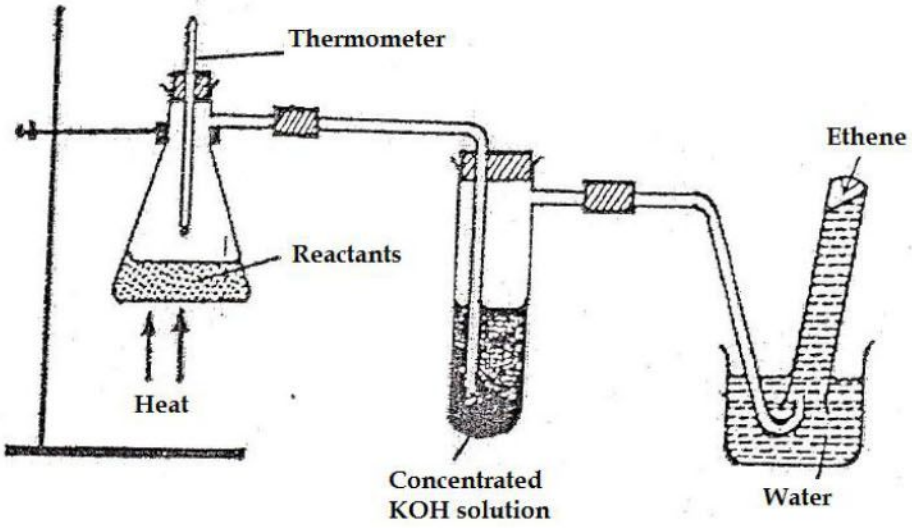
(b) Write the equation of the reaction that gives substance:
(i) C; (ii) D; (iii) F; (iv) G. **(4 marks)**

(b) The purity of sulphuric acid prepared in the contact process is 98% by mass which means 98 g of pure sulphuric acid in 100 g of the solution. **(2 marks)**

(i) What mass of the acid is present in 1 litre of prepared sulphuric acid? (1 millilitre of prepared sulphuric acid weighs 1.84 g)

(ii) What is the molar concentration of this so1ution? **(1 mark)**
(S = 32, H = 1, O = 16)

18. Study the diagram below that shows the preparation of ethane in the laboratory and answer the questions that follow:



(a) Name the reactants. **(1 mark)**

(b) Write the equation of the reaction between the reactants. **(1 mark)**

(c) At which maximum temperature are the reactants heated? **(1 mark)**

(d) Why is it possible to collect ethane over water? **(1 mark)**

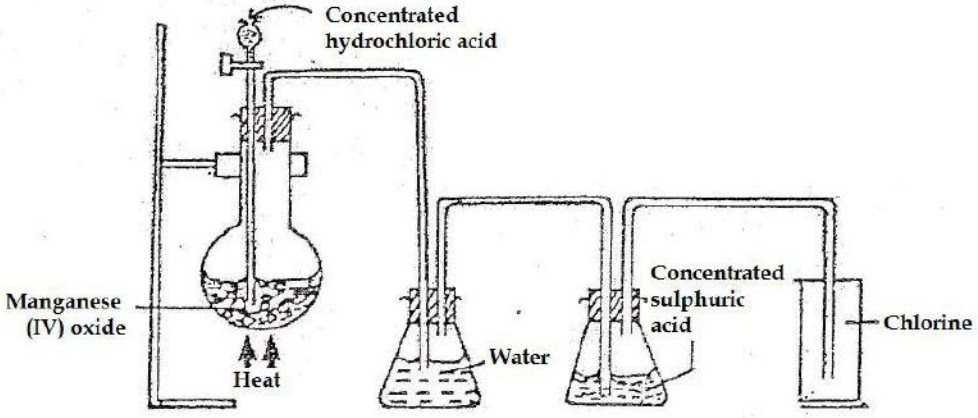
(e) In this experiment, what is the use of:
(i) Concentrated potassium hydroxide? **(1 mark)**
(ii) The thermometer? **(1 mark)**

(f) Write the equation of the reaction in the tube containing KOH. **(1 mark)**

(g) If the empirical formula of compound W is C_2H_3O and its molecular mass is 258. Find the molecular formula of W. **(3 marks)**
(Atomic mass: H = l, C = 12, O =16)

19. In an experiment to titrate the solution of hydrochloric acid, 15.9g of pure anhydrous sodium carbonate (Na_2CO_3) was dissolved in distilled water to make 500cm^3 of the solution. 20cm^3 of this solution neutralised 15cm^3 of HCl acid using methyl orange. (Atomic masses: H =1, Cl = 35.5, Na = 23, C = 12, O = 16)
    (a) What was observed during the titration? **(1 mark)**
    (b) Write the equation of the reaction during the titration. **(1 mark)**
    (c) What was the role of methyl orange in this experiment? **(1 mark)**
    (d) Calculate the concentration of Na_2CO_3 in g/dm^3. **(1.5 marks)**
    (e) Calculate the morality of Na_2CO_3 solution. **(1.5 marks)**
    (f) Calculate the moles of Na_2CO_3 that reacted with HCl. **(1 mark)**
    (g) Find the moles of HCI that reacted with Na_2CO_3. **(1 mark)**
    (h) Calculate the morality of the solution of HCl. **(1 mark)**
    (i) Find the concentration of hydrochloric acid in g/dm^3. **(2 marks)**

20. Dry chlorine can be prepared by the reaction between manganese (IV) oxide with concentrated sulphuric acid. Below is a diagram of this preparation:



    (a) Write the chemical equation of the reaction between manganese (IV) oxide and concentrated hydrochloric acid. **(1 mark)**
    (b) What are the roles of water and concentrated sulphuric acid in this experiment? **(2 marks)**
    (c) When chlorine reacts with iron:
        (i) Why is iron (II) chloride not formed? **(1 mark)**
        (ii) State the compound that is formed instead of iron (II) chloride? **(1 mark)**
    (d) With the aid of ionic equation, state what would be observed if chlorine was bubbled through the solution of:
        (i) Iron (II) sulphate **(2 marks)**
        (ii) Potassium iodide **(2 marks)**
    (e) Chlorine is a bleaching agent when in the presence of cold water. Write an equation for the reaction between chlorine and cold water. **(1 mark)**

SECTION C: ATTEMPT ONLY ONE QUESTION. (15 marks)

21. The figure below shows a part of the periodic table. The letter is not a correct symbol of the elements.

I	II	III	IV	V	VI	VII	VIII
J							
			G		E		
A						R	D
	X						

(a) Which of the elements are metals? **(2 marks)**

(b) Write the formula of the compounds formed between:

(i) X and R. **(1 mark)**

(ii) J and G. **(1 mark)**

(c) Which element is least reactive? Explain your answer. **(2 marks)**

(d) Which of the compounds (aqueous solution) formed between A and R, or between G and would conduct electricity? Explain your answer. **(2 marks)**

(e) State which formula of the following: R_2, E_2, D_2, A_2 is written correctly. **(2 marks)**

(f) X is in period IV and group II of the periodic table. Give its electronic structure. **(1 mark)**

(g) State the type of bond that exists in the chloride of X and write the formula of the ion formed by X. **(2 marks)**

(h) The nitrate of X was strongly heated.

(i) State what was observed. **(1 mark)**

(ii) Write the equation of the reaction. **(1 mark)**

22. Substance A_2 reacts with B_2 to produce AB_3 according to the following equation (the letters A and B are not correct symbols of elements.

A_2 (g) + $3B_2$ (g) → $2AB_3$ (g) + heat

(a) Is this reaction exothermic or endothermic? Explain. **(2 marks)**

The table below shows the percentage yield of AB_3 at various temperatures and pressure.

Temperature	Pressure (atmosphere)		
	10	200	1000
250	30 %	75 %	96 %
500	1 %	18 %	60 %
1000	0%	0.1 %	60 %

(b) Draw a graph showing the percentage yield of AB_3 at different pressures and 250°C. (%: X - axis, pressure: Y - axis) **(6.5 marks)**

(c) Using the graph, find the percentage yield of AB_3 at 700 atm. and 250°C. **(2.5 marks)**

(d) State:

(i) How the percentage yield of AB_3 varies with the temperature at constant pressure. **(1 mark)**

(ii) How the percentage yield of AB_3 varies with pressure at constant temperature. **(1 mark)**

(e) At which temperature and pressure is the production of AB_3 maximum? **(2 marks)**

MARKING OF ORDINARY LEVEL CHEMISTRY NATIONAL EXAMINATION 2015

Section A: Answer all questions

1. a) X: 2, 8, 6
   b) Z = 16
   c) 16 Protons
   d) 18

2. a) Group VIII or Group O.
   b) Inert means non-reactive or very stable. Or they don't lose or gain electrons.
   c) Due to the fact that the element has got 8 electrons on the outermost. (2 electrons for He).

3. a) Fractional distillation
   b) Chromatography
   c) Filtration, decanting
   d) Sublimation

4. a) i) A white precipitate was formed/ the solution turns milky or chalky or cloudy.
   ii) K_2CO_3 (aq) + Ca^{2+} (aq) → $CaCO_3$ (s) + 2 K^+ (aq)
   b) i) Effervescence occurred or a gas is evolved /produced. Or disappearance of a white precipitate or a hissing sound.
   ii) $CaCO_3$ (s) + 2HCl (aq) → $CaCl_2$ (aq) + CO_2 (g) + H_2O (l)

5. a) According to the equation:
   1 mole of H_2 → 24 g of Mg
   24000 cm^3 or 24dm^3 → 24 g of Mg
   720 cm^3 or 0.72 dm^3 → $\frac{24\ g}{24000 cm^3} \times 720\ cm^3 = 0.72\ g$
   Moles of Mg = $\frac{0.720\ g}{24\ g/mole} = 0.03\ mole$
   b) To be sure that all the quantity of magnesium has reacted.

6. a) The molar mass of Fe_2O_3 = (56 X 2) + (16 X 3) = 160 g/mole
   b) Moles of Fe_2O_3 in 4.8 g = $\frac{4.8\ g}{160\ g/mole} = 0.03\ mole$

1 mole of Fe_2O_3 contains 6.023 X 10^{23} molecules = 6.023 X 10^{23} X3 atoms of oxygen.
0.03 mole of Fe_2O_3 contains 6.023 X 10^{23} X 0.03 molecules = 6.023 X 10^{23} X 3 X 0.03 atoms of oxygen = 6.023 X 10^{23} X 3 X 0.03 atoms of oxygen = 0.542 X 10^{23} = 5.42 X 10^{22}

7. a) **Reagent:** Barium nitrate, $Ba(NO_3)_2$ with dilute nitric acid, HNO_3.
Observation: With $S0_4^{2-}$, a white precipitate insoluble in excess HNO_3 /nitric acid is formed.
With CO_3^{2-}, a white precipitate which dissolves in excess nitric acid is formed. There is also effervescence.
b) **Reagent:** Sodium hydroxide (NaOH)
Observation with Fe^{2+}, a green precipitate insoluble in excess.
With Fe^{3+}, a reddish brown precipitate insoluble in excess NaOH is formed.

8. a) W is a solid, X is a gas, Y is a liquid, Z is a liquid.
b) Y is water.

9. a) i) Sodium oxide
ii) Sulphur dioxide
iii) Aluminium oxide
b) Mass of oxygen = 14.2 g – 6.2 g = 8 g

	W	O
Moles	$= \frac{6.2}{31} = 0.2$	$= \frac{8}{16} = 0.5$
Mole ratio	$\frac{0.2}{0.2} = 1$	$\frac{0.5}{0.2} = 2.5$
X 2 on both sides	1 X 2 = 2	2.5 X 2 = 5

The empirical formula of the oxide id W_2O_5.

10. a) Q is the anode, P is the cathode
b) i) Impure copper
ii) Pure copper
c) Copper II sulphate solution

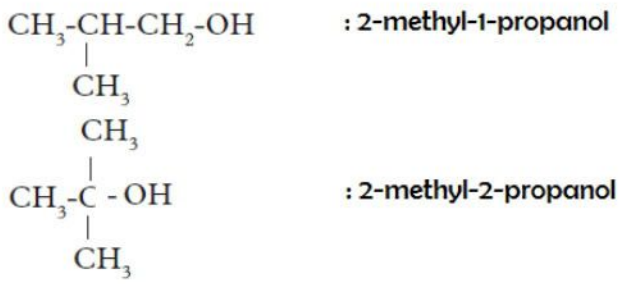
d) i) Anode: $Cu\ (s) \rightarrow Cu^{2+}\ (aq) + 2e^-$

ii) Cathode: $Cu^{2+}\ (aq) + 2e^- \rightarrow Cu\ (s)$

11.

$CH_3\ CH_2\ CH_2\ CH_2\ OH$: 1- butanol

$CH_3\ CH\ OH\ CH_2\ CH_3$: 2-butanol



: 2-methyl-1-propanol

: 2-methyl-2-propanol

12. a) C, b) A, c) D, d) B, e) B + E

13. a) $Na_2CO_3.nH_2O \xrightarrow{heat} Na_2CO_3 + nH_2O$

b) Mass of water = 14.2 g – 10.6 g = 3.6 g

Molar mass of H2O = (1 X2) + (16 X 1) = 18 g/mole

Number of moles $= \frac{Mass}{Molar\ mass} = \frac{3.6\ g}{18\ g/mole} = 0.2\ mole$

Molar mass of Na_2CO_3 = (23 X 2) + (12 X 1) + (16 X 3) = 106 g/mole

Moles of $Na_2CO_3 = \frac{10.2\ g}{106\ g/mole} = 0.1\ mole$

$Na_2CO_3 : H_2O$ = 0.1 : 0.2 = 1 : 2. So n = 2

c) $Na_2CO_3.2H_2O$.

14.

a) $CH_3COOH + CH_3CH_2OH \rightarrow CH_3COOCH_2CH_3 + H_2O$

b) $CH_3CH = CH_2 + Br_2 \rightarrow CH_3CHBrCH_2Br$

c) $CH_2 = CH_2 + HCl \rightarrow CH_3CH_2Cl$

15. a) Warm dilute Nitric acid in a beaker and add Lead (II) oxide to it until no more will dissolve.

Then filter off excess Lead (II) oxide.

The filtrate which is lead (II) nitrate solution is heated to evaporate until it crystalizes.

The crystals are then removed and carried between filter paper.

SECTION B: ANSWER ONLY THREE QUESTIONS

16. a) i) Copper (II) oxide or CuO.

ii) $CuCO_3\ (s) \xrightarrow{\Delta} CuO\ (s) + CO_2\ (g)$

iii) Lime water or calcium hydroxide solution or $Ca(OH)_2$

Equation: $Ca(OH)_2\ (aq) + CO_2\ (g) \rightarrow CaCO_3\ (s) + H_2O\ (l)$

b) i) A blue solution was observed (the black solution disappeared to form a blue solution.

ii) $Cu^{2+} + 2OH^- \rightarrow Cu(OH)_2\ (s)$

17. a) A = S; B = O_2; C = SO_2; D = SO_3; E = V_2O_5; F = $H_2S_2O_7$

b) i) C: $S\ (s) + O_2\ (g) \rightarrow SO_2\ (g)$

ii) D: $2SO_2\ (g) + O_2\ (g) \rightarrow 2SO_3\ (g)$

iii) F: $SO_3\ (g) + H_2SO_4 \rightarrow H_2S_2O_7$

c) i) 1ml of solution contains 1.84 g

1000 ml of solution contain 1.84 g X 1000 = 1840 g

Mass of H_2SO_4 98 % in 1 litre of solution $= \frac{98 \times 1840g}{1000} = 1803.2\ g$

Molar mass of = (1 X 2) + 32 + (16 X 4) = 98 g/mole

Molarity of the solution $= \frac{1803.2\ g/L}{98\ g/mole} = 18.4\ mole/L$

18. a) Ethanol and sulphuric acid

b) Equation: $CH_3\ CH_2\ OH \xrightarrow{H_2SO_4} CH_2 = CH_2 + H_2O$

c) 170°C - 180°C

d) Ethane is insoluble in water.

e) i) KOH reacts with CO_2 or SO_2 produced as an impurity.

ii) The thermometer helps to maintain the temperature at l7O°C.

f) $2KOH\ (aq) + CO_2\ (g) \rightarrow K_2CO_3\ (s) + H_2O$

g) (C_2H_3O) X n = 258

(24 + 3 + 16) X n = 258

43 n = 258

$n = \frac{258}{34} = 6$

Therefore, $(C_2H_3O)_n = (C_2H_3O)_6 = C_{12}H_{18}O_6$

The molecular formula of W is $C_{12}H_{18}O_6$

19. a) Effervescence or a gas was given off.

b) $Na_2CO_3\ (aq) + 2HCl\ (aq) \rightarrow 2NaCl\ (aq) + H_2O\ (l) + CO_2\ (g)$

c) Methyl orange indicates the end of titration (the reaction).

d) 500 cm^3 of the solution of Na_2CO_3 contain 15.9 g of pure Na_2CO_3.

1000 cm^3 of the solution of Na_2CO_3 contain $\frac{15.9\ g \times 1000 cm^3}{500 cm^3} = 31.8 g/dm^3$

e) Mm of Na_2CO_3 = (23 X 2) + 12 + (16 X 3) = 106 g/mole.

Moles of Na_2CO_3 in dm^3 of the solution (M) $= \frac{31.8 g/dm^3}{106 g/mole} = 0.3 mole/dm^3$

f) Moles of Na_2CO_3 that reacted with HCl

= 0.02 dm^3X 0.3 mole.dm^{-3} = 0.006 mole

g) Moles of HCl that reacted with Na_2CO_3 = 0.006 mole X 2 = 0.012 mole.

h) Molarity of HCl $= \frac{n}{V} = \frac{0.012\ mole}{0.013 dm^3} = 0.8 mole.dm^{-3}$

i) Mm of HCl = 1 + 35.5 = 36.5 g/mole

Mass of HCl in dm^3 of the solution = 36.5g/mole X 0.8 mole/dm^3 = 29.2 g/dm^3.

20. a) $MnO_2 + 4HCl \rightarrow MnCl_2\ (aq) + 2H_2O\ (l) + Cl_2\ (g)$

b) Water is used to remove hydrogen chloride gas, conc H_2SO_4 is used to dry chlorine g.

c) i) Because it is immediately oxidized to iron (III) chloride.

ii) Iron (III) chloride.

d) i) **Observation:** the pare green solution turns brown or yellow.

Ionic equation: $Cl_2\ (g) + 2Fe^{2+}\ (aq) \rightarrow 2Cl^-\ (aq) + 2Fe^{3+}$

ii) **Observation:** The solution turns brown.

Ionic equation: $Cl_2\ (g) + 2I^- \rightarrow 2Cl^-\ (aq) + I_2\ (s)$

e) $Cl_2 + H_2O \rightarrow HCl\ (aq) + HOCl$

SECTION C: ATTEMPT ONLY ONE QUESTION

21. a) A and X or Na and Ca.

b) i) XR_2 or $CaCl_2$

ii) J_4G or CH_4

c) Element D or Ar because it has full octet or because it has full shell with 8 electrons.

d) A and R because their aqueous solutions contain ions whereas that of G and J do not.

e) R_2 or E_2 / Cl_2 or O_2.

f) 2: 8: 8: 2

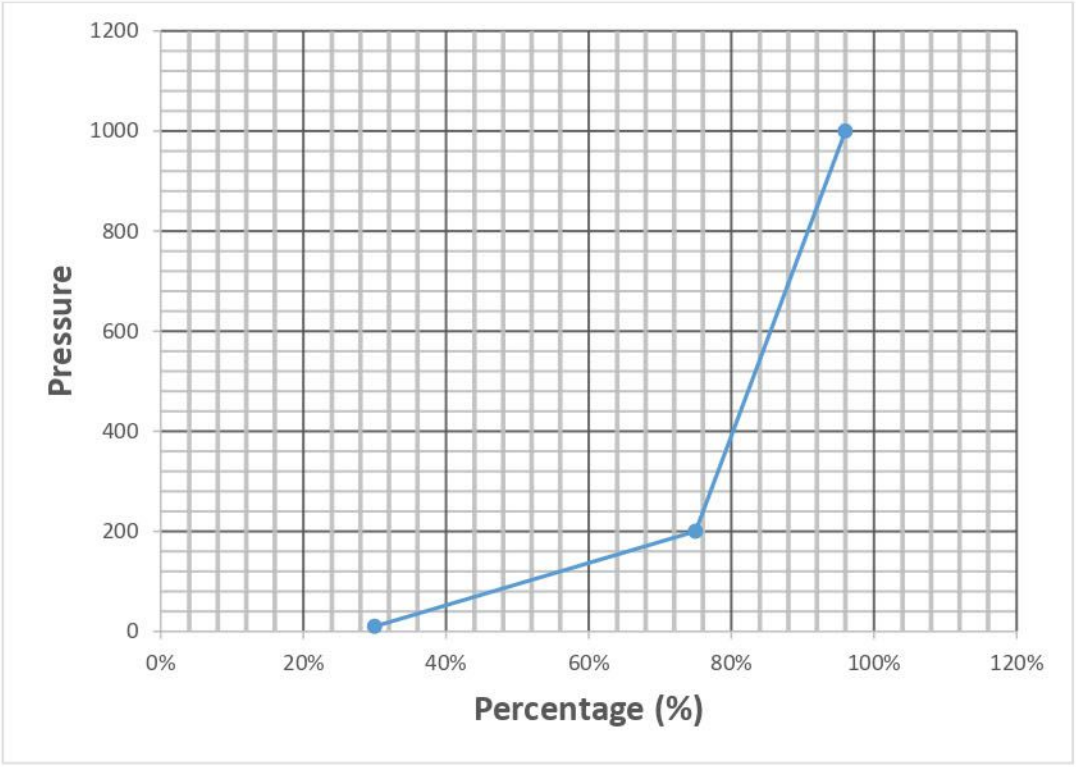
g) Ionic bond. Ion is X^{2+} or Ca^{2+}

h) i) Reddish brown fumes are evolved / produced.

ii) $2X(NO_3)_2\ (s) \xrightarrow{\Delta} 2XO\ (s) + 4NO_2\ (g) + O_2\ (g)$

22. a) Exothermic reaction because it produces heat.

b)



c) The percentage yield of ammonia at 700 atmosphere and a temperature of 250°C is equal to 90 %.

d) i) The percentage yield of AB_3 (ammonia) decreases with increasing temperature at constant pressure.

ii) The percentage yield of AB_3 (ammonia) increases with increase in pressure at constant temperature.

e) Temperature of 250°C and pressure of 1000 atmosphere.

Chemistry I

002

14 Nov. 2016 08.30 am – 11.30 am

Rwanda Education Board

ORDINARY LEVEL NATIONAL EXAMINATIONS, 2016

SUBJECT: CHEMISTRY I

DURATION: 3 HOURS

INSTRUCTIONS:

1. Write your names and index number on the answer booklet as they appear on your registration form, and **DO NOT** write your names and index number on additional answer sheets of paper if provided.
2. Do not open this paper until you are told to do so.
3. This paper consists of **three** sections **A**, **B** and **C**
   - Answer **ALL** questions in section A. **(55 marks)**
   - Answer **THREE** questions in section B. **(30 marks)**
   - Answer only **one** question in section C **(15 marks)**
4. Silent non-programmable calculators may be used.
5. You do not need the periodic Table.
6. Use only a **blue** or **black pen** for answering and a **pencil** for drawing.

SECTION A: Attempt all questions from this section. (55 marks)

1. Iron metal undergoes rusting when it is exposed to air for a long period of time.
   (a) Indicate names of 2 chemical substances that are necessary for causing rusting of iron, Fe. **(2 marks)**
   (b) Mention 2 means that are used, to prevent rusting of objects which are made of iron (Fe) metal. **(2 marks)**

2. Water is used for various domestic purposes
   (a) State 2 natural sources of water. **(2 marks)**
   (b) Briefly describe one method used, to treat unclean drinking water to be ready for cooking food. **(2 marks)**

3. A student uses 100 cm^3 of a 0.5 $mole.dm^{-3}$ sodium hydroxide solution to react with excess sulphuric acid.
   (a) Calculate the number of moles of NaOH contained in 100 cm^3 of solution. **(2 marks)**
   (b) Calculate the mass of sodium sulphate crystals that are formed after evaporation of the resultant solution. . **(2 marks)**
   Equation: H_2SO_4 (aq) + 2NaOH (aq) → Na_2SO_4 (aq) + $2H_2O$ (aq)
   (Atomic mass: Na = 23, S = 32, O = 16, H =1)

4. (a) When hydrated sodium sulphate crystals are heated gently, water is given off. State the name of the reagent used to test the presence of water and the expected observation for a positive test. **(2 marks)**
   (b) Pure oxygen for industrial use can be obtained from atmospheric air. State the percentage composition of oxygen gas by volume in air. **(1 mark)**

5. In the upper atmosphere, there is a layer of ozone surrounding the earth.
   (a) Explain the importance of this layer in terms of human health. **(2 marks)**
   (b) State the type of chemical substances that destroy the ozone layer. **(1 mark)**

6. Calcium is a metal of group IIa of the periodic table.
   (a) Using Bohr model of the representation of electrons on shells, draw the structure of calcium atom. **(2 marks)**
   (b) Write a balanced equation of the reaction that takes place when calcium reacts with oxygen (O_2). (Atomic number of Ca = 20). **(2 marks)**

7. Sodium atom loses 1 electron and sulphur accepts 2 electrons to form ions.
   (a) Deduce the chemical formula of the compound formed between sodium and sulphur. **(2 marks)**

(b) State one physical and one chemical property of the compound formed when sodium reacts with sulphur. (Atomic number: Na = 11, S = 16) **(2 marks)**

8. When calcium reacts with water, hydrogen gas is evolved and an alkaline solution is formed.
   (a) State two observable changes that take place when calcium reacts with water. **(2 marks)**
   (b) Write the equation of reaction between calcium and water; include state symbols. **(2 marks)**

9. Magnesium is an alkaline earth metal; copper is a transition element. State one difference between these two metals in terms of
   (a) Melting point. **(1 mark)**
   (b) Density. **(1 mark)**
   (c) Colour. **(1 mark)**

10. In an experiment, SO_2 gas was dissolved in a test tube of cold water; blue and red litmus papers were put in the resultant mixture.
    (a) Indicate the litmus paper that changed colour. **(1 mark)**
    (b) Write down the chemical equation for the reaction which took place between SO_2 and H_2O. **(2 marks)**

11. State the reagents that you would use to differentiate between each of the pair of compounds and give the observable change for a positive test:
    (a) Sulphur dioxide, SO_2 and hydrogen sulphide H_2S. **(2 marks)**
    (b) Copper II nitrate $Cu(NO_3)_2$ and Iron II nitrate $Fe(NO_3)_2$. **(2 marks)**

12. Alkanes are members of a homologous series of saturated hydrocarbons with the general formula C_nH_{2n+2}.
    (a) Write the chemical equation of reaction for the combustion of an alkane with 4 carbon atoms. **(2 marks)**
    (b) State 2 uses of hydrocarbon compounds. **(2 marks)**

13. Silicon dioxide has a similar structure to that of diamond. Suggest the reason why silicon dioxide:
    (a) Does not conduct electricity. **(2 marks)**
    (b) Is solid at 25°C. **(2 marks)**

14. A student added 3.0 g of magnesium to an excess sulphuric acid solution of 0.5 mole.dm^{-3} by concentration to react in a container.
    (a) Calculate the number of moles contained in 3.0 g of magnesium. **(2 marks)**
    (b) Calculate the maximum volume of sulphuric acid that reacted with all the 3.0 g of magnesium. (Atomic mass, Mg= 24). **(2 marks)**
    Equation of reaction:
    $Mg\ (s) + H_2SO_4\ (aq) \rightarrow MgSO_4\ (aq) + H_2\ (g)$

15. (a) Write the chemical formula of 1 weak base. **(1 mark)**

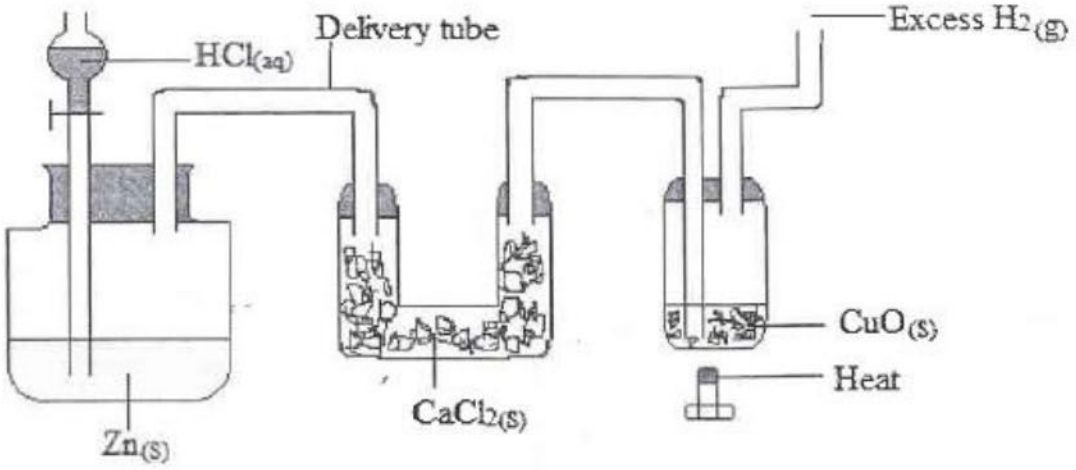
(b) Describe the difference between a strong acid and a weak acid.
(1 mark)

SECTION B: ATTEMPT ANY THREE QUESTIONS (30 MARKS)

16. A mixture of Zinc and Zinc oxide were reacted with excess sulphuric acid. 400 cm^3 of hydrogen gas were produced (measured at room temperature and pressure). If the mixture had a mass of 2 g and only Zinc reacted with the acid to produce H_2 gas, determine:
(a) The number of moles of H_2 gas produced. **(2 marks)**
(b) The number of moles of Zn that reacted with the acid. **(2 marks)**
(c) The mass of zinc in the mixture. **(2 marks)**
(d) The mass of zinc oxide in the mixture. **(2 marks)**
(e) The percentage composition of Zinc oxide by mass in the mixture.
(2 marks)

Equation:
$Zn\ (s) + H_2SO_4\ (aq) \rightarrow ZnSO_4\ (aq) + H_2\ (g)$
(Atomic mass: Zn = 65, O =16; 1 mole of a gas occupies 24000 cm^3 at room temperature and pressure)

17. Copper II oxide, CuO can be reduced by hydrogen gas H_2. Study the set-up of the diagram below and answer the questions that follow:

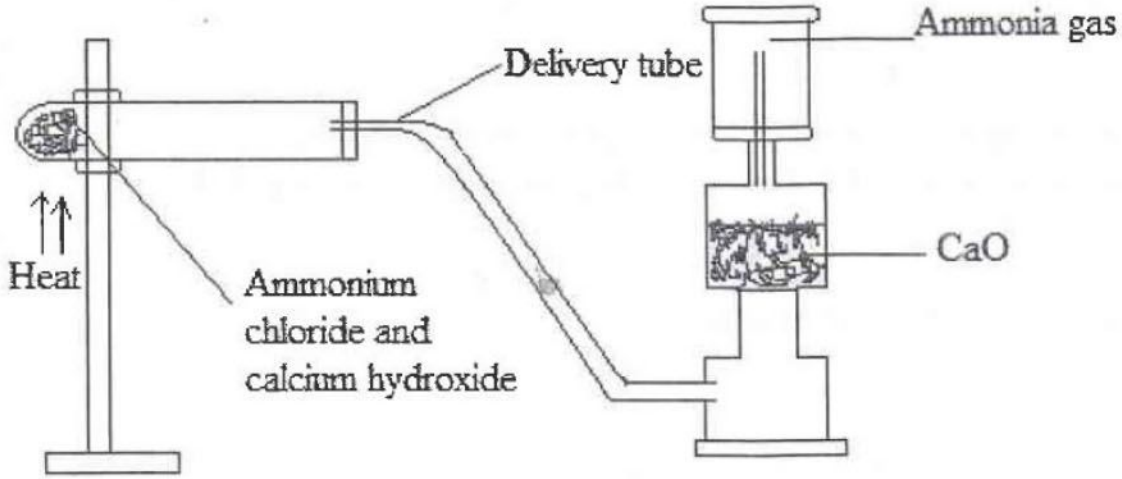


(a) Write the equation of the reaction that takes place when copper II oxide reacts with hydrogen gas. **(2 marks)**
(b) State the observable colour change when copper II oxide has completely been reduced by hydrogen. **(2 marks)**
(c) State the role of $CaCl_2$ in the tube. **(1 mark)**
(d) Zn reacts with dilute HCl to produce H_2:
(i) Indicate 1 physical property of H_2 gas. **(1 mark)**
(ii) Mention 1 test for H_2 gas and give the observation of the test.
(2 marks)
(e) Copper II oxide can also be reduced by carbon on heating.
Write the equation of reaction between CuO and C. **(2 marks)**

18. The set-up apparatus below is for the preparation of ammonia gas in the laboratory.

Equation for the reaction:

$Ca(OH)_2$ (s) + $2NH_4Cl$ (s) → $2NH_3$ (g) + $2H_20$ (g) + $CaCl_2$ (s)



(a) (i) State the role of calcium oxide (CaO) in the apparatus. **(1 mark)**

(ii) State the type of method used for the collection of the gas NH_3 in the set up. **(1 mark)**

(iii) Write a balanced equation of reaction between NH_3 and H_2SO_4. **(2 marks)**

(iv) State 2 uses of ammonia on a large scale. **(2 marks)**

(b) Nitric acid is used to prepare fertilizers.

(i) Write a balanced equation of the reaction between HNO_3 and $Ca(OH)_2$. **(2 marks)**

(ii) State 1 danger of using chemical fertilizers. **(1 mark)**

(c) Nitrogen gas from the atmosphere is absorbed by plants via root nodules to form nitrate fertilizers. State the percentage composition of nitrogen gas in the atmosphere. **(1 mark)**

19. The table below shows some symbols of elements of the periodic table. Study the table and answer the questions that follow:

Element symbol	**Group of element**	**Period of element**	**Atomic number**
Li	I	2	3
O	VI	2	8
Ca	II	4	20
Cl	VII	3	17
Al	III	3	13
N	V	2	7

(a) Write the electronic configuration of the oxygen atom (O). **(1 mark)**

(b) Write a chemical equation that represents the ionization (ion formation) of Li. **(2 marks)**

(c) Deduce the formula of the compound formed by reaction of Al and Cl. **(2 marks)**

(d) State 2 physical properties of a compound formed between N and O. **(2 marks)**

(e) Indicate 1 important use of compounds of N element. **(1 mark)**

(f) Give 2 reasons to suggest why Al is the best of the above elements at being used as electric cables. **(2 marks)**

20. (a) Draw a well labelled diagram for the preparation of chlorine gas in the laboratory. **(3 marks)**

(b) A red litmus paper is placed in chlorine gas for 5 minutes, state 2 observable changes on the red litmus paper during the exposure in chlorine gas. **(2 marks)**

(c) Chlorine gas dissolves in cold water:

(i) Write a chemical equation of the reaction that takes place between Cl_2 and H_2O. **(2 marks)**

(ii) Describe the observation seen when $AgNO_3$ solution is added to the solution of Cl_2. **(2 marks)**

(d) State 1 use of chlorine. **(1 mark)**

SECTION C: THIS QUESTION IS COMPULSORY (15 MARKS)

21. Graphite and diamond are allotropes of carbon with different physical properties.

(a) Write 1 physical property of:

(i) Graphite. **(1 mark)**

(ii) Diamond. **(1 mark)**

(b) Write a chemical equation of the reaction between carbon (C) and iron oxide (Fe_2O_3). **(2 marks)**

(c) State 1 use of:

(i) Graphite. **(1 mark)**

(ii) Diamond. **(1 mark)**

(d) Carbon reacts with oxygen during combustion according to the equation:

$C\ (s) + O_2\ (g) \rightarrow CO_2\ (g)$

In insufficient oxygen, the reaction shown below takes place:

$2C\ (s) + O_2\ (g) \rightarrow 2CO\ (g)$

(i) Mention 2 important uses of CO_2 in nature. **(2 marks)**

(ii) State 1 important use and 1 danger of CO gas. **(2 marks)**

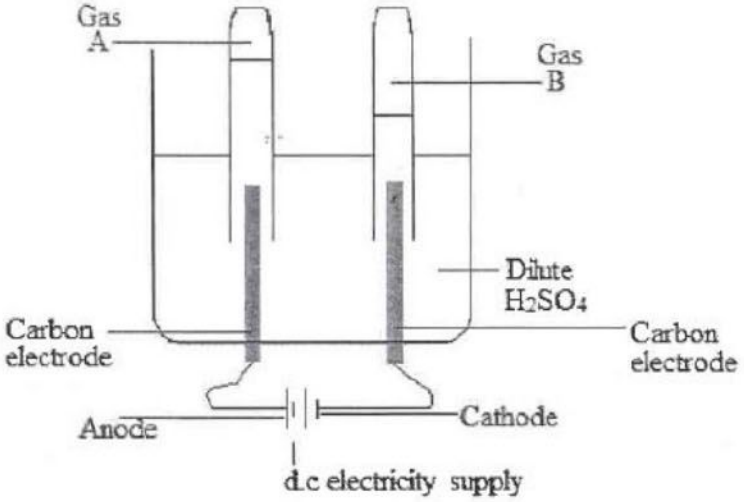
(e) Carbon dioxide (CO_2) causes global warming. Describe 2 means of reducing CO_2 from the atmosphere. **(2 marks)**

(f) Marble rock that is formed of carbonates can be degraded by acid rain.

(i) Write the equation of the reaction between calcium carbonate, $CaCO_3$, and hydrochloric acid, HCl. **(2 marks)**

ii) Temporary hard water contains hydrogen carbonates, HCO_3^-. Indicate 1 means that is used to soften (eliminate) HCO_3^- from hard water.
(1 mark)

22. (a)Describe the term "electrolyte" substance. **(2 marks)**
(b) Write the chemical formula of 1 electrolyte substance. **(1 mark)**
(c) Study the diagram below and answer the questions that follow:



(i) Write the chemical equation of the reaction that takes place at the "anode" and at the "cathode". **(4 marks)**
(ii) Describe a simple test for gas B and the observation for this test.
(2 marks)

(d) When carbon electrodes are replaced with copper electrodes using copper sulphate solution ($CuSO_4$) instead of H_2SO_4; the following reactions take place:

Anode: $Cu\ (s) \rightarrow Cu^{2+}\ (aq) + 2e^-$
Cathode: $Cu^{2+}\ (aq) + 2e^- \rightarrow Cu\ (s)$

(i) Indicate 1 observable change in the mixture when the reaction is almost complete. **(1 mark)**
(ii) State 2 important applications of electrolysis on a large scale.
(2 marks)

(d) Zinc metal is put in a solution of copper sulphate. The following reaction takes place:

$Zn\ (s) + CuSO_4\ (aq) \rightarrow Cu\ (s) + ZnSO_4\ (aq)$

(i) If Zn and Cu metals are connected in an electrochemical cell; which of the two metals can act as "anode"? **(1 mark)**
(ii) Indicate a reagent substance that can be used to distinguish $ZnSO_4$ solution and $CuSO_4$ solution and the observable change when the reagent reacts in each case. **(2 marks)**

MARKING SCHEME OF ORDINARY LEVEL CHEMISTRY NATIONAL EXAMINATION 2016

Section A: Answer all questions

1. (a) Water, oxygen
   (b)Painting iron objects, galvanization (electroplating) of iron, alloy formation of iron, covering iron with oil.

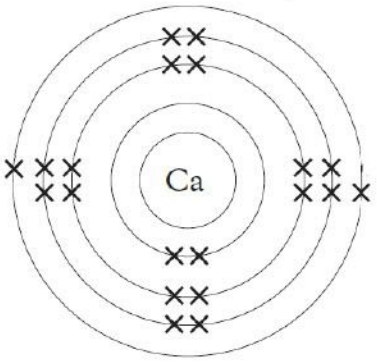
2. (a) Rain, lakes, rivers, underground.
   (b) - A flocculant such as aluminium sulphate is put in unclean water to precipitate solid mud particles.
   - The water is kept in a vessel for decantation to occur.
   - Clear water is taken to be boiled. The boiled water is safe for use and can be left to cool.

3. (a) Number of moles = M X V
   V = 100 cm^3 = 0.1 dm^3
   Number of moles = 0.5 $mole.dm^{-3}$ X 0.1 dm^3 = 0.05 mole.
   H_2SO_4 (aq) + 2NaOH (aq) $\rightarrow$ Na_2SO_4 (aq) + $2H_20$ (l)
   Number of moles of Na_2SO_4 that are formed from NaOH = 0.05 mole / 2 = 0.025 mole.
   Mass of Na_2SO_4 = n X Mm
   Molar mass of Na_2SO_4 = (23 X 2) + 32 + (16 X 4) = 142 g/mole
   M = 142 g/mole X 0.024 mole = 3.55 g

4. (a) - The reagent used to test the presence of water is "anhydrous cobalt paper''.
   - Anhydrous cobalt paper (blue) in colour turns pink (red).
   Or The reagent used to test the presence of water is "anhydrous copper sulphate crystals".
   - Anhydrous copper sulphate crystals (white) in colour turn blue.
   (b) The percentage composition of oxygen in the atmosphere is 21 %.

5. (a) Ozone layer absorbs ultraviolet light of the sun and prevent them from arriving on the earth ta cause cancer in humans.
   (b) Chlorofluorocarbons (organic products) destroy the ozone layer.

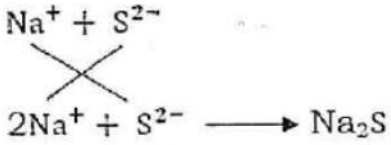
6. (a) Calcium atom representation:



(b) $2Ca\ (s) + O_2\ (g) \rightarrow 2\ CaO\ (s)$

7. (a) $Na \rightarrow Na^+ + e^-$

$S + 2\ e^- \rightarrow S^{2-}$



(Exchange of valency numbers)

(b) - Physical properties of Na_2S: It has a high melting point, high boiling point, solid at room temperature, conducts electricity in molten / aqueous state.

- Chemical properties of Na_2S: It reacts with water / acids.

8. (a) 2 observable changes when calcium reacts with water:
   - Evolution of a colourless gas.
   - Heat is liberated (evolved) during the reaction.

   (b) $Ca\ (s) + 2H_2O\ (l) \rightarrow Ca(OH)_2\ (aq) + H_2\ (g)$

9. Differences between magnesium and copper:
   (a) Copper has a higher melting point than magnesium.
   (b) Copper has a higher density than magnesium.
   (c) Copper is brownish red, magnesium is white in colour.

10. (a)The blue litmus paper turned red.
    (b) Equation of reaction: $SO_3 + H_2O \rightarrow H_2SO_3$

11. (a) Use lead nitrate solution, $Pb(NO_3)_2$. When H_2S is bubbled in lead nitrate solution, a black precipitate is formed. There is no black precipitate formed if SO_2 is used.

(b) $Cu(NO_3)_2$ forms deep blue precipitate when ammonia (NH_3) solution is added to it.

$Fe(NO_3)_2$ forms a greenish precipitate when ammonia (NH_3) solution is added to it.

12. (a) $C_4H_{10} + \frac{13}{2}O_2 \longrightarrow 4CO_2 + 5H_2O$

(b) 2 uses of hydrocarbon compounds:

- Hydrocarbons are used for domestic heating.
- Hydrocarbons are used to make plastic materials such as basins.

13. (a) Silicon dioxide forms a giant structure with covalent bonds. There are no mobile electrons in the structure.

(b) Silicon dioxide forms a giant structure with covalent bonds. The covalent bonds are continuous to form a macromolecule that is hard.

14. (a) Number of moles in 3g of Mg $= \frac{3\ g}{24\ g/mole} = 0.125\ mole$

(b) Number of moles of H_2SO_4 = number of moles of Mg reacted

Number of moles of H_2SO_4 = 0.125 mole

Molarity $= \frac{Number\ of\ moles}{Volume}$

$Volume = \frac{Number\ of\ moles}{Molarity} = \frac{0.125\ mole}{0.5\ mole/dm^3} = 0.25\ dm^3$

15. (a) Chemical formula of 1 weak base: NH_3

(b) A strong acid dissociates completely while a weak acid dissociates partially in water to give H^+ ions.

SECTION B: ANSWER ONLY THREE QUESTIONS

16. (a) Number of moles of H_2 gas produced $= \frac{400\ cm^3}{24000\ cm^3} = 0.0166\ mole$

(b) According to the equation:

Number of moles of H_2 produced = number of moles of Zn that reacted

Number of moles of Zn that reacted = 0.0766 mole

(c) Mass of Zn in the mixture = 0.0166 X 65 = 1.079 g

(d) Mass of ZnO in the mixture = 2 g – 1.079 g = 0.921 g

(e) The percentage composition of ZnO in the mixture

$= \frac{0.921\ g}{2\ g} \times 100 =$ 46.05%

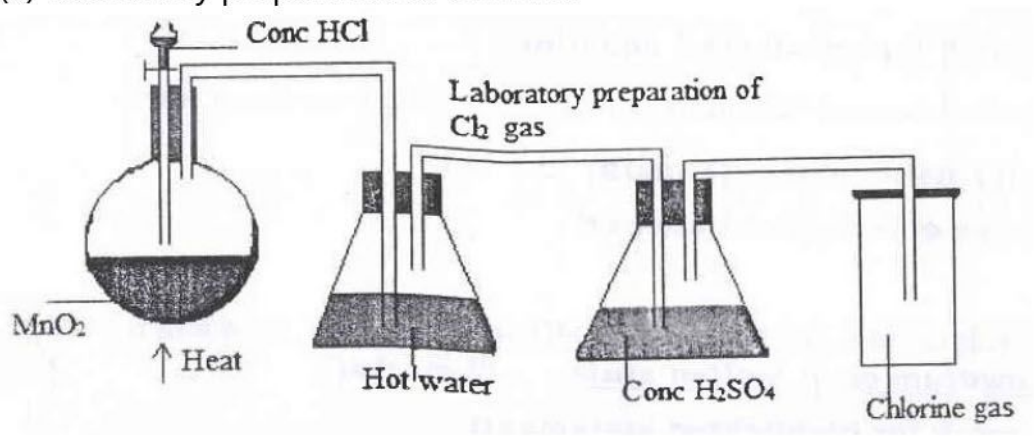
17. (a) Equation: $CuO + H_2 \rightarrow Cu + H_2O$

(b) Black colour of CuO changes to brownish red colour of Cu.
(c) The role of $CaCl_2$ is to remove water vapour (to dry the evolved gas mixture).
(d) (i) 1 Physical properties of H_2 : H_2 is less denser than air.
(ii) Test of H_2 is a burning splint. H_2 burns to make a pop sound.
(e) Equation: $CuO + C \rightarrow Cu + CO$
Or: $2CuO + C \rightarrow 2Cu + CO_2$

18.(a) (i) The role of CaO is to dry the gas mixture.
(ii) Type of method: Upward delivery or downward displacetnent of air.
(iii) Equation: $2NH_3 + H_2SO_4 \rightarrow (NH_4)_2SO_4$
(iv) 2 uses of NH_3 on a large scale:
- NH_3 is used to produce fertilizers.
- NH_3 is used to manufacture polymer materials.
(b) (i) Equation: $2HNO_3 + Ca(OH)_2 \rightarrow Ca(NO_3)_2 + 2H_2O$.
(ii) 1 danger of using chemical fertilizers: Chemical fertilizers can pollute the water in the oceans or lakes so that aquatic animals and plants lack oxygen for respiration (eutrophication).
(d) Percentage composition of nitrogen in the atmosphere: 78 %.

19.(a) Electronic configuration of oxygen atom, O = 2: 6
(b) Equation: $Li \rightarrow Li + 1e^-$
(c) $Al \rightarrow Al^{3+} + 3\ e^-$
$Cl + e^- \rightarrow C1^-$
By exchange of valency number of charges
1 Al^{3+} reacts with 3 Cl^-
So the formula is $AlCl_3$
(d) 2 Physical properties of a compound formed between N and O:
- The compound has a low melting point.
- The compound does not conduct electricity.
(e) 1 important use of compounds of N:
-To manufacture fertilizers.
(f) 2 Reasons of Al being used as electric cables:
- It does not undergo corrosion on exposure to water and other substances.
- It is lighter than other metal conductors of electricity.

20.(a) Laboratory preparation of chlorine:



(b) The red litmus paper does not change the red colour. After long exposure in chlorine gas, the red colour discharges and the paper becomes white.

(c) (i) $Cl_2 + H_2O \rightarrow HCl + HClO$

(ii) The colourless solution of $AgNO_3$ turns white precipitate.

(e) 1 Use of chlorine: Cl_2 is used to disinfect water in water treatment plants.

SECTION C: ATTEMPT ONLY ONE QUESTION

21.(a) 1 physical properties of:

(i) Graphite: It conducts electricity.

(ii) Diamond: It is hard.

(b) $Fe_2O_3 + 3C \rightarrow 2Fe + 3CO_2$

(c) 1 use of:

(i) Graphite: It is used to make pencils.

(ii) Diamond: It is used to cut metals.

(d) (i) 2 important uses of CO_2 :

- It is used in soft drinks (feezy drinks).
- It is used to extinguisher.
- It is used by plants in photosynthesis to make their own food.

(ii) -Importance of CO: It is used to reduce iron oxide during extraction of iron.

-Danger of CO: It is a poisonous gas to humans if inhaled.

(e) 2 Means of reducing global warming:

- Planting trees.
- Reduce the emission of CO_2 from industries.

(f) (i) Equation: $CaCO_3 + 2HCl \rightarrow CaCl_2 + CO_2 + H_2O$

(ii) 1 means that is used to soften (eliminate) HCO_3^- from hard water:

boiling the hard water.

22. (a) "Electrolyte" is a substance that dissociates into ions when it is dissolved in water (or in a certain medium or in molten state).

(b) Formula: NaCl

(c) (i) **Anode:** $4OH^-(aq) \rightarrow 2H_2O(l) + O_2(g) + 4e^-$

Cathode: $2H^+(aq) + 2e^- \rightarrow H_2(g)$

(ii) **Test for gas B:** Burning splint

Observation: The gas burns with a pop sound.

(d) (i) - The anode reduces in size.

- The cathode increases in size.

(ii) 2 important applications of electrolysis on a large scale:

- Extraction of metals.
- Production of chlorine and sodium hydroxide.

(e) (i) Zn will act as anode.

(ii) - **Reagent:** NH_3 solution.

- **Observable change**: $CuSO_4$ turns into blue precipitate that becomes deep in excess of NH_3 solution.

$ZnSO_4$ turns white precipitate that becomes a colourless solution in excess of NH_3 solution.

Chemistry I

002

24/11/2017 08.30 AM – 11.30 AM

Rwanda Education Board

ORDINARY LEVEL NATIONAL EXAMINATIONS, 2017

SUBJECT: CHEMISTRY I

DURATION: 3 HOURS

INSTRUCTIONS:

1. Write your names and index number on the answer booklet as they appear on your registration form, and **DO NOT** write your names and index number on additional answer sheets of paper if provided.
2. Do not open this paper until you are told to do so.
3. This paper consists of **three** sections **A**, **B** and **C**
   - Answer **ALL** questions in section A. **(55 marks)**
   - Answer **THREE** questions in section B. **(30 marks)**
   - Answer only **one** question in section C **(15 marks)**
4. Silent non-programmable calculators may be used.
5. You do not need the periodic Table.
6. Use only a **blue** or **black pen** for answering and a **pencil** for drawing.

SECTION A: Attempt all questions from this section. (55 marks)

1. The number of protons, neutrons and electrons in particles W, X, Y, and Z are shown in the table below.

Particles	Number of protons	Number of neutrons	Number of electrons
W	6	6	6
X	9	10	10
Y	12	12	10
Z	19	20	19

(a) Which one of the particles is: **(3 marks)**
(i) a cation?
(ii) an anion?
(iii) neutral?

b) Write the electronic configuration of Z. **(1 mark)**

c) (i) State the valency of Z. **(1 mark)**

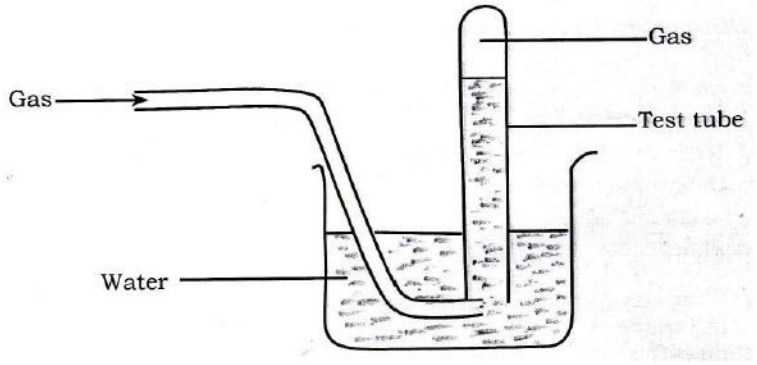
(ii) Give a reason for your answer in 1 c) (i) above. **(1 mark)**

2. Sodium, aluminium and sulphur can combine with oxygen to form oxides. Copy and complete the following table to show the formula and class (amphoteric, acidic or basic) of the oxide of each of these elements. (K: Z = 19; Al: Z = 13; S: Z = 16; O: Z = 8) **(6 marks)**

Element	Formula of oxide	Class of oxide
Potassium		
Aluminium		
Sulphur		

3. You are given a list of different gases: hydrogen chloride, hydrogen sulphide, sulphur dioxide and carbon dioxide. From the above list, identify the gas that has the following properties: **(3 marks)**
a) turns blue litmus paper red,
b) forms white fumes with ammonia,
c) forms a white precipitate with aqueous silver nitrate.

4. State which of the following gases: NH_3, O_2, HCl and F_2, can be collected by the method shown in the figure below and explain why the others cannot. **(3 marks)**



5. Calculate the mass percentage of water of crystallization in $CuSO_4.5H_2O$. (Atomic mass: Cu = 64; S = 32; O= 16; H = 1) **(3 marks)**

6. An alkane X of formula mass 30 consists of 80% carbon by mass.
   a) Determine the empirical formula of X. **(2 marks)**
   b) Determine the molecular formula of X. **(1 mark)**
   c) Write a chemical equation for the complete combustion of X in oxygen. **(1 mark)**

7. Ethene can react to form a solid whose molecular mass is more than 10,000.
   a) Name the reaction that occurs. **(1 mark)**
   b) Write the chemical equation of that reaction. **(1 mark)**
   c) (i) State what is observed when ethene reacts with bromine. **(1 mark)**
   (ii) Write the equation for the reaction in 7(c)(i) above. **(1 mark)**

8. Explain why:
   a) Hard water requires a lot of soap to form a lather. **(1 mark)**
   b) Isotopes of an element show similar chemical reactions. **(1 mark)**
   c) When carbon dioxide is bubbled through lime water, the lime water turns milky and finally clears. **(1 mark)**

9. Calculate the mass of nitric acid (HNO_3) required for preparing $200cm^3$ of 2M HNO_3 solution. (Atomic mass: H= 1, N = 14, O= 16) **(2 marks)**

10. Soap can be prepared by boiling vegetable oil with sodium hydroxide and adding a solution of sodium chloride to the reaction mixture.
    a) What name is given to the reaction leading to the formation of soap? **(0.5 mark)**
    b) Name one crop from which oil for making soap can be obtained. **(1 mark)**
    c) Why is sodium chloride added to the reaction mixture? **(1 mark)**
    d) State one advantage of using detergents instead of soap. **(1 mark)**

11. When hydrogen gas was passed over X g of strongly heated copper (II) oxide until there was no further change, 4 g of a solid was formed.
    (Atomic mass: Cu = 64, O = 16)
    a) State what was observed. **(1 mark)**
    b) Write the equation for the reaction. **(1 mark)**
    c) Determine the value of X. **(2 marks)**

12. Acidified water was electrolyzed using platinum electrodes.
    a) Write the chemical equation of reaction that took place at the:
    (i) Anode
    (ii) Cathode **(2marks)**
    b) Name any other substance that can be used as electrodes in the electrolysis of acidified water. **(0.5 mark)**

13. Describe the industrial preparation of nitric acid from ammonia (the diagram is not required). Your description should include equations for reactions that occur. **(6 marks)**

14. The formation of methanol from hydrogen and carbon monoxide is represented by the equation:
$2H_2$ (g) + CO (g) ↔ CH_3OH (g); the released energy = 92kJ /mol.
Calculate the energy that is released, in kJ/mole, when 96g of methanol is formed. (Relative mass: C= 12, H= 1 and O = 16) **(2 marks)**

15. Magnesium reacts with steam to give solid X and gas y.
    a) Identify:
    (i) Solid X. **(0.5 mark)**
    (ii) Gas Y. **(0.5 mark)**
    b) Describe how Y could be tested. **(1 mark)**
    c) Write the chemical equation for the reaction between X and hydrochloric acid. **(1 mark)**

SECTION B: ATTEMPT ANY THREE QUESTIONS (30 MARKS)

16. a) Substance X reacts with a solid chloride to produce hydrogen chloride.
    (i) Identify X. **(1 mark)**
    (ii) State the conditions for the reaction. **(1.5 marks)**
    (iii) Write the equation for the reaction. **(1 mark)**
    b) (i) Name the substance that is formed when hydrogen chloride is dissolved in water. **(1 mark)**
    (ii) Explain why an aqueous solution of hydrogen chloride is an electrolyte whereas the solution of the gas in organic compounds is a non-electrolyte (no equation is required). **(2 marks)**
    c) An aqueous solution of hydrogen chloride was added drop-wise to 4.2 g of solid sodium hydrogen carbonate until there was no further change. A colourless gas was evolved.
    (i) Write the chemical equation(s) for the reaction between sodium hydrogen carbonate and hydrogen chloride. **(1 mark)**
    (ii) Calculate the volume of the gas, measured at s.t.p that was evolved.
    (1 mole of gas occupies a volume of 224OO cm^3 at s.t.p, Na = 23, H= 1, C = 12, O= 16) **(2.5 marks)**

17. a) Copper (II) carbonate was heated strongly until there was no further change.
    (i) State what was observed. **(1 mark)**
    (ii) Write the chemical equation for the reaction. **(1 mark)**
    b) Excess dilute sulphuric acid was added to the residue in 17 (a) (ii) and the mixture warmed.
    (i) State what was observed. **(1 mark)**
    (ii) Write the chemical equation for the reaction. **(1 mark)**
    c) To the product in 17 (b) above was added dilute sodium hydroxide solution drop wise until in excess.
    (i) State what was observed. **(1 mark)**

(ii) Write the chemical equation for the reaction. **(1 mark)**

d) 25.0 cm^3 of 0.1M hydrochloric acid required 10.0 cm^3 of sodium carbonate for complete neutralization. **(1 mark)**

(i) Write the chemical equation for the reaction which took place between sodium carbonate and hydrochloric acid. **(1 mark)**

(ii) Calculate the concentration of sodium carbonate in mole/dm^3. **(3 marks)**

18. 5.34g of a salt of formula M_2SO_4 (where M is a metal) were dissolved in water. The sulphate ion was precipitated by adding excess barium chloride solution and 4.66g of barium sulphate ($BaSO_4$) were obtained
(Atomic mass: S = 32, O = 16, Ba= 137;
Avogadro constant = 6.023×10^{23} mol^{-1})

a) Write the ionic equation of the reaction that leads to formation of the precipitate. **(1 mark)**

b) How many moles of sulphate ions were precipitated as barium sulphate? **(1.5 marks)**

c) How many moles of M_2SO_4 were in the solution? **(1.5 marks)**

d) What is the formula mass of M_2SO_4? **(2.5 marks)**

e) What is the relative atomic mass of M? **(2.5 marks)**

f) What is the mass of $6O^{23} \times 1O^{21}$ atoms of M? **(1 mark)**

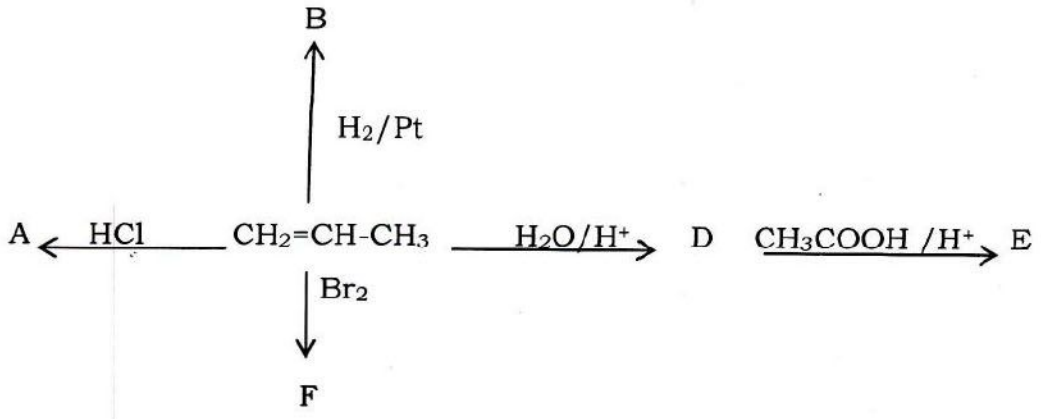
19. a) (i) State two properties which show that air is a mixture. **(1 mark)**

(ii) Name two gases other than oxygen that are constituents of air and give their approximate percentages in air. **(2 marks)**

b) Describe an experiment to determine the percentage of oxygen in air. (Show how the percentage can be calculated from the results). **(6marks)**

c) Write the chemical equation of the reaction that takes place in the silica tube. **(1 mark)**

20. a) Write the molecular formula of A, B, D, E and F: **(5 marks)**



b) Name the reactants $CH_2 = CH\text{-}CH_3$ and CH_3COOH and the products A, B and F. **(5 marks)**

SECTION C: THIS QUESTION IS COMPULSORY (15 marks)

21. a) What is meant by "rate of chemical reaction"? **(1 mark)**
b) Explain how the following factors affect the rate of a chemical reaction:
(i) Temperature. **(1 mark)**
(ii) Surface of the reactants. **(1 mark)**
c) The table below shows the volume of hydrogen gas collected at various time intervals when magnesium was reacted with 2 M hydrochloric acid.

Time (seconds)	0	1	2	3	4	5	6	7
Volume of H_2 collected (cm^3)	0	25	45	60	70	75	77	77

(i) Write the chemical equation of the reaction. **(1 mark)**
(ii) Plot a graph of volume of hydrogen versus time. **(6 marks)**
(iii) Determine the rate of reaction at 3 seconds (take the tangent at 3 seconds and find the slope, $s = \frac{\Delta y}{\Delta x} = rate$) **(2 marks)**
(iv) Determine the volume of hydrogen evolved at 3.5 seconds. **(2 marks)**
(v) When did the reaction end? **(1 mark)**

22. a) (i) Draw a labelled diagram to show how a sample of oxygen gas can be prepared in the laboratory from hydrogen peroxide. **(5 marks)**
(ii) Write the chemical equation for the reaction that takes place in 22)a)(i) above. **(1 mark)**
b) State and explain what happens when each of the following substances are lowered in a gas jar of oxygen and water added to the products.
(i) Hot sodium. **(3 marks)**
(ii) Ignited magnesium. **(2 marks)**
(iii) Hot iron. **(2 marks)**
c) Name one natural process by which oxygen can be obtained. **(1 mark)**
d) State one use of oxygen. **(1 mark)**

MARKING SCHEME OF ORDINARY LEVEL CHEMISTRY NATIONAL EXAMINATION 2017

Section A: Answer all questions

1. a) i) Y
   ii) X
   iii) W or Z
   b) 2: 8: 8: 1
   c) i) 1
   ii) Because it loses one electron to attain a noble gas state.

2.

Element	Formula of oxide	Class of oxide
Potassium	K_2O	Basic oxide
Aluminium	Al_2O_3	Neutral oxide
Sulphur	SO_2	Acidic oxide

3. a) Hydrogen chloride. All gases can also turn blue litmus paper to red (carbon dioxide, sulphur dioxide and hydrogen sulphide).
   b) Hydrogen chloride ($HCl + NH_3 \rightarrow$ white fumes of NH_4Cl)
   c) Hydrogen chloride ($HCl + AgNO_3 \rightarrow$ white precipitate of $AgCl + HNO_3$)

4. H_2 and O_2 because they are not soluble in water.

5. Percentage of water of crystallization in $CuSO_4.5H_2O$
   Molar mass of $CuSO_4.5H_2O = 64 + 32 + 16 \text{ X } 4 + 5(1 \text{ X } 2 + 16)$
   $= 96 + 64 + 10 + 80 = 250$ g/mole
   Mass of water in this compound = 90
   % of water $= \frac{90 \times 100}{250} = 36\ \%$

6. a) % of H = 100 – 80 = 20 %

	C	H
Moles	$\frac{80}{12}$	$\frac{20}{1}$
	= 6.66	= 20

Ratio $\frac{6.66}{6.66}$: $\frac{20}{6.66}$

1 : 3

Empirical formula: CH_3

b) $(CH_3)n = 30$

$(12 + 1 \times 3)\, n = 30$

$15\, n = 30$

$n = \frac{30}{15} = 2$

Molecular formula = $(CH_3)_2 = C_2H_6$

c) $2C_2H_6 + 7O_2 \rightarrow 4CO_2 + 6H_2O$

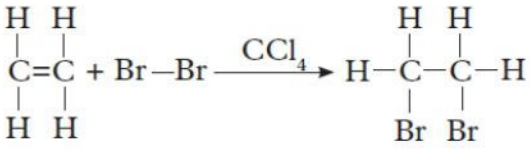
7. a) Polymerization

b)

Ethene (monomer) Polythene (polymer)

c) i) When ethene reacts with bromine water, it decolourises bromine water.

ii)



8. a) Because hard water therefore contains calcium ions (Ca^{2+}) and /or magnesium ions (Mg^{2+}).

b) Because they have the same number of electrons.

c) When CO_2 is bubbled through lime water, immediately a milky precipitate is observed. $Ca(OH)_2 + CO_2 \rightarrow CaCO_2 + H_2O$: milky precipitate.

When excess CO_2 is bubbled, the milky precipitate disappears and a colourless solution is observed. $CaCO_3 + H_2O + CO_2 \rightarrow Ca(HCO_3)_2(aq)$

9. The mass of nitric acid (HNO_3) required for preparing $200cm^3$ of 2M HNO_3 solution.

Mm of $HNO_3 = 1 + 14 + 16 \times 3 = 63$ g/mole

Number of moles in $0.2dm^3$ = M X V = 2 moles/dm^3 X 0.2 dm^3 = 0.4 mole.

Mass = n X Mm = 0.4 mole X 63 g/mole = 25.2 g

10. a) Saponification
    b) Palm tree, avocado
    c) To separate the mixture of soap, glycerol and water.
    d) They are not affected by hardness of water; they clean better than soap; they do not form scum.

11. a) Formation of a brown solid water vapours.
    b) $H_2 + CuO \rightarrow Cu + H_2O$
    c) Number of moles of Cu formed $= \frac{m}{Mm} = \frac{4\ g}{64\ g/mole} = 0.0625\ mole$

    From the equation one mole of CuO gives one mole of Cu.
    So 0.0625 mole of Cu is formed from 0.0625 mole of CuO.
    Mass of CuO = n X Mm
    Mm of CuO = 64 + 16 = 80 g/mole
    Mass of CuO = 0.0625 mole X 80 g/mole = 5 g

12. a) i) Cathode: $2H^+(aq) + 2e^- \rightarrow H_2(g)$
        ii) $4OH^-(aq) \rightarrow O_2(g) + 2H_2O + 4e^-$
    b) Graphite

13. Ammonia reacts with oxygen in the presence of platinum (Pt) - Rhodium (Rh) catalyst to form nitrogen monoxide and water as shown in the equation below.

$$4NH_3(g) + 5O_2(g) \xrightarrow[900°C]{\text{Pt-Rh}} 4NO(g) + 6H_2O(g)$$

The nitrogen monoxide is further oxidised to form nitrogen dioxide gas characterised by red-brown fumes. This is an acidic gas.

$$2NO(g) + O_2(g) \longrightarrow 2NO_2(g)$$
(Red-brown fumes)

When nitrogen dioxide is dissolved in water, nitrous acid and nitric acid are formed.

$$2NO_2(g) + H_2O(l) \longrightarrow HNO_3(aq) + HNO_2(aq)$$

Nitrous acid is further oxidised to form nitric acid. Nitric acid is the one that turns blue litmus paper red.

$$2HNO_2\,(aq) + O_2\,(g) \longrightarrow 2HNO_3\,(aq)$$

14. $2H_2$ (g) + CO (g) ↔ CH_3OH (g); the released energy = 92kJ /mol.
During the formation of 1 mole of methanol, 92kJ is released.
Mm of CH_3OH = 12 + 1 X 3 + 16 + 1 = 32 g/mole
Number of moles of $CH_3OH = \frac{m}{Mm} = \frac{96\,g}{32\,g/mole} = 3\,moles$
Energy released = 3 moles X 92kJ /mole = 276 KJ

15. a) i) MgO
ii) Hydrogen
b) It burns with a pop sound.
c) MgO (s) + 2HCl (aq) → $MgCl_2$ (aq) + H_2O (l)

SECTION B: Attempt any THREE questions in this section

16. a) i) H_2SO_4
ii) Concentrated sulphuric, heat
iii) 2NaCl + H_2SO_4 → Na_2SO_4 + 2HCl
b) Hydrochloric acid (aq)
c) $NaHCO_3$ (s) + HCl → NaCl (aq) + H_2O (l) + CO_2 (g)
Mm of $NaHCO_3$ = 23 + 1 + 12 + 16 X 3 = 84 g/mole
Number of moles of $NaHCO_3 = \frac{m}{Mm} = \frac{4.2\,g}{84\,g/mole} = 0.05\,mole$
From the equation one mole of $NaHCO_3$ gives one mole of CO_2.
0.05 mole of $NaHCO_3$ will give 0.05 mole of CO_2.
Volume of CO_2 = n X M_V = 0.05 mole X 22400cm^3/mole = 1120 cm^3.

17. a) i) A black solid
ii) $CuCO_3$ (s) $\xrightarrow{\Delta}$ 2CuO (s) + CO_2 (g)
b) i) The black solid disappears to form a blue solution.
ii) H_2SO_4 (aq) + CuO (s) → $CuSO_4$ (aq) + H_2O (l)
c) i) Formation of a blue precipitate of $Cu(OH)_2$.
ii) $CuSO_4$ (aq) + 2NaOH (aq) → Na_2SO_4 + $Cu(OH)_2$ (s)
d) i) 2HCl (aq) + Na_2CO_3 (aq) → 2NaCl (aq) + CO_2 (g) + H_2O (l)
ii) Number of moles of HCl= M XV= 0.1 mole/dm^3 X 0.025dm^3 = 0.0025 mole

From the equation, two moles of HCl react with one mole of Na_2CO_3

0.0025 mole of HCl will react with 0.00125 mole of Na_2CO_3

$M = \frac{n}{V} = \frac{0.00125\ mole}{0.01\ dm^3} = 0.125\ mole/dm^3$

Concentration of Na_2CO_3 in g/dm^3 = M X Mm

Mm of = 23 X 2 + 12 + 16 X 3 = 106 g/mole

Concentration of Na_2CO_3 in g/dm^3 = 0.125 $mole/dm^3$ X 106 g/mole = 13.25 g/dm^3

18.a) M_2SO_4 (aq) + $BaCl_2$ (aq) → 2MCl (aq) + $BaSO_4$ (s)

Ionic equation: Ba^{2+}(aq) + SO_4^{2-} (aq) → $BaSO_4$ (s)

b) Number of moles of $BaSO_4 = \frac{n}{Mm}$

Mm of $BaSO_4$ = 137 + 32 + 16 X 4 = 233 g/mole

Number of moles of $BaSO_4 = \frac{4.66\ g}{233\ g/mole} = 0.02\ mole$

c) From the equation, one mole of $BaSO_4$ is produced from one mole of M_2SO_4

0.02 mole of $BaSO_4$ is produced from 0.02 mole of M_2SO_4

There were 0.02 mole of M_2SO_4 in the solution.

d) Formula mass of $= \frac{m}{n} = \frac{5.34\ g}{0.02\ mole} = 267$

e) M X 2 + 32 + 16 X 4 = 267

2M + 32 + 64 = 267

2M + 96 = 267

2M = 267 – 96

2M = 171

$M = \frac{171}{2} = 85.5$

The relative atomic mass of M is 85.5

f) 6.023 X 10^{23} weigh 85.5 g (one mole weighs N_A atoms)

6023 X 10^{21} will weigh $\frac{85.5\ g \times 6.023 \times 10^{23}}{6023 \times 10^{21}} = \frac{85.5\ g \times 6.023 \times 10^{23}}{60.23 \times 10^{23}} = 8.55\ g$

19.a) i) Air is a mixture because its components can be separated by physical means.

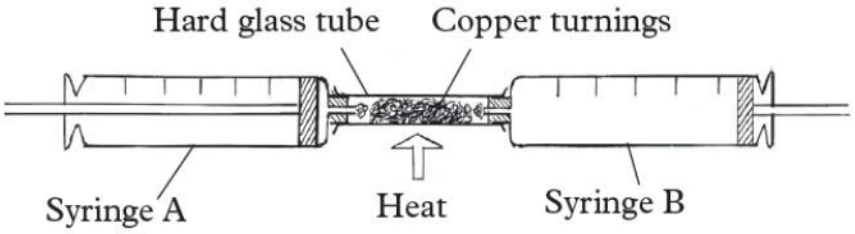
ii) Nitrogen: 78%; carbon dioxide: 0.03%

iii) **Investigating the percentage of the most active part of air**

Apparatus: Syringes, hard glass tube, glass wool, Bunsen burner, matchbox.

Procedure

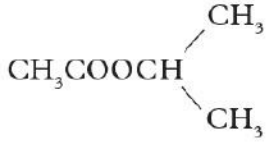
1. Place a small amount of copper turnings into a hard glass tube. Then put glass wool at both ends of the tube.
2. Label one syringe A. Remove all the air from this syringe by pushing the plunger inside. Fix it lightly to one end of the glass tube. Label the other syringe B. Pull the plunger of B out to 100cm^3 mark to fill the syringe with air.



3. Heat the tube containing copper turnings strongly. Pass air over them by slowly pushing the plunger of the syringe B towards syringe A several times.
4. When there is no further change in the volume of air left in the syringe B, allow the apparatus to cool.
5. Record the volume of air left in syringe B. What is the colour and name of the solid residue in the tube? Calculate the volume of air used up in the experiment.
The copper turnings that were brown at the start of the experiment, become grey- black. Also the volume of air decreases from 100 to about 79 cm^3.

Calculations
Initial volume of air in syringe B = 100 cm^3
Final volume of air in syringe B = 79 cm^3
Volume of air used= 100 – 79 = 21 cm^3
Percentage of air used = $\frac{21 \times 100}{100}$ = 21%
This means that only 21% of air was used when copper was heated.
c) $2Cu\ (s) + O_2\ (g) \rightarrow 2CuO\ (s)$

20. a) **A:** $CH_3 – CHCl – CH_3$; **B:** $CH_3 – CH_2 – CH_3$; **D:** $CH_3 – CHOH – CH_3$ or $CH_3 – CH_2 – CH_2OH$; **E:** $CH_3\text{-}COOCH_2\text{-}CH_2\text{-}CH_3$ or



F: $CH_2Br – CHBr – CH_3$

b) CH_2 = CH-CH_3: but-1-ene; CH_3COOH: acetic acid / ethanoic acid

A: CH_3 – CHCl – CH_3: 2-Chloropropane; **B:** CH_3 – CH_2 – CH_3: propane

F: CH_2Br – CHBr – CH_3: 1, 2-dibromopropane.

SECTION C: ATTEMPT ONLY ONE QUESTION

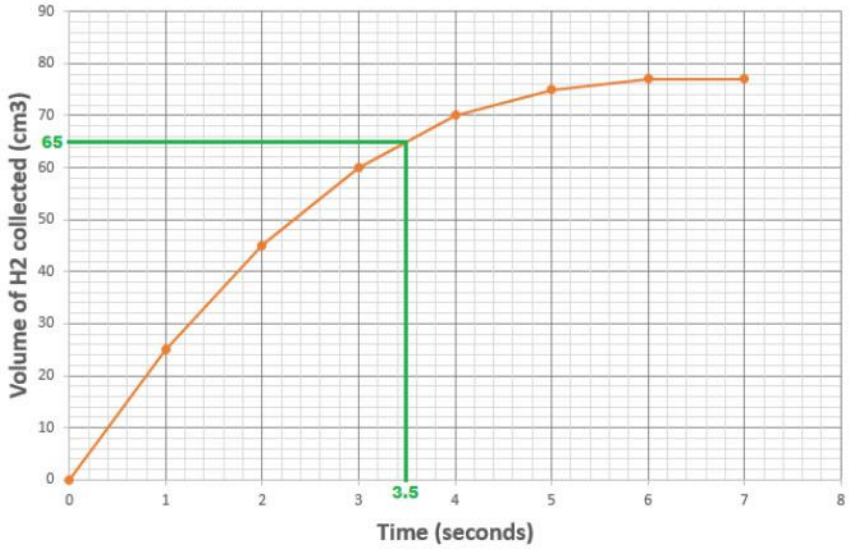
21.a) Rate of reaction is a measure of how fast or slow a reaction takes place. It can also be defined as change of an amount or concentration of a particular reactant or product per unit time.

b) i) Increasing the temperature increases also the rate of reactions. The rate of reaction increases because the velocity of all the reacting particles increase as the temperature rises. Increase in velocity increases the frequency of collisions of reacting particles. This is because of the increase in kinetic energy which provides the particles with the necessary activation energy required for the reaction to occur. The reaction therefore proceeds at a faster rate.

ii) The higher the concentration of the reactants, the faster the rate of reaction. This is because increasing the concentration of reactants increases the frequency of fruitful collisions between reacting particles. The greater the number of collisions, the faster the rate of reaction.

c) i) Mg (s) + 2HCl (aq) → $MgCl_2$ (aq) + H_2 (g)

ii)

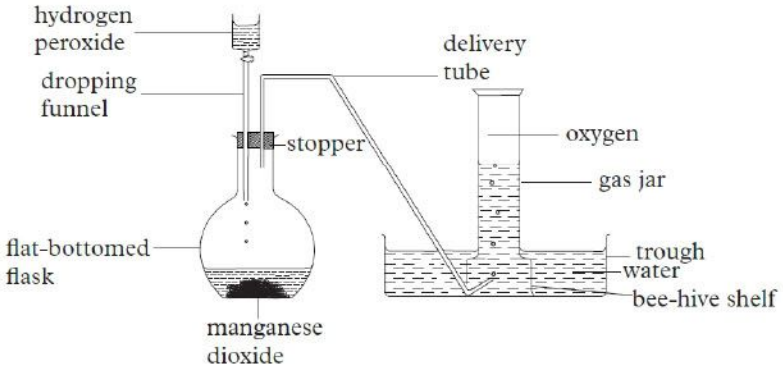


iii) Cancelled

iv) The volume of hydrogen evolved at 3.5 seconds = 65 cm^3

v) The reaction ends at 6 seconds.

22.a) i)



ii) $2H_2O_2\ (l) \xrightarrow{MnO_2} 2H_2O\ (l) + O_2\ (g)$

b) i) Hot sodium burns with a yellow flame.

$4Na\ (s) + 2O_2\ (g) \rightarrow 2Na_2O_2$

Sodium peroxide reacts with H_2O to liberate O_2.

$Na_2O_2 + H_2O \rightarrow NaOH + O_2$

ii) With ignited Mg: $2Mg\ (s) + O_2\ (g) \rightarrow 2MgO\ (s)$

In water: $MgO\ (s) + H_2O\ (l) \rightarrow Mg(OH)_2$

iii) With hot iron: $Fe(s) + O_2\ (g) \rightarrow Fe_2O_3\ (s)$

$Fe_2O_3\ (s)$ is insoluble in water.

c) Photosynthesis

d) Oxygen is used in respiration. Oxygen also supports combustion.

CHEMISTRY I

002

23/11/2018 08.30 AM – 11.30 AM

REB
Rwanda Education Board

ORDINARY LEVEL NATIONAL EXAMINATIONS, 2018

SUBJECT: CHEMISTRY I

DURATION: 3 HOURS

INSTRUCTIONS:

1. Write your names and index number on the answer booklet as they appear on your registration form, and **DO NOT** write your names and index number on additional answer sheets of paper if provided.
2. Do not open this paper until you are told to do so.
3. This paper consists of **three** sections **A**, **B** and **C**
   - Answer **ALL** questions in section A. **(55 marks)**
   - Answer **THREE** questions in section B. **(30 marks)**
   - Answer only **one** question in section C **(15 marks)**
4. Silent non-programmable calculators may be used.
5. You do not need the periodic Table.
6. Use only a **blue** or **black pen** for answering and a **pencil** for drawing.

SECTION A: Attempt all questions from this section. (55 marks)

1. The atomic number of helium, neon and argon are 2, 70 and18 respectively. The three elements are in group VIIIa.
   (a) Write the electronic configuration of argon, Ar. **(1 mark)**
   (b) Explain briefly why these elements are not reactive. **(2 marks)**

2. Briefly explain how the following mixtures can be separated:
   (a) Water and ethanol. **(2 marks)**
   (b) Sand and iron nails. **(2 marks)**

3. (a) Describe what is observed when a solution containing magnesium ions, Mg^{2+} is added to a solution of sodium hydroxide, NaOH. **(2 marks)**
   (b) Write the chemical equation for the reaction between magnesium metal, Mg and dilute hydrochloric acid, HCl. **(2 marks)**

4. The atomic mass of magnesium, oxygen and chlorine are 24, 16 and 35.5 respectively.
   (a) Calculate the number of moles in 18g of MgO. **(2 marks)**
   (b) Calculate the mass of $MgCl_2$ produced when 18g of MgO react completely with excess HCl. **(2 marks)**
   Equation:
   $$MgO + 2HCI \rightarrow MgCl_2 + H_2O$$

5. State a reagent that can be used to distinguish between the following pairs of ions and state the observable change in each case.
   (a) CO_3^{2-} and Cl^- **(2 marks)**
   (b) Cu_{2+} and Ca^{2+} **(2 marks)**

6. Consider the following oxides: CaO, NO_2 and Al_2O_3.
   (a) Indicate the oxide among the 3 above that is:
   (i) Acidic **(1 mark)**
   (ii) Amphoteric. **(1 mark)**
   (b) Write a balanced chemical equation of the reaction between CaO and H_2O. **(2 marks)**

7. (a) Write the structural formula of ethanol, C_2H_5OH. **(1 mark)**
   (b) State 2 uses of ethanol on a large scale. **(2 marks)**

8. $CuSO_4.5H_2O$ of 16.5g by mass is heated to drive off water of crystallisation.
   Equation: $CuSO_4.5H_2O\ (s) \xrightarrow[\Delta]{} CuSO_4\ (s) + 5H_2O\ (g)$
   (a) Calculate the mass of anhydrous $CuSO_4$ (s) formed. **(2 marks)**
   (b) State the colour change that takes place when all H_2O is removed from $CuSO_4.5H_2O$. (Atomic mass: Cu = 63.5, S = 32, O = 16, H =1)
   (2 marks)

9. (a) Complete the following equation of combustion reaction and balance it:

$C_3H_8 + O_2 \rightarrow$ **(2 marks)**

(b) State 2 uses of alkanes on a large scale. **(2 marks)**

10. Lead oxide, PbO reacts with aqueous sodium hydroxide as well as dilute nitric acid, HNO_3.

Equations: $PbO\ (s) + 2OH^-\ (aq) + H_2O\ (l) \rightarrow Pb(OH)_4^{2-}\ (aq)$

$PbO\ (s) + 2\ HNO_3\ (aq) \rightarrow Pb(NO_3)_2\ (aq) + H_2O\ (l)$

(a) State a reagent and conditions that can be used to test for the presence of Pb^{2+} ions in $Pb(NO_3)_2$ (aq) solution and mention the observable colour change. **(2 marks)**

(b) Write the chemical equation of the reaction between ZnO and the following reactant to show its amphoteric properties:

(i) ZnO and aqueous dilute HCl solution. **(1 mark)**

(ii) ZnO and aqueous NaOH solution. **(1 mark)**

11. Sulphur reacts with some metals:

(a) Write a balanced equation of the reaction between sulphur and iron. **(1 mark)**

(b) State the names of 2 allotropes of sulphur. **(2 marks)**

12. (a) Consider the equation of the reaction that is given below and answer the question that follows:

$CuO + C \rightarrow Cu + CO\ (g)$

State the type of reaction that takes place to convert CuO to Cu. **(1 mark)**

(b) Indicate the observable changes that take place when CO_2 is bubbled in lime water slowly until in excess of CO_2 gas in the solution. **(2 marks)**

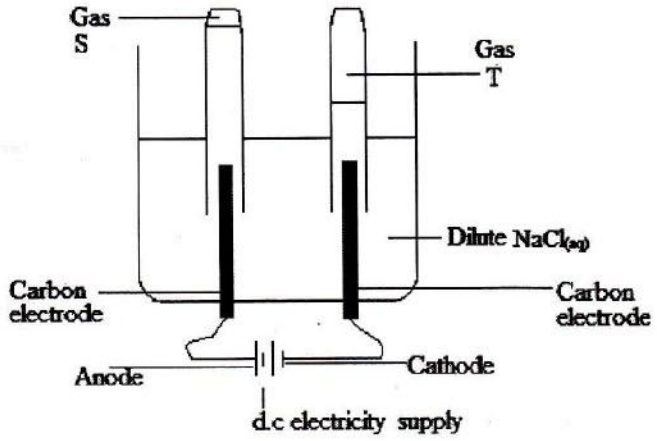
13. Calcium reacts with dilute following equation:

$Ca\ (s) + H_2SO_4\ (aq) \rightarrow CaSO_4\ (s) + H_2\ (g)$

(a) Give one reason to explain why the above reaction occurs for a short period of time and stops. **(1 mark)**

(b) State 2 uses of compounds of group IIa elements. **(2 marks)**

14. The diagram below represents electrolysis of aqueous sodium chloride; NaCl solution prepared using distilled water.



(a) Write the symbols of all ions present in the solution of aqueous sodium chloride, NaCl. **(2 marks)**

(b) Write the chemical equation of the reaction that takes place at the:

(i) Anode **(1 mark)**

(ii) Cathode. **(1 mark)**

15. Chlorine gas is prepared in the laboratory using HCl acid and MnO_2 powder.

(a) Write a balanced equation of the reaction between HCl acid and MnO_2 powder when hot.

(b) State 2 uses of chlorine by man.

SECTION B: ATTEMPT ANY THREE QUESTIONS (30 Marks)

16. During titration, 25 ml of a 0.2 mole/litre NaOH solution was poured in a beaker. An appropriate indicator (phenolphthalein) was added to the NaOH base. Titration of H_2SO_4 (aq) from a burette was done. Neutralisation of the base was reached on addition of 23.50m1 of H_2SO_4 (aq).

Equation:

$H_2SO_4 + 2NaOH \rightarrow 2H_2O + Na_2SO_4$

(a) State the name of another acid-base indicator that can be used to detect NaOH solution and the colour of this indicator in the base. **(2 marks)**

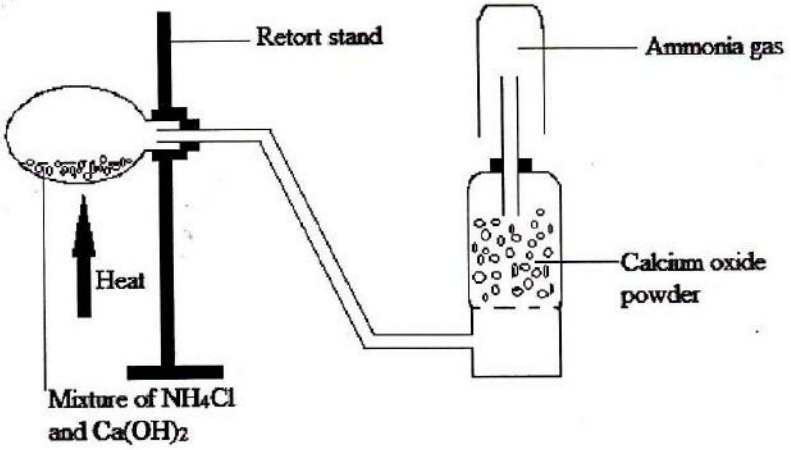
(b) Calculate the number of moles of NaOH present in 25ml of solution. **(2 marks)**

(c) Determine the number of moles of H^+ ions (aq) in 23.50ml of H_2SO_4 solution. **(2 marks)**

(d) Calculate the number of moles of H_2SO_4 (aq) in 23.50m1 of its solution. **(2 marks)**

(e) Calculate the molarity (moles /litre) of H_2SO_4 (aq). **(2 marks)**

17. Study the diagram below and answer the questions that follow:



(a) Explain the reason why calcium oxide, CaO is used instead of H_2SO_4 to dry ammonia gas in the apparatus set-up. **(1 mark)**

(b) Write a chemical equation of reaction between NH_4CI and $Ca(OH)_2$.

(2 marks)

(c) State the name of the method of collection of ammonia gas used in the apparatus set-up above. **(1 mark)**

(d) Indicate the observable colour changes that take place when ammonia solution is dissolved in a solution of Cu^{2+} ions until in excess. **(2 marks)**

(e) Write the equation of reaction that takes place when NH_3 gas reacts with HCl gas and state the observable change. **(2 marks)**

(f) State 2 physical properties of ammonia, NH_3. **(2 marks)**

18. Organic compound X is constituted of 85.71% carbon and 14.28% hydrogen by mass. The mass of 4.2g of hydrocarbon X occupies a volume of 2400 cm^3 when it is vaporised at room temperature and pressure.

(a) Calculate the molar mass of compound X. **(3 marks)**

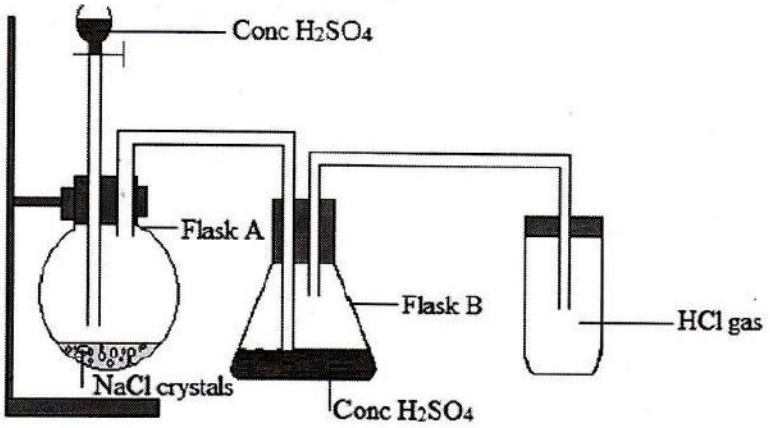
(b) Determine the empirical formula of compound X. **(2 marks)**

(c) Determine the molecular formula of compound X. **(2 marks)**

(d) Write a balanced equation for the reaction of combustion of organic compound X in oxygen. **(2 marks)**

(e) State 1 use of compound X on a large scale.
(Atomic mass: C =12, H = 1) (Molar volume of a gas at room temperature and pressure = 24000 cm^3) **(1 mark)**

19. Study the diagram below and answer the questions that follow:



(a) Write the equation of reaction between concentrated sodium chloride NaCl solution and concentrated sulphuric acid, H_2SO_4 to liberate HCl gas. **(2 marks)**

(b) State the role of concentrated H_2SO_4 in conical flask B. **(1 mark)**

(c) State 2 physical properties of hydrogen chloride gas, HCl. **(2 marks)**

(d) Write a balanced equation of the reaction between magnesium metal, Mg and HCl acid. **(2 marks)**

(e) (i) write the equation of the reaction between concentrated $KMnO_4$ solution and concentrated HCl acid to liberate chlorine gas, Cl_2 . **(1 mark)**

(ii) State a reagent that can be used to detect Cl_2 gas and describe the observable colour change for a positive test. **(2 marks)**

20. The table below shows a part of the periodic table. The letters are not the correct symbols of elements.

Periods	Groups																
	I	II										III	IV	V	VI	VII	VIII
1																	F
2	A												C		E		
3		B												D			
4																	
5																	

(a) Which letters shown on the diagram are:
(i) Two elements that are metals? **(2 marks)**
(ii) Two elements that are in one period? **(1 mark)**
(ii) An unreactive inert gas? **(1 mark)**
(b) Write the formula of a compound formed between A and E. **(2 marks)**
(c) State 2 physical properties of element B. **(2 marks)**
(d) State the type of bond that exists between element D and E. **(1 mark)**
(e) Element C is in group IV and in period 2. Write the electronic configuration of C. **(1 mark)**

SECTION C: ATTEMPT ONLY ONE QUESTION (15 Marks)

21. Oxides are formed by reaction of oxygen with different elements.
(a) State the name of a compound resulting from combination of oxygen with another element. **(1 mark)**
(b) Write a chemical formula of such a compound mentioned in 21 (a) above. **(1 mark)**
(c) Write the name of 1 rare gas found in its important use by man. **(2 marks)**
(d) Describe the properties of oxygen that allows it to be collected upwards in a water tank. **(1 mark)**
(e) State 1 example of:
(i) Slow oxidation. **(1 mark)**
(ii) Rapid oxidation. **(1 mark)**
(f) Draw a labelled diagram of the laboratory preparation of ethene from ethanol. **(3 marks)**
(g) State 2 main chemical reactants used for the preparation of soap. **(2 marks)**
(h) 1g of sucrose sugar is put in a pyrex test tube, 2 ml of concentrated H_2SO_4 is added to it:
(i) State what is observed after 1 hour of reaction. **(1 mark)**
(ii) Give a brief description of the term "hygroscopic substance" and give an example of such a substance. **(2 marks)**

22. You are provided with substance Y. Study the observations in the table below and deduce the type of cation S and anion T present in substance Y.

Test	**Y (solution) + Reagent**	**Observation**	**Possible ions present (symbols of Ions)**
1	Y (aq) + NaOH	Pale blue precipitate formed	
2	Y (aq) + KI (aq)	Brown precipitate formed	
3	Y (aq) + Na_2CO_3 (aq)	Pale blue precipitate formed	
4	Y (aq) + NH_3 (aq) then add in excess of NH_3 (aq)	Pale blue precipitate formed that turns deep blue in excess of NH_3 (aq)	
5	Y (aq) + $BaNO_3$ (aq)	White precipitate formed	
6	Y (aq)+ Mg (s)	Brown solid deposited on the bottom of the test tube	

(a) Copy the table and write the possible ions present in tests 1, 2, 3, 4, 5 and 6 respectively. **(12 marks)**

(b) Cation present in Y is: ..... **(1mark)**

(c) Anion present in Y is: ..... **(1 mark)**

(d) The chemical formula of substance Y is: ..... **(1 mark)**

MARKING SCHEME OF ORDINARY LEVEL CHEMISTRY NATIONAL EXAMINATION 2018

SECTION A: Answer all questions

1. (a) Electronic configuration of argon is: 2: 8: 8
   (b) These elements are not reactive because the outermost shell is full of electrons and are therefore stable.

2. (a) Water and ethanol can be separated by fractional distillation. The mixture is heated as the more volatile component in vapour separates out at lower temperatures to move up in the fractionating column.
   (b) Sand and iron nails can be separated using a magnet to attract and leave sand in the container.

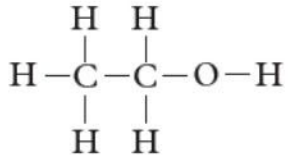
3. (a) The colourless solution of Mg^{2+} ions turns to white precipitate.
   (b) $Mg\ (s) + 2HCl\ (aq) \rightarrow MgCl_2\ (aq) + H_2\ (g)$

4. (a) Molar mass of MgO = 24 + 16 = 40 g/mole
   Number of moles in 8 g of MgO $= \frac{m}{Mm} = \frac{18\ g}{40\ g/mole} = 0.45\ mole$
   (b) Number of moles of $MgCl_2$ is also equal to 0.45 mole since the ratio is 1 : 1
   m = n X Mm
   Molar mass of $MgCl_2$ = 24 + (35.5 X 2) = 95 g/mole
   M = 0.45 mole X 95 g/mole = 42.75 g

5. (a) CO_3^{2-} and Cl^-: add $AgNO_3$ solution followed by dilute HNO_3, the Cl^- turns to white precipitate but the CO_3^{2-} solution does not form a precipitate.
   (b) Add NH_3 solution: a blue precipitate forms for Cu^{2+} solution but not with Ca^{2+} solution.
   Or add H_2SO_4: a white precipitate forms with Ca^{2+} ions but not with Cu^{2+} solution.

6. (a) (i) Acidic oxide: NO_2
   (ii) Amphoteric oxide: Al_2O_3
   (b) Equation: $CaO\ (s) + H_2O\ (l) \rightarrow Ca(OH)_2\ (aq)$

7. (a) Structural formula of ethanol, C_2H_5OH.



(b) 2 uses of ethanol on a large scale:
Used as organic solvent
Used as disinfectant.

8. (a) Mm of $CuSO_4.5H_2O$ = 63.5 + 32 + 16 X 4 + 5 (1 X 2 + 16) = 249.5 g/mole
Mm of $CuSO_4$ = 63.5 + 32 + 16 X 4 = 159.5 g/mole
Mass of $CuSO_4$ anhydrous formed $= \frac{159.5 \times 16.5\ g}{249.5} = 10.548\ g$
(b) The blue crystals turn to white powder.

9. (a) $C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4\ H_2O$
(b) Uses of alkanes on a large scale:
- Combustion in domestic heating appliances in kitchens.
- To prepare important organic compounds like alkenes.

10. (a) NaCl
Formation of white precipitate which disappear on heating.
(b) (i) $ZnO\ (s) + 2HCl\ (aq) \rightarrow ZnCl_2\ (aq) + H_2O\ (l)$
(ii) $ZnO\ (s) + 2OH^-\ (aq) + H_2O \rightarrow Zn(OH)_4^{2-}$

11. (a) $Fe\ (s) + S\ (s) \rightarrow FeS\ (s)$
(b) Rhombic and monoclinic.

12. (a) Reduction
(b) There is formation of a white precipitate.
The white precipitate disappears in excess of CO_2 gas.

13. (a) There is a layer of solid $CaSO_4$ formed that stops further reaction with the acid.
b) Elements of group IIa are used to make:
Chalk, cement

14. (a) Ions present: Na^+, Cl^-, OH^-, H^+.
(b) Equation:
(i) Anode: $2Cl^- \rightarrow Cl_2\ (g) + 2e^-$
(ii) Cathode: $2H^+\ (aq) + 2e^- \rightarrow H_2\ (g)$

15. (a) $MnO_2 + 4HCl \rightarrow MnCl_2 + 2H_2O + Cl_2$

(b) Uses of chlorine by man:

- To kill germs by man
- To make pharmaceuticals drugs.

Section B: Answer only 3 questions

16. (a) Name of indicator: methyl orange.

Colour of indicator in NaOH solution: yellow.

(b) Number of moles of NaOH present in 25 ml of solution = M X V

= 0.2 mole/l X 0.035 l = 0.005 mole

(c) Number of moles of H^+ ions (aq) in 23.50 ml of H_2SO_4 solution:

Since the ratio of OH^- : H^+ = 1

Number of moles of H^+ ions (aq) in 23.50 ml of H_2SO_4 solution = 0.005 mole

(d) Number of moles of H_2SO_4 in 23.50 ml of its solution

$= \frac{0.005\ mole}{2} = 0.0025\ mole$

(e) The molarity of $H_2SO_4 = \frac{n}{V} = \frac{0.0025\ mole}{0.02350\ l} = 0.1063\ mole/litre$

17. (a) H_2SO_4 would react with NH_3.

(b) $2NH_4Cl + Ca(OH)_2 \rightarrow 2NH_3 + CaCl_2 + 2H_2O$

(c) Upward delivery or downward displacement of air.

(d) There is formation of a light blue precipitate which turns deep blue in excess of NH_3.

(e) Formation of white powder fumes.

(f) Ammonia is less denser than air.

Ammonia is very soluble in water.

18. (a) Molar mass of compound X

Number of moles $= \frac{volume}{Molar\ volume} = \frac{2400\ cm^3}{24000\ cm^3/mole} = 0.1\ mole$

Molar mass $= \frac{Mass}{Number\ of\ moles} = \frac{4.2\ g}{0.1\ mole} = 42\ g/mole$

(b) Empirical formula of compound X

C	:	H
$\frac{85.71}{12}$	:	$\frac{14.28}{1}$
7.14	:	14.28

$\frac{7.14}{7.14}$: $\frac{14.28}{7.14}$

1 : 2

The empirical formula is CH_2

(c) The molecular formula of X is:

$(CH_2)n = 42$

$(12 + 2)n = 42$

$14n = 42$

$n = \frac{42}{14} = 3$

The molecular formula of X is C_3H_6

(d) Equation for the reaction of combustion of organic compound X in oxygen:

$C_3H_6 + 9/2\ O_2 \rightarrow 3CO_2 + 3H_2O$

(e) Production of energy (cooking)

19. (a) $H_2SO_4 + NaCl \rightarrow HCl + NaHSO_4$

Or $H_2SO_4 + 2NaCl \rightarrow 2HCl + Na_2SO_4$

(b) To dry HCl gas.

(c) It is denser than air.

It is very soluble in water.

(d) $Mg + 2HCl \rightarrow MgCl_2 + H_2$

(e) i) $2KMnO_4 + 16\ HCl \rightarrow 2KCl + 5Cl_2 + 8H_2O + 2MnCl_2$

Or $2MnO_4^- + 10\ Cl^- + 16H^+ \rightarrow 2Mn^{2+} + 5Cl_2 + 8H_2O$

ii) Blue litmus paper.

The litmus paper turns red and then it is bleached to become white.

20. (a) (i) A and B.

(ii) B and D.

(ii) F

(b) A_2E

(c) It is lustrous in appearance

It conducts electricity.

(d) Covalent bond.

(e) 2: 4

SECTION C: ATTEMPT ONLY ONE QUESTION

21. (a) Oxide

(b) CaO

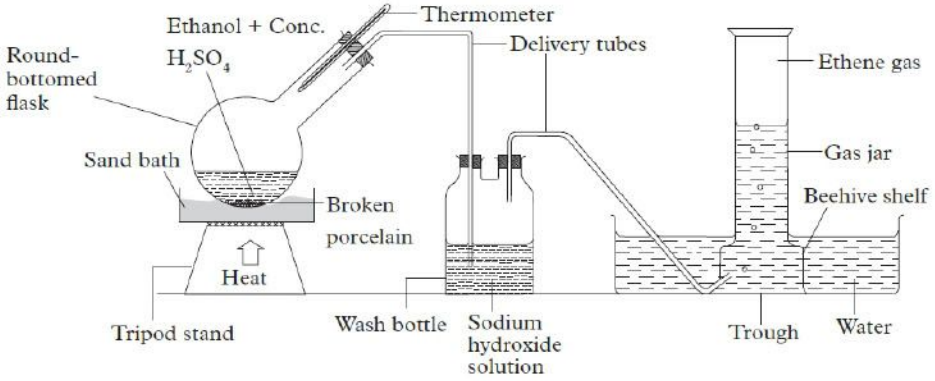
(c) Neon or Argon: is put in electric bulbs

(d) Oxygen is slightly soluble in water, so little oxygen dissolves in water and most of it moves to form a layer on top of water.

(e) (i) Slow oxidation: rusting of iron

(ii) Rapid oxidation: combustion of charcoal.

(f) Diagram of preparation of ethanol



(g) Sodium hydroxide and palm oil

(h) (i) There is formation of a black substance from sugar.

(ii) It is a substance that absorbs water from the surroundings.

22. (a) Possible ions present in:

1. Cu^{2+}, Fe^{2+}, Cr^{3+}, Ni^{2+}
2. Cu^{2+}
3. Cu^{2+}, Fe^{2+}, Cr^{3+}
4. Cu^{2+}
5. SO_4^{2-}, SO_3^{2-}
6. Cu^{2+}, Pb^{2+}

(b) Cation present in Y is: Cu^{2+}

(c) Anion present in Y is: SO_4^{2-} or SO_3^{2-}

(d) Chemical formula of substance Y is: $CuSO_4$ or $CuSO_3$.

Chemistry I

002

15/11/2019 08.30 AM – 11.30 AM

Rwanda Education Board

ORDINARY LEVEL NATIONAL EXAMINATIONS, 2019

SUBJECT: CHEMISTRY I

DURATION: 3 HOURS

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3. This paper consists of **three** sections **A**, **B** and **C**
   - Answer **ALL** questions in section A. **(55 marks)**
   - Answer **THREE** questions in section B. **(30 marks)**
   - Answer only **one** question in section C **(15 marks)**
4. Silent non-programmable calculators may be used.
5. You do not need the periodic Table.
6. Use only a **blue** or **black pen** for answering and a **pencil** for drawing.

SECTION A: Attempt all questions from this section. (55 marks)

1. a) The atomic number of aluminium is 13. Draw the structure of aluminium atom (Bohr model) showing electrons on shells. **(1 mark)**
   b) Explain why aluminium is used to make electric wires. **(2 marks)**

2. a) Give one example of a mixture having 2 substances that can be separated by decantation. **(1 mark)**
   b) In hospitals, blood constituents are separated using centrifuge machines in order to know illnesses of patients. **(2 marks)**
   (i) Explain how the different constituents separate during centrifugation.
   (ii) State two other mixtures that can be separated by centrifugation in hospitals. **(2 marks)**

3. A sports medal has a total surface area of 150 cm^2. It was evenly coated with silver by electrolysis. Its mass increased by 0.216g. How many atoms of silver were deposited per cm^2 on the medal surface? **(3 marks)**
   (Atomic mass: Ag = 107)
   (1 mole = 6.02 X 10^{23} atoms)

4. You want to prepare $ZnSO_4$ using H_2SO_4 and Zn metal:
   a) Write the equation of the reaction between Zn and H_2SO_4 solution indicating state symbols. **(2 marks)**
   b) Explain the method you would use to obtain $ZnSO_4$ crystals from its aqueous solution. **(2 marks)**

5. An organic compound contains 4.07% hydrogen, 24.27% carbon and 71.65% chlorine by mass. Its molar mass is 99 g/mol.
   a) Determine the empirical formula of the compound. **(2 marks)**
   b) Determine the molecular formula of the compound. **(2 marks)**
   (Atomic mass: C = 12, H = 1, Cl = 35.5)

6. a) Suggest two ways you can use to avoid pollution of water. **(2 marks)**
   b) Describe two effects of polluted water to humans. **(2 marks)**

7. Silicon and germanium are metalloids.
   a) Give two physical or chemical properties of metalloids. **(2 marks)**
   b) State two important uses of silicon on a large scale. **(2 marks)**

8. a) Ethanol is a compound in the homologous series of alcohols.
      (i) Write the molecular formula of ethanol. **(1 mark)**
      (ii) State one use of ethanol on a large scale. **(1 mark)**
   b) Evaluate the social-economic importance of biogas which is produced by the decomposition of cow dung in domestic composts in Rwanda. **(2 marks)**

9. Aluminium is extracted from its ores by means of electrolysis of a solution of Al^{3+}.

a) Write the equation of the reaction which takes place at the cathode during this electrolysis. **(1 mark)**

b) Discuss the economic importance of aluminium to the Rwandan society. **(2 marks)**

10. (a) Give two conditions necessary for rusting of iron to take place and hence write the chemical formula of iron rust. **(2 marks)**

(b) State two means that can be used to prevent rusting of iron objects. **(2 marks)**

11. Carbon atoms are linked by three (3) covalent bonds in graphite and the fourth electron of every carbon is free and mobile.

a) State one physical property that results due to the mobility of electrons in graphite. **(1 mark)**

b) Diamond is a carbon allotrope. State the type of bonding and one of the physical properties of diamond. **(2 marks)**

12. (a)Calcium carbonate reacts with hydrochloric acid according to the equation:

$$CaCO_3\ (s) + 2\ HCl\ (aq) \rightarrow CaCl_2\ (aq) + H_2O\ (l) + CO_2\ (g)$$

State two conditions that can be used to obtain the highest rate of production of carbon dioxide at room temperature. **(2 marks)**

b) State one important use of: **(2 marks)**

(i) Calcium carbonate

(ii) Calcium oxide.

13. In your school laboratory, suppose that some iron debris (pieces) and about 5 ml of water have been accidentally put in a cup half-filled with table salt. Describe the method you can use to remove the iron and water so that you obtain again the salt in pure form. **(3 marks)**

14. (a) Explain why it is dangerous to keep the charcoal stove burning in a house while the doors and windows are closed. **(2 marks)**

b) Explain how biodegradable solid wastes such as remains of plants and animals can be disposed of (dumped) to produce useful products in our homes. **(2 marks)**

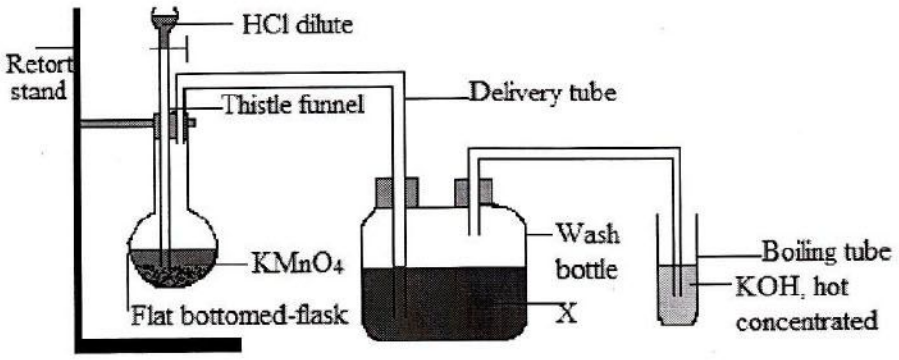
15. Burning magnesium continues to burn when put in pure carbon dioxide.

a) Write the equation of the reaction between Mg and CO_2. **(2 marks)**

b) State two observable changes during the combustion process.**(1 mark)**

SECTION B: Attempt only three questions **(30 marks)**

16. Study the diagram given below for the production of chlorine gas and answer the questions that follow:



(a) Give the name or chemical formula of the substance X present in the bottle. **(1 mark)**

(b) Write the equation for the reaction between hydrochloric acid, HCl and cold $KMnO_4$ (potassium permanganate) solution to form chlorine. **(2 marks)**

(c) State the colour change in the flat-bottomed flask as the reaction between HCl and $KMnO_4$ proceeds to completion. **(1 mark)**

(d) Give a test reagent (substance) for chlorine and describe the observable change for a positive test. **(2 marks)**

(e) Suggest one important use of chlorine on a large scale. **(1 mark)**

(f) Write the chemical equation for the reaction between Cl_2 and hot, concentrated KOH in the boiling tube. **(2 marks)**

(g)State one important use of $KClO_3$. **(1 mark)**

17. During titration, 25 ml of a 0.1 mole/litre Na_2CO_3 solution was poured in a beaker. An appropriate indicator (3 drops of phenolphthalein) was added to the Na_2CO_3 alkaline solution. Titration of HCl (aq) from a burette was done. Neutralisation of the base was reached on addition of 27.50ml of HCl (aq).

Equation:

$$2HCl\ (aq) + Na_2CO_3\ (aq) \rightarrow 2NaC1\ (aq) + CO_2\ (aq) + H_2O\ (l)$$

a) State the name of another acid-base indicator that can be used to detect

Na_2CO_3 solution and the colour of this indicator in the base. **(2 marks)**

b) Calculate the number of moles of Na_2CO_3 present in 25m1 of solution. **(2 marks)**

c) Calculate the number of moles of HCl (aq) in 27.50ml of the solution. **(2 marks)**

d) Calculate the molarity of HCl (aq) **(2 marks)**

e) Calculate the mass of anhydrous Na_2CO_3 that was used to prepare 25 ml of the solution. **(2 marks)**

(Atomic mass: Na = 23, C = 12, 0 = 16)

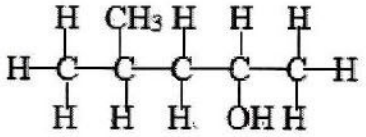
18. a) An organic compound X is constituted of 40% carbon, 6.72% hydrogen and 53.28% oxygen by mass. *(Atomic mass: C = 12, H = 1, O = 16)*

(i) Determine the empirical formula of compound X. **(3 marks)**

(ii) Determine the molecular formula of compound X if its molar mass is 180g/mo1. **(2 marks)**

b) Draw the structural formula of the following organic compound: 3,3-dimethyl but-1-ene **(1 mark)**

c) Give the IUPAC name of the following organic compound: **(1 mark)**

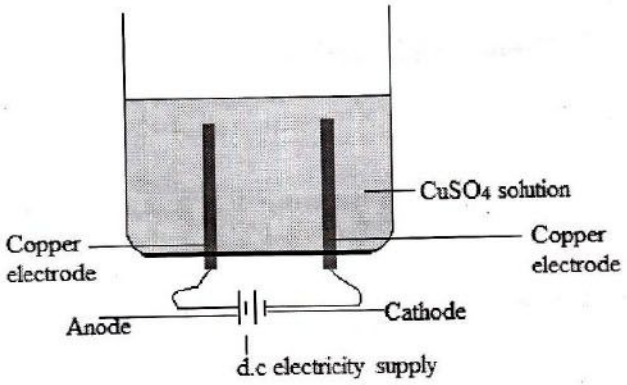


d) Write the structural formula of the organic compound Y obtained in the following reaction: **(1 mark)**

$CH_3CH_2OH + K_2Cr_2O_7 + H_2SO_4 \rightarrow Y$

e) State two sources of alcohols. **(2 marks)**

19. Study the diagram for the laboratory electrolysis of copper sulphate solution ($CuSO_4$) using copper electrodes and answer the questions that follow.



a) Write the chemical symbols of all ions present in $CuSO_4$ solution. **(2 marks)**

b) Write the chemical equation of the reaction that takes place at the:
(i) Anode
(ii) Cathode **(2 marks)**

(c) What will be the product of the reaction at the anode if copper electrodes are replaced with carbon electrodes? **(1 mark)**

(d) State two useful applications of electrolysis of copper sulphate on a large scale. **(2 marks)**

(e) Two iron nails are put in 20 ml of a 0.05 mole/litre solution of copper sulphate in a boiling tube and are kept there for one week;

(i) State two observable changes in the boiling tube after one week. **(1 mark)**

(ii) Write the chemical equation for the reaction between iron, Fe and copper ions in the solution (include state symbols). **(2 marks)**

20. Study the table shown below and answer the questions that follow:

(a) Arrange the metals Fe, Pb, Mg, and Zn in order of increasing reactivity (start from the least reactive). **(3 marks)**

(b) Construct a balanced equation for the reaction of iron oxide, Fe_2O_3 with Zinc, Zn. **(2 marks)**

(c) A student prepared zinc sulphate by adding powdered, zinc carbonate to a beaker half-filled with dilute sulphuric acid.
Equation:
$ZnCO_3 + H_2SO_4 \rightarrow ZnSO_4 + CO_2 + H_2O$
Describe the method that can be used to show that all the zinc carbonate has reacted. **(2 marks)**

d) Give a reagent or set of reagents that can be used to test for the presence of Zn^{2+} ions in a solution and the observation made. **(2 marks)**

e) Give one reason to explain why aluminium is used in the manufacture of aircrafts. **(1 mark)**

SECTION C: Attempt only one question (15 marks)

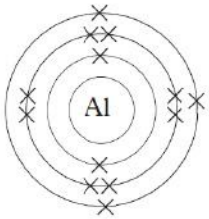
21. (a) Describe the term "polymerization". **(1 mark)**
(b) State two different uses of polymers. **(2 marks)**
(c) Describe the technique used during the separation of various fractions of crude oil in the refining process. **(2 marks)**
(d) Write the chemical equation between methanoic acid and potassium hydroxide and give the product of the reaction. **(2 marks)**
(e) Discuss the economic importance and environmental effects of the deposition of cow dung in domestic composts in Rwanda for the production of methane (biogas). **(3 marks)**
(f) Give two reasons to explain why alkanes are preferred for use as fuels instead of alkenes. **(2 marks)**
(g) Calculate the volume which is occupied by 4.2 g of CH_4 gas at 45°C and at l520 mmHg of pressure. **(3 marks)**
(Atomic mass: C = 12, H = 1)
(1 mole of a gas occupies 24 dm^3 at 25°C and 76O mmHg pressure)

22. The relative densities of oxygen O_2 and carbon dioxide CO_2 are 16 and 22 respectively. It is found that 25 cm^3 of carbon dioxide CO_2 diffuses out in 75 seconds.
(a) State Graham's law of diffusion of gases. **(2 marks)**
(b) Calculate the volume of oxygen that will diffuse in 100 seconds. **(4 marks)**
(c) State Charles' law of ideal gases that relates the variation of gas volumes with temperature change. **(1.5 marks)**
(d) State Boyle's law of ideal gases that relates the variation of gas volumes with pressure change. **(1.5 marks)**
(e) The volume of an ideal gas is 15OO cm^3 at 17°C and 700 mmHg of pressure.
i) Calculate the volume of this gas at 0°C and 76O mmHg. **(2 marks)**
ii) Calculate the number of moles of this gas present in the above volume.
Discuss the important effects of gases in either inflated vehicle tyres, or during the process of rotation of engines when combustion of fuel takes place in engine cylinders. **(2 marks)**
(0°C = 273 Kelvins, 1 mole of a gas occupies 22400 cm^3 at 0°C and 760 mmHg pressure)

MARKING SCHEME OF ORDINARY LEVEL CHEMISTRY NATIONAL EXAMINATION 2019

SECTION A: Answer all questions

1. (a)



(b) Aluminium is used to make electric wires because the metal contains free mobile electrons which carry electric charges with metallic bond in the metal.

2. (a) A mixture of chalk and water. Or water and oil
   (b) (i) During centrifugation, heavy particles settle on the bottom of the test tube due to the centrifuge force.
   Or during centrifugation, the blood plasma float on the top while the blood cells settle at the bottom of the test tube.
   (ii) Blood, urine, synovial fluid, lymph.

3. Mass per $cm^2 = \frac{0.216\,g}{150} = 0.00144\ g/cm^2$
   Number of moles per $cm^2 = \frac{0.00144\,g}{107\,g/mole} = 1.345 \times 10^{-5}\ mole$
   Number of atoms per $cm^2 = 1.345 \times 10^{-5} \times 6.02 \times 10^{23} = 8.1 \times 10^{18}\ atoms$

4. (a) $Zn\ (s) + H_2SO_4\ (aq) \rightarrow ZnSO_4\ (aq) + H_2\ (g)$
   (b) Filter the mixture to remove unreacted solid particles.
   Heat without boiling and evaporate the solution to about a fifth of its original volume.
   Allow the concentrate solution to cool until crystals form.

5. (i) Empirical formula of the compound:

C		H		Cl
$\frac{24.27}{12}$	:	$\frac{4.07}{1}$	:	$\frac{71.65}{35.5}$
2.0225	:	4.07	:	2.018

$$\frac{2.0225}{2.018} : \frac{4.07}{2.018} : \frac{2.018}{2.018}$$

1 : 2 : 1

Empirical formula is CH_2Cl

(ii) Molecular formula of the compound:

$(CH_2Cl)\ n = 99$

$(12 + 2 + 35.5)n = 99$

$49.5\ n = 99$

$n = 2$

Molecular formula is $C_2H_4Cl_2$

6. (a) 2 ways you can use to avoid pollution of water are:
   Avoid releasing industrial liquid wastes in water bodies.
   Avoid overuse of fertilizers.
   Do not throw any forms of litter down the drain.
   (b) 2 effects of polluted water to humans are:
   Aquatic animals are killed by polluted water.
   Polluted water causes many diseases to humans.

7. (a) 2 physical or chemical properties of metalloids:
   Metalloids have relatively good electrical conductivity.
   Metalloids are luster in appearance and brittle in hardness.
   (b) 2 important uses of silicon are:
   Used as semi-conductor materials in electric devices such as radios.
   It is used in making diodes and transistors.

8. (a) (i) The molecular formula of ethanol is C_2H_5OH or CH_3CH_2OH
   (ii) One use of ethanol:
   Ethanol is used as a disinfectant to kill germs.
   Ethanol is used as an organic solvent.
   (b) Biogas is used to cook food in kitchens so that cutting of trees is reduced which results in the protection of the environment against global warming.

9. (a) At cathode: $Al^{3+}(aq) + 3e^- \rightarrow Al(s)$
   (b) Aluminium is used to make electrical cables.
   Aluminium is used in making packaging materials.

10. (a) Conditions necessary for rusting:

Presence of water.
Presence of oxygen.

Formula: $Fe_2O_3.nH_2O$

(b) 2 means that can be used to prevent rusting:
- Painting
- Electroplating
- Oiling
- Galvanizing
- Manufacture of alloys by adding various substances to iron such as carbon and manganese to make steel.

11. (a) Electric conductivity of graphite.
(b) Diamond is hard
Covalent bonding with a giant structure.

12. (a) **2 conditions:**
Increase of the surface area of $CaCO_3$ by crushing it into powder.
Increase of the concentration of HCl.
Shaking.
(b) **One important use of:**
(i) Calcium carbonate: to make chalk.
(ii) Calcium oxide: neutralize acidity of soil.

13. I can put a magnet in the mixture to remove iron debris, then warn the mixture to evaporate water from solution.

14. (a) The charcoal stove consumes oxygen and emits carbon monoxide in the house. When the concentration of carbon monoxide increases, people die of suffocation. Carbon monoxide binds with haemoglobin irreversibly and prevents it from transporting oxygen.
(b) Biodegradable solid wastes can be disposed in domestic composts and produce fertilizers after decay.

15. (a) $2Mg + CO_2 \rightarrow 2MgO + C$
(b) 2 observable change:
The solid magnesium becomes a white ash.
There is formation of black solid powder particles of carbon.

Section B: Answer only 3 questions

16. (a) X = H_2SO_4

(b) $2MnO_4^- + 10\ Cl^- + 16H^+ \rightarrow 2Mn^{2+} + 5Cl_2 + 8H_2O$

Or $2KMnO_4 + 16\ HCl \rightarrow 2KCl + 5Cl_2 + 8H_2O + 2MnCl_2$

(c) The colour changes from purple to brown then brown to colourless as the reaction proceed to completion. Or greenish gas is evolved.

(d) Blow chlorine gas on a moist blue litmus paper, the litmus change to red colour then bleached or wet litmus paper is bleached.

(e) Chlorine is used in killing bacteria in water treatment.

(f) $6KOH + 3Cl_2 \rightarrow KClO_3 + 5KCl + 3\ H_2O$

(g) $KClO_3$ is used to produce oxygen gas.

17. (a) Colour of the indicator in the base.

Phenolphtalein: Pink

Methyl orange : Yellow

Litmus paper : Blue

(b) Number of moles of Na_2CO_3 = M X V = 0.1 mole.dm^{-3} X 0.025 dm^3

= 0.0025 mole

(c) Number of moles of HCl = 0.0025 mole X 2 = 0.005 mole.

(d) Molarity of HCl $= \frac{n}{V} = \frac{0.005\ mole}{0.0275\ dm^3} = 0.1818\ mole/dm^3$

(e) Mass of Na_2CO_3 = n X Mm

Mm of Na_2CO_3 = 23 X 2 + 12 + 16 X 3 = 106 g/mole

Mass of Na_2CO_3 = n X Mm = 0.0025 mole X 106 g/mole = 0.265 g

18. (a) (i) Empirical formula of the compound X:

C		H		O
$\frac{40}{12}$	:	$\frac{6.72}{1}$	:	$\frac{53.28}{16}$
3.33	:	6.77	:	3.33
$\frac{3.33}{3.33}$	:	$\frac{6.77}{3.33}$	:	$\frac{3.33}{3.33}$
1	:	2	:	1

Empirical formula is CH_2O

(ii) Molecular formula of the compound:

(CH_2O) n = 180

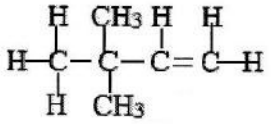
$(12 + 2 + 16)n = 180$

$30\ n = 180$

$n = 6$

Molecular formula is $C_6H_{12}O_6$

(b)



(c) 4 – methylpentan-2-ol

(d) 2 sources of alcohols:

Fermentation of simple sugars

From hydrolysis of alkenes.

19. (a) H^+, OH^-, Cu^{2+}, SO_4^{2-}

(b) (i) Anode: $Cu\ (s) \rightarrow Cu^{2+}\ (aq)$

(ii) Cathode: $Cu^{2+} + 2e^- \rightarrow Cu\ (s)$

(c) H_2O and O_2

(d) Refining of copper

Production of oxygen

Electroplating

(e) (i) The blue copper sulphate turns pale green (brown).

There is deposition of brown solid on the bottom of the test tube.

(ii) $Fe\ (s) + Cu^{2+}\ (aq) \rightarrow Fe^{2+}\ (aq) + Cu\ (s)$

Or $2Fe\ (s) + 3Cu^{2+}\ (aq) \rightarrow 2Fe^{3+}\ (aq) + 3Cu\ (s)$

20. (a) $Pb < Fe < Zn < Mg$ or $Mg > Zn > Fe > Pb$

(b) $Fe_2O_3 + 3Zn \rightarrow 3ZnO + 2Fe$

(c) White $ZnCO_3$ disappears

Or no bubbles of CO_2 are observed.

(d) **Reagent:** NH_3

Observation: Formation of white precipitate that disappears in excess and turns to a colourless solution.

(e) Aluminium is not heavy (light) because it has a low atomic mass. Or Aluminium is strong, hard and resists corrosion.

SECTION C: ATTEMPT ONLY ONE QUESTION

21.(a) Polymerization is a chemical reaction in which a compound called polymer is made by the addition or condensation of smaller molecules called monomers.

(b) Used in the making of pipes and plastic bags

Used in the production of clothes

Used in the production of insulating materials

(c) By fractional distillation based on different boiling points of the components.

(d) $HCOOH + KOH \rightarrow HCOOK + H_2O$

(e) The cow dung decomposes to produce methane gas and as a result money used to buy charcoal is saved.

The remaining of solid material become manure for fertilizing the soil for better plant growth.

The substitution of wood and charcoal by methane gas helps to preserve the environment in many ways.

(f) Alkanes are more stable than alkenes.

Alkanes have simple bonds while alkenes have double bonds.

(g) Number of moles of $CH_4 = \frac{m}{Mm} = \frac{4.2\ g}{(12+1\times4)\ g/mole} = \frac{4.2\ g}{16\ g/mole} = 0.2652\ mole$

V = n X Vo = 0.2652 mole X 24 dm^3/mole = 6.3 dm^3 at 298 K and 760 mmHg

V of CH_4 at 318 K and 1520 mmHg

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

$$\frac{760\times6.3}{298} = \frac{1520\times V_2}{318}$$

$$V_2 = \frac{760\times6.3\times318}{298\times1520} = 3.361\ dm^3$$

22.(a) Graham's law of diffusion of gases: under similar conditions of temperature and pressure, the rate of diffusion of gases are inversely proportional p to the square root of their densities.

(b) Rate of diffusion of O_2 be rate 1

Rate of diffusion of CO_2 be rate 2

$$\frac{Rate\ 1}{Rate\ 2} = \frac{1}{\sqrt{16}} \times \frac{\sqrt{22}}{1}$$

$$\frac{\frac{x}{100}}{\frac{25}{75}} = \frac{\sqrt{22}}{\sqrt{16}}$$

$$x = 39\ cm^3$$

(c) The volume of a given mass of gas is directly proportional to its temperature provided the pressure is constant.

(d) The volume of a given mass of gas is inversely proportional to the pressure applied to it provided the temperature is constant.

(e)

(i) $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$

$$\frac{1500 \times 700}{290} = \frac{760 \times V_2}{273}$$

$$V_2 = 1300\ cm^3$$

(ii) $n = \frac{V}{V_0} = \frac{1300\ cm^3}{22400\ cm^3} = 0.058\ mole$

(f) The pressure of gases in vehicles tyres results in the support of the weight of the vehicles.

When the vehicles shakes during motion, the weight fluctuates and the gas can compress a little bit and thus enable comfort during the motion.

Chemistry I

002

27/07/2021 08.30 AM – 11.30 AM

NESA NATIONAL EXAMINATION AND SCHOOL INSPECTION AUTHORITY

ORDINARY LEVEL NATIONAL EXAMINATIONS, 2020-2021

SUBJECT: CHEMISTRY I

DURATION: 3 HOURS

INSTRUCTIONS:

1) Write your names and index number on the answer booklet as they appear on your registration form, and **DO NOT** write your names and index number on additional answer sheets of paper if provided.
2) Do not open this paper until you are told to do so.
3) This paper consists of **three** sections **A**, **B** and **C**
   - **SECTION A**: Attempt **ALL** questions. **(55 marks)**
   - **SECTION B:** Attempt any **THREE** questions. **(30 marks)**
   - **SECTION C:** Attempt only **one** question. **(15 marks)**
4) You do not need the periodic Table.
5) Silent non-programmable calculators may be used.
6) Use only a **blue** or **black pen**.

SECTION A: Attempt all questions from this section. (55 marks)

1. Hydrated iron sulphate, $FeSO_4.7H_2O$ undergoes decomposition when heated to form iron sulphate and water. When heated further, the $FeSO_4$ decomposes to form Fe_2O_3, sulphur dioxide and sulphur trioxide.
   a) Write a balanced chemical equation for the thermal decomposition of $FeSO_4$. **(2 marks)**
   b) State the colour changes that occur when $FeSO_4.7H_2O$ decomposes to $FeSO_4$ then Fe_2O_3. **(3 marks)**

2. A student uses 100 cm^3 of a 0.2 $mole.dm^{-3}$ sodium hydroxide solution to react with excess sulphuric acid.
   (a) Calculate the number of moles of NaOH contained in 100 cm^3 of solution. **(2 marks)**
   (b) Calculate the mass of sodium sulphate crystals that are formed after evaporation of the resultant solution. . **(2 marks)**
   Equation: H_2SO_4 (aq) + 2NaOH (aq) → Na_2SO_4 (aq) + $2H_2O$ (aq)
   (Atomic mass: Na = 23, S = 32, O = 16, H =1)

3. a) Sodium sulphate crystals are obtained by reacting H_2SO_4(aq), with 2NaOH(aq). Using appropriate reagents or other means, describe a method that can be used to test (identify) the sulphate ions in Na_2SO_4 indicating the observations for a positive test. **(2 marks)**
   b) Pure oxygen for industrial use can be obtained from atmospheric air. State one use of oxygen in industry and one of its uses for medical purposes. **(2 marks)**

4. In the upper atmosphere, there is a layer of ozone surrounding the earth.
   (a) Explain the importance of this layer in terms of human health. **(2 marks)**
   (b) State the type of chemical substances that destroy the ozone layer. **(1 mark)**

5. Aluminium is a metal of group IIIa of the periodic table.
   (a) Using Bohr model of the representation of electrons on shells, draw the structure of aluminium atom. **(2 marks)**
   (b) Write a balanced equation of the reaction that takes place when aluminium reacts with sulphur (S). **(2 marks)**
   (Atomic number of Al = 13, S = 16).

6. Sodium atom loses 1 electron and sulphur accepts 2 electrons to form ions.
   (a) Deduce the chemical formula of the compound formed between sodium and sulphur. **(2 marks)**
   (b) Discuss the socio-economic importance of sodium compounds in our society. (Atomic number: Na = 11, S = 16) **(2 marks)**

7. When calcium reacts with water, hydrogen gas is evolved and an alkaline solution is formed.
   (a) Write the equation of reaction between calcium and water; include state symbols. **(2 marks)**
   (b) Explain effects of acid rain to buildings and monuments which are constructed in calcium carbonate compounds. **(2 marks)**

8. Magnesium is an alkaline earth metal; copper is a transition element.
   a) Explain why copper is preferred to be used in coating (cover) monetary coins rather than magnesium. **(2 marks)**
   b) Write a balanced chemical equation of combustion of magnesium in oxygen gas. **(2 marks)**

9. In an experiment, CO_2 gas was dissolved in a test tube of cold water; blue and red litmus papers were put in the resultant mixture.
   (a) Indicate the litmus paper that changed colour. **(1 mark)**
   (b) State 2 uses of CO_2 gas by man on a large scale. **(2 marks)**

10. State a reagent that you would use to differentiate between each of the pair of compounds and give an observable change for a positive test:
    a) Sodium nitrate, $NaNO_3$ and sodium a chloride, NaCl. **(2 marks)**
    b) Zinc II nitrate $Zn(NO_3)_2$ and aluminium III nitrate $Al(NO_3)_3$. **(2 marks)**

11. Alkanes are members of a homologous series of saturated hydrocarbons with the general formula C_nH_{2n+2}.
    (a) Write the chemical equation of reaction for the combustion of an alkane with 5 carbon atoms. **(2 marks)**
    (b) Write a chemical equation for the combustion of C_3H_8 in excess oxygen. **(2 marks)**

12. Silicon dioxide has a similar structure to diamond.
    (a) Suggest the reason why silicon dioxide does not conduct electricity. **(2 marks)**
    (b) Give 2 uses of diamond on a large scale. **(2 marks)**

13. A gas of known identity as X diffuses at a rate of 83.3 ml/second in a diffusion apparatus in which carbon dioxide diffuses at a rate of 102 ml/second. Calculate the molecular mass of gas X. **(4 marks)**
    (Molar mass: CO_2 = 44 g/mole)

14. a) Write two uses of strong acids. **(2 marks)**
    b) Give the difference between a strong base and a weak base. **(2 marks)**

SECTION B: Attempt only three questions **(30 marks)**

15. a) It takes 243 seconds for 4.46 $x10^{-5}$ mole of Xenon (Xe) to diffuse through a tiny hole. What time will it take 4.46 x 10^{-5} mole of Neon (Ne) to diffuse through the hole under the same conditions? **(4 marks)**

b) Two cotton plugs, one moistened with NH_3 and another with HCl are simultaneously inserted into opposite ends of a glass tube that is 87dm length, a white ring of NH_4Cl forms where gaseous NH_3 and gaseous HCl first meet (come into contact). It takes 80 seconds for NH_3 gas to move distance Y, HCl gas moves in this distance Y in 117.2 seconds.
(Molar mass: NH_3 = 17 g/mole, HCl = 36.5 g/mole)

(i) Determine how much faster NH_3 diffuses than HCl (percentage rate of NH_3 to the rate of HCl). **(1 mark)**
(ii) Calculate the distance travelled by NH_3 gas to meet HCl gas. **(5 marks)**

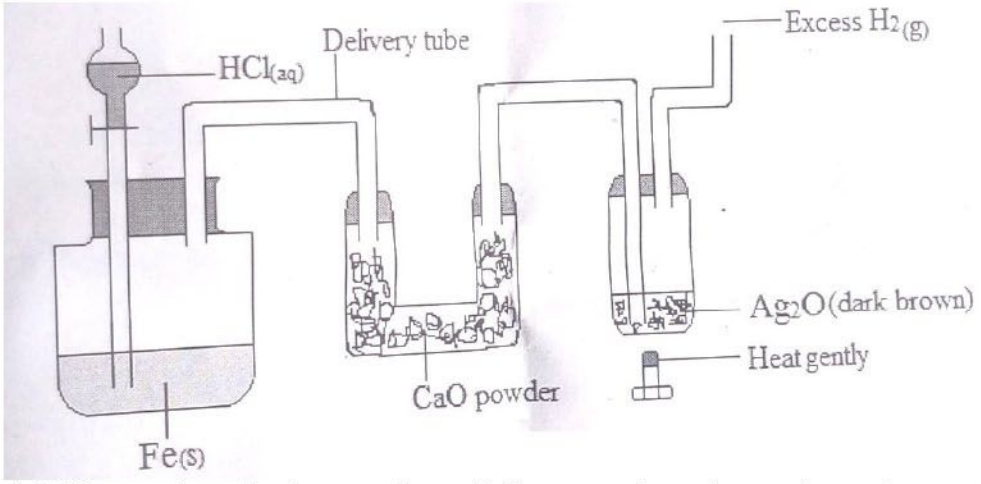
16. A student added 8.0 g of magnesium to an excess of a 0.5 $mol.dm^{-3}$ sulphuric acid solution to react in a container.
(a) Calculate the number of moles contained in 8.0 g of magnesium. **(2 marks)**
(b) Calculate the maximum volume of sulphuric acid that reacted with all the 8.0 g of magnesium. (Atomic mass, Mg= 24). **(2 marks)**
Equation of reaction: $Mg\ (s) + H_2SO_4\ (aq) \rightarrow MgSO_4\ (aq) + H_2\ (g)$

c) A hydrated zinc sulphate; $ZnSO_4XH_2O$ contained 56.09% of $ZnSO_4$ by mass. Determine the value of X in the equation (X = number of moles of water of crystallization). **(4 marks)**
(Atomic mass: Zn = 65, S = 32, O = 16, H = 1)

d) Write a chemical ionic equation for the reaction between Zn^{2+} ions and OH^- ions in aqueous solution using:
(i) Little of OH^- solution. **(1 mark)**
(ii) Excess of OH^- solution. **(1 mark)**

17. a) Write a chemical equation of the reaction between aluminium and water. **(2 marks)**
b) Explain why aluminium metal is used to make overhead electric cables on streets. **(2 marks)**
c) Aluminium reacts with chlorine according to the following equation:
$2\ Al + 3Cl_2 \rightarrow 2AlCl_3$
(i) Calculate the mass of $AlCl_3$ produced when 5.4 g of aluminium reacts completely with excess chlorine. **(3 marks)**
(ii) Calculate the volume of Cl_2 gas required to react with 5.4 g of aluminium at room temperature and pressure. **(3 marks)**
(1 mole of a gas occupies $24dm^3$ at room temperature and pressure, atomic mass of Al = 27. Atomic mass of Cl = 35.5 g/mol).

18. Silver oxide, Ag_2O can be reduced by hydrogen gas H_2; study the set up diagram below and answer the questions that follow:



a) Write a chemical equation of the reaction that takes place when Silver oxide reacts with hydrogen gas. **(2 marks)**

b) Explain why hydrogen gas reduces silver oxide but cannot reduce zinc oxide. **(2 marks)**

c) State the role of CaO powder in the tube. **(1 mark)**

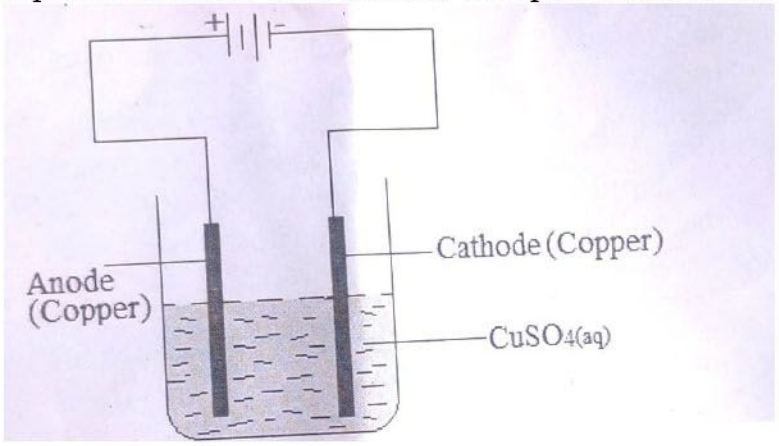
d) Fe reacts with dilute HCl to produce H_2.

(i) State the method of collection of H_2 gas in the above apparatus set up. **(1 mark)**

(ii) Indicate one test for the excess H_2 gas and give the observation for a positive test. **(2 marks)**

e) Zinc oxide can be reduced by carbon on heating. Write a chemical equation of the reaction between ZnO and C. **(2 marks)**

19. Study the set-up diagram below for the electrolysis of aqueous copper sulphate solution and answer the questions that follow:



a) Write a chemical equation for the reaction that takes place at the:

(i) Anode **(1.5 marks)**

(ii) Cathode. **(1.5 marks)**

b) Describe the observable changes on the volume of both electrodes as the reaction proceeds. **(2 marks)**

c) Indicate the direction of flow of electrons in the external circuit. **(1 mark)**

d) Suggest one application of copper sulphate electrolysis on a large scale. **(1 mark)**

e) Describe what would happen to the reaction in the beaker of $CuSO_4$ electrolyte if copper electrodes were replaced by carbon electrodes. **(3 marks)**

SECTION C: Attempt only one question (15 marks)

20. A 0.095 g of impure sample of K_2CO_3 is dissolved in enough water to make 20 ml of solution **X**. The 20.0 ml of solution **X** is put into an Erlenmeyer flask and 20 ml of a 0.17 mole/litre HCl id added.
The resulting solution is titrated against a 0.1048 mole/litre NaOH solution using phenolphthalein indicator.
The volume of NaOH required to neutralize excess HCl is 24.16 ml.
Equations:
Preparation of solution X:
$K_2CO_{3\,(aq)} + 2HCl_{(aq)} \rightarrow 2KCl_{(aq)} + CO_{2(g)} + H_2O_{(l)}$
During titration: $HCl_{(aq)} + NaOH_{(aq)} \rightarrow NaCl_{(aq)} + H_20_{(l)}$

a) State the colour change of phenolphthalein indicator in the flask solution when the end-point of titration is reached. **(1 mark)**

b) Calculate the number of moles of NaOH in 24.16ml. **(2 marks)**

c) Calculate the number of moles of HCl that react with NaOH in the flask. **(2 marks)**

d) Calculate the number of moles of HCl (0.17 mole/litre) in 20.0 ml. **(2 marks)**

e) Deduce the number of moles of HCl that react with K_2CO_3. **(1 mark)**

f) Calculate the number of moles of K_2CO_3 present in 0.048 g of sample. **(2 marks)**

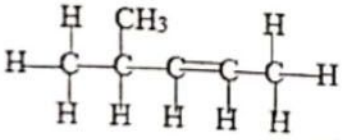
g) Calculate the actual mass of K_2CO_3 in 0.095 g of impure sample. **(2 marks)**

h) Calculate the percentage composition by mass of K_2CO_3 in 0.095 g impure sample. **(3 marks)**

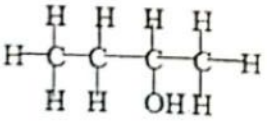
(Atomic mass: K = 39, C = 12, O = 16)

21. a) Give the names of the following compounds: **(2 marks)**

(i)



(ii)



b) State 2 physical properties of alcohols. **(1 mark)**

c) Write a balanced chemical equation for:

(i) Combustion of $CH_3CH_2CH_2OH$ in enough oxygen. **(2 marks)**

(ii) Oxidation of CH_3CH_2OH by $K_2Cr_2O_7$ in acidic (H_2SO_4) medium. **(2 marks)**

d) State 2 uses of alcohols on a large scale. **(2 marks)**

e) Describe two health hazards caused by drinking too much alcohol. **(4 marks)**

f) Explain why alcohols are not used so often as fuel in vehicle engines as much as alkanes. **(2 marks)**

MARKING SCHEME OF ORDINARY LEVEL CHEMISTRY NATIONAL EXAMINATION 2020-2021

SECTION A: Answer all questions

1. a) $2FeSO_4 \xrightarrow{\Delta} Fe_2O_3 + SO_2 + SO_3$

   b) When hydrated iron (II) sulphate is gently heated, it decomposes to give a white greenish powder of anhydrous iron (II) sulphate and droplets of a colourless liquid collect on the cooler parts of the test tube.
   On further heating the anhydrous iron (II) sulphate decomposes to give a brown powder of iron (III) oxide which is formed together with a mixture of sulphur trioxide and sulphur dioxide gases.

2. (a) Number of moles = M X V
   V = 100 cm^3 = 0.1 dm^3
   Number of moles = 0.2 mole.dm^{-3} X 0.1 dm^3 = 0.02 mole.
   (b) H_2SO_4 (aq) + 2NaOH (aq) → Na_2SO_4 (aq) + $2H_20$ (l)
   Number of moles of Na_2SO_4 that are formed from NaOH
   = 0.02 mole / 2 = 0.01 mole.
   Mass of Na_2SO_4 = n X Mm
   Molar mass of Na_2SO_4 = (23 X 2) + 32 + (16 X 4) = 142 g/mole
   M = 142 g/mole X 0.01 mole = 1.42 g

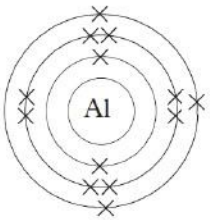
3. a) Sulphate ions are tested by adding 3 drops of barium nitrate followed by few drops of dilute nitric acid in excess.

   Observation: A **white precipitate of barium sulphate** forms which **does not dissolve in excess of dilute nitric acid**.
   $Ba^{2+}_{(aq)} + SO_4^{2-}{}_{(aq)} \rightarrow BaSO_{4\ (s)}$

   b) **Industrial use of oxygen:** oxygen is used in oxy-acetylene for welding and cutting metals. This flame has very high temperature which enables it to melt and cut metals.
   Medical use of oxygen: industrially manufactured oxygen is used as a respiratory aid in places where natural supply of oxygen is insufficient. For example in: Hospitals by patients with breathing difficulties and also when an anaesthetic is being administered to patients.

4. (a) Ozone layer absorbs ultraviolet light of the sun and prevent them from arriving on the earth to cause cancer in humans.
   (b) Chlorofluorocarbons (organic products) destroy the ozone layer.

5. (a)



(b) $Al + S \rightarrow Al_2S_3$

6. a) Na_2S
   b) Sodium chloride is used as table salt.
   Sodium chloride is used in the manufacture of sodium carbonate by Solvay process, manufacture of soap, as a food preservative among other uses.
   Sodium hydroxide is used in the manufacture of soap.

7. a) $Ca_{(s)} + H_2O_{(l)} \rightarrow Ca(OH)_{2\ (aq)} + H_{2\ (g)}$
   b) Acid rain destroys the buildings and monuments which are constructed in calcium carbonate compounds. Acid reacts with carbonates to form a salt, carbon dioxide and water.

8. a) Copper is preferred to be used in coating (cover) monetary coins rather than magnesium because **copper is less oxidised in air** while magnesium does. **Copper is also harder than magnesium and hence it is less corrosive**.

   b) $2Mg + O_2 \rightarrow 2MgO$

9. (a) The blue litmus paper turned red.
   (b) 2 uses of CO_2 by man on a large scale:
   - Carbon dioxide is used in **the manufacture of sodium carbonate used in baking of cakes and bread among others**. It is also an ingredient in some health salts to relieve constipation.
   - Carbon dioxide is used **as preservative** in the production of mineral water and carbonated drinks like coca-cola (also called aerated or effervescence drinks).
   - Solid carbon dioxide commonly known as **dry ice** is a preferred **refrigerant** to ordinary ice (solid water).
   - Carbon dioxide is used in **fire extinguishers**.

10. a)

Compound	NaCl	$NaNO_3$
Test	Add dilute nitric acid then followed by ammonia solution	Add freshly prepared Iron (ii) sulphate followed by concentrated sulphuric acid carefully down the side of the test tube
Observation	**Formation of a white precipitate formed which dissolves** in ammonia solution to give a colourless solution.	A **brown ring** forms at the interface of two layers

b)

Compound	$Zn(NO_3)_2$	$Al(NO_3)_3$
Test	(i) To the first part add sodium hydroxide solution dropwise until in excess. (ii) To the second part add ammonia solution dropwise until in excess.	Add litmus solution and then aq. NH_3 until alkaline.
Observation	Formation of a **white precipitate soluble in excess ammonia and sodium hydroxide solution** to give a colourless solution.	The dye is taken up by the **precipitate which is coloured blue**.

11. a) $C_5H_{12} + 8O_2 \rightarrow 5CO_2 + 6H_2O$ + Energy
    b) $C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$ + Energy

12. a) Silicon dioxide forms a giant structure with covalent bonds. There are no mobile electrons in the structure.
    b) Uses of diamond on a large scale:
    - Because of its **hardness, it is used for making drill tips** used when drilling or cutting metals.
    - It is also used **to make glass cutters**.
    - Used in **making jewellery** due to its beautiful sparkling radiance and lustre.

13. V_1 = 83.3 ml/second; M_1 = ?

V_2 = 102 ml/second; M_2 = 44 g/mole

$$\frac{V_1}{V_2} = \sqrt{\frac{M_2}{M_1}}$$

$$\frac{83.3}{102} = \sqrt{\frac{44}{M_1}}$$

$$0.8166 = \sqrt{\frac{44}{M_1}}$$

$$0.6669 = \frac{44}{M_1}$$

$$M_1 = \frac{44}{0.6669} = 65.9 \cong 66\ g/mole$$

14. a) Two uses of strong acids:
They can be used as electrolytes.
Hydrochloric acid is produced in the human stomach. It is used to aid in the process of digestion.
Sulphuric acid is used in car batteries, manufacture of plastics, pesticides, detergents and pharmaceutical products. It is also used in the manufacturing of some fertilisers.

b) **A strong electrolyte** is an electrolyte which is completely ionised in water and thus produces a large amount of ions. For example, hydrochloric acid, nitric acid and sulphuric acid.
A weak electrolyte is an electrolyte which is partially ionised in water and thus produces a small amount of ions. For example, acetic acid and carbonic acid.

Section B: Answer only 3 questions

15. a) Rate of diffusion $= \frac{Amount\ gas\ transferred}{Time}$

Graham's law:

$$\frac{Rate\ of\ diffusion\ Xe}{Rate\ of\ diffusion\ of\ gas\ Ne} = \frac{\sqrt{M_{Ne}}}{\sqrt{M_{Xe}}}$$

$$\frac{Time\ for\ Ne}{243\ s} = \sqrt{\frac{20.2}{131.3}}$$

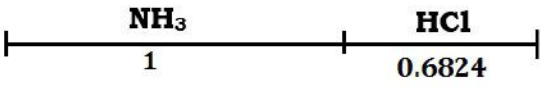
$$Time\ for\ Ne = 243 \times \sqrt{\frac{20.2}{131.3}} = 95.3$$

b) ii) $\frac{Rate\ of\ diffusion\ of\ gas\ HCl}{Rate\ of\ diffusion\ of\ gas\ NH_3} = \sqrt{\frac{M_{NH_3}}{M_{HCl}}}$

$$\frac{Rate\ of\ diffusion\ of\ gas\ HCl}{Rate\ of\ diffusion\ of\ gas\ NH_3} = \sqrt{\frac{17}{36.5}} = \sqrt{0.4657} = 0.6824$$

This means that if NH_3 move a distance equal to 1, HCl will move a distance equal to 0.6824.

i)



Total = 1.6824

16. a) Number of moles of Magnesium is $n = \frac{m}{Mm} = \frac{8.0\ g}{24\ g/mole} = \frac{1}{3} = 0.333\ mole$

b) Mg (s) + H_2SO_4 (aq) → $MgSO_4$ (aq) + H_2 (g)
1 mole of Mg reacts with 1 mole of H_2SO_4
0.333 mole of Mg will react with 0.333 mole of H_2SO_4
$M = \frac{n}{V}$

$V = \frac{n}{M} = \frac{0.333\ mole}{0.5\ mole.dm^{-3}} = 0.1665\ dm^3 = 166.5\ cm^3$

c) Mm of $ZnSO_4$ = 65 +32 + 16 x 4 = 161 g/mole

Mm of H_2O = 16 + 1 x 2 = 18 g/mole

Percentage of $ZnSO_4$ = 56.08 %

Percentage of H_2O = 43.92 %

Number of moles $ZnSO_4$ is $n = \frac{56.08}{65} = 0.86\ mole$

Number of moles H_2O is $n = \frac{43.92}{18} = 2.44\ mole$

Divide by the smallest number

Number of moles $ZnSO_4$ is $n = \frac{0.86}{0.86} = 1$

Number of moles H_2O is $n = \frac{2.44}{0.86} = 2.82 \cong 3$

The formula of the hydrated zinc sulphate is $ZnSO_4.3H_2O$

d) (i) $Zn^{2+} + 2OH^- \rightarrow Zn(OH)_2$

(ii) $Zn^{2+} + 4OH^- \rightarrow Zn(OH)_4^{2-}$

17. a) $2Al + 3H_2O \rightarrow Al_2O_3 + 3H_2$

b) Aluminium metal is used to make overhead electric cables because it **very ductile** and it is a **very good conductor of heat**.

c) $2Al + 3Cl_2 \rightarrow 2AlCl_3$
(i) Mass of aluminium is m = 5.4 g

Number of moles of aluminium is $n = \frac{m}{Mm} = \frac{5.4g}{27g/mole} = 0.2\ mole$

2 moles of Al produces 2 moles of $AlCl_3$

0.2 moles of Al will produce 0.2 moles of $AlCl_3$

Mm of $AlCl_3$ = 27 + 35.5 x 3 = 27 + 106.5 = 133.5 g/mole

Mass of $AlCl_3$ produced = $m \times Mm = 0.2 \times 133.5 = 26.5\ g$

(ii) Volume of Cl_2 required

2 moles of aluminium react with 3 moles of Cl_2

1 moles of aluminium reacts with 1.5 moles of Cl_2

0.2 mole of aluminium will react with 0.3 mole of Cl_2

Volume of Cl_2 = n x Mv = $0.3\ mole \times 24\ dm^3.mole^{-1} = 7.2\ dm^3$

18. a) $Ag_2O + H_2 \rightarrow 2Ag + H_2O$

b) According to the reactivity series**, hydrogen is more reactive is more reactive than silver,** hence **hydrogen can displace silver from the compound** Ag_2O while **hydrogen is less reactive than zinc**; **hence hydrogen can displace zinc from the compound** ZnO.

c) It is used as **drying hydrogen gas**.

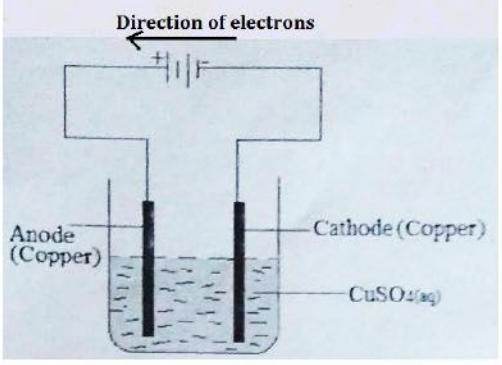
d) (i) The method of collection of hydrogen gas is by **upward delivery**.
(ii) Test: hydrogen gas is tested with **burning splint**.
Observation: Hydrogen produces a **pop sound**.

e) $2ZnO + C \rightarrow 2Zn + CO_2$

19. a) (i) Anode: $Cu_{(s)} \rightarrow Cu^{2+} + 2e^-$
(ii) Cathode: $Cu^{2+} + 2e^- \rightarrow 2Cu_{(s)}$

b) When we electrolyse copper (II) sulphate solution using copper electrodes, the mass of both electrodes change. **The anode loses mass** while the **cathode gains mass**. The loss in mass at the anode is equal to the mass gained at the cathode.

c) Direction of flow of electrons in the external circuit.



d) It is used in electroplating
Refining of metals
Copper plating

e) At the positive electrode: $4OH^-_{(aq)} \rightarrow 2H_20_{(l)} + O_{2(g)} + 4e^-$ (oxidation)

At the negative electrode: $Cu^{2+}_{(aq)} + 2e^- \rightarrow Cu_{(s)}$ (reduction)

As copper ions are being discharged and deposited at the cathode as copper metal, the blue color of the solution fades (disappears slowly).

SECTION C: ATTEMPT ONLY ONE QUESTION

20. a) Phenolphthalein indicator changes from colourless to purple (violet).

b) Number of moles of NaOH in 24.16 ml = M x V
V = 24.16 ml = 0.02416 dm^3
$n = M \times V = 0.1048\, mole.dm^{-3} \times 0.02416\, dm^3 = 0.0025\, mole$

c) Number of moles of HCl that react with NaOH in the flask
$HCl_{(aq)} + NaOH_{(aq)} \rightarrow NaCl_{(aq)} + H_20_{(l)}$
One mole of NaOH reacts with 1 mole of HCl
0.0025 mole of NaOH reacts with 0.0025 mole of HCl

d) The number of moles of HCl (0.17 mole/litre) in 20.0 ml
$= M \times V = 0.17 \frac{mole}{litre} \times 0.02\, litre = 00034\, mole$

e) The number of moles of HCl that react with K_2CO_3
$= 0.0034\, mole - 0.0025\, mole = 0.0009\, mole$

f) Number of moles of K_2CO_3 present in 0.048 g of sample
Mm of K_2CO_3 = 39 x 2 + 12 + 16 x 3 = 138 g/mole
$n = \frac{m}{Mm} = \frac{0.048\, g}{138\, g/mole} = 0.00034\, mole$

g) $K_2CO_{3\,(aq)} + 2HCl_{(aq)} \rightarrow 2KCl_{(aq)} + CO_{2(g)} + H_2O_{(l)}$
2 moles of HCl react with 1 mole of K_2CO_3
0.0009 mole of HCl will react with 0.00045 mole of K_2CO_3
Mass of K_2CO_3 = n x Mm = 0.00045 mole x 138 g/mole = 0.0621 g

h) Percentage composition by mass of K_2CO_3 in 0.095g

$$= \frac{0.061\, g}{0.095\, g} \times 100 = 65.3\,\%$$

21. a) i) 3-methyl-2-butene or 3-methylbut-2-ene
ii) 2-butanol or butan-2-ol

b) Most common **alcohols are colourless liquids**. Alcohols containing more than 10 carbon atoms in their molecules are solids. Lower alcohols have a characteristic odour and burning taste.

Lower alcohols such as methyl alcohol, ethyl alcohol **are soluble in water, completely miscible.** Solubility of alcohols in water decreases with an increase in the number of carbon atoms in the molecule.
Alcohols do not conduct electricity. This is because alcohols are not ionised.
Alcohols have no effect on litmus. Alcohols do not change the colour of litmus. This is because alcohols are neutral compounds.
The boiling points of alcohols increase with an increase in their molecular masses, thus, an alcohol containing larger number of carbon atoms in its molecule has higher boiling point than alcohol containing lesser number of carbon atoms.

c) i) $2CH_3CH_2CH_2OH + 9O_2 \rightarrow 6CO_2 + 8H_2O + \text{Energy}$

ii) $CH_3CH_2OH \xrightarrow{K_2Cr_2O_7/H^+} CH_3CH = O \xrightarrow{K_2Cr_2O_7/H^+} CH_3COOH$

d) Uses of alcohols on a large scale:

- Ethanol is used as a solvent to dissolve substances water cannot. It evaporates easily, so it is used a solvent in glues, printing inks, perfumes and aftershave.
- Alcohols are used as solvents in fuel engines, to make chemicals such as esters among others.
- In some cultures, ethanol produced by fermentation is used for making alcoholic drinks.
- Ethanol is used as an anti-freeze in automobile radiators.
- Ethanol is used as a preservative for biological specimens.
- Ethanol is used as an antiseptic to sterilise wounds in hospitals.

e) **Health hazards caused by drinking too much alcohol**:

- Accidents and bodily injuries
- Violent behaviour or victim of violence
- Having unprotected sex that could lead to unplanned pregnancies and sexually transmitted diseases.
- Loss of personal possessions
- Alcohol poisoning.
- Too much alcohol affects the brain, heart, liver, pancreas and is linked to some types of cancer.

f) Alcohols do not produce as much energy as alkanes and produce much soot than alkanes.

Chemistry I

002

29/07/2022 08.30 AM – 11.30 AM

NESA NATIONAL EXAMINATION AND SCHOOL INSPECTION AUTHORITY

ORDINARY LEVEL NATIONAL EXAMINATIONS, 2021-2022

SUBJECT: CHEMISTRY I

DURATION: 3 HOURS

INSTRUCTIONS:

1) Write your names and index number on the answer booklet as they appear on your registration form, and **DO NOT** write your names and index number on additional answer sheets of paper if provided.
2) Do not open this paper until you are told to do so.
3) This paper consists of **three** sections **A**, **B** and **C**
   - **SECTION A**: Attempt all questions. **(55 marks)**
   - **SECTION B:** Attempt any **three** questions. **(30 marks)**
   - **SECTION C:** This section **is compulsory**. **(15 marks)**
4) **You do not need the periodic Table.**
5) Silent non-programmable calculators may be used.
6) Use only a **blue** or **black pen**.

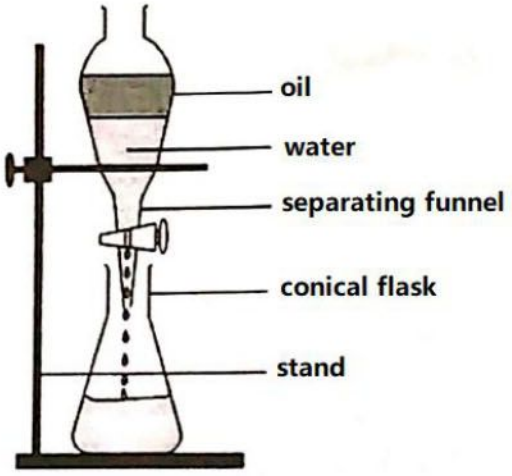
SECTION A: Attempt all questions from this section. (55 marks)

1. a) A student entered a chemistry laboratory and found two solutions which were not labelled. One is known to be acidic and the other alkaline. He/she uses phenolphthalein indicator to test them. State the colour he/she observed:

   (i) In acidic solution. **(1 mark)**
   (ii) In basic solution. **(1 mark)**

   b) List any two rules and regulations that students must follow during an experiment in a chemistry laboratory. **(2 marks)**

2. Study the experimental setup below and answer the questions.



   a) Which type of method for mixture separation does the diagram show? **(1 mark)**
   b) State to which type of mixture the method above in (2 a) can be applied? **(1 mark)**
   c) State why liquid oil forms the upper layer. **(1 mark)**

   d) Give an example of other mixture that can be separated by the same separation technique. **(1 mark)**

3. Air can be liquefied by cooling it cooling it to about – 200˚C. The boiling point of oxygen is – 180˚C and the boiling point of nitrogen is – 196˚C.
   a) When warming liquid air, which substance will boil off first and why? **(2 marks)**
   b) Give one use of nitrogen. **(1 mark)**

   c) Give one industrial use of oxygen. **(1 mark)**

4. The number of protons, neutrons and electrons in particles W, X, Y and Z are shown in the table below.

Substance	Number of Protons	Number of Neutrons	Number of Electrons
W	9	9	10
X	11	11	11
Y	12	12	10
Z	16	17	16

a) Which one(s) of the particles is/are:
i) A cation. **(1 mark)**
ii) An anion. **(1 mark)**
iii) Neutral. **(1 mark)**

b) Write the electronic configuration of X. **(1 mark)**

c) i) State the valency of X. **(1 mark)**
ii) Give a reason for your answer in c)(i). **(1 mark)**

5. Sodium, Aluminium, Carbon and Sulphur can combine with oxygen to form oxides. Copy and complete the following table to show the formula and class (amphoteric, acidic, basic, neutral) of the oxide formed by each of these elements.
(Na: Z = 11, Al: Z = 13, S: Z = 16, C: Z = 12, O: Z = 8)

Element	Formula of oxide	Class of oxide
Sodium		
Aluminium		
Sulphur		
Carbon		

(4 marks)

6. Aluminium is a metal of group IIIa of the periodic table.
a) Using Bohr model of representation of electrons on shells, draw the structure of Aluminium atom. **(1 mark)**

b) Write a balanced chemical equation of a reaction that takes place when aluminium reacts with chlorine. **(2 marks)**
Atomic numbers: Al (Z = 13), Cl (Z = 17)

c) How many grams of Aluminium chloride could be produced from 34g of Aluminium and 39g of chlorine? **(4 marks)**
Relative mass: Al = 27, Cl = 35.5

7. Aluminium metal conducts electricity in both solid and molten states but aluminium chloride conducts electricity in molten state and not in solid state.
a) Explain this statement. **(2 marks)**

b) Which particles are responsible for the conduction of electricity in:
(i) Aluminium? **(1 mark)**

(ii) Aluminium chloride? **(1 mark)**

8. Compare the reactivity of the following atoms:
   a) Magnesium, Mg (Z = 12) and Calcium, Ca (Z = 20) **(3 marks)**

   b) Sulphur, S (Z = 16) and chlorine, Cl (Z = 17) **(3 marks)**

9. Magnesium reacts with chlorine to form magnesium chloride.
   (Atomic number: Mg = 12, Cl = 17)
   Using this reaction, explain how ionic compounds are formed. **(2 marks)**

10. The molecular formula of an organic substance X is C_4H_{10}.
    a) Write down the structural formulae of 2 isomers of substance X and give their chemical names. **(2 marks)**

    b) Write a balanced chemical equation for the reaction of X with chlorine. **(3 marks)**

11. Five steps in an acid-base titration are shown below.

    Step 1 – Slowly add the acid from a burette into a conical flask until the indicator becomes colourless.

    Step 2 – Add thymolphthalein.

    Step 3 – Use a volumetric pipette to add a fixed volume of alkali to a conical flask.

    Step 4 – Read and record the initial volume of acid in the burette.

    Step 5 – Read and record the final volume of acid in the burette.

    a) Choose the letter that illustrates the correct sequencing of acid-base titration. **(1 mark)**
       A) $2 \rightarrow 4 \rightarrow 1 \rightarrow 5 \rightarrow 3$
       B) $3 \rightarrow 2 \rightarrow 4 \rightarrow 1 \rightarrow 5$
       C) $3 \rightarrow 4 \rightarrow 1 \rightarrow 5 \rightarrow 2$
       D) $4 \rightarrow 3 \rightarrow 1 \rightarrow 2 \rightarrow 5$

    b) State the role of thymolphthalein in the titration process. **(1 mark)**

    c) Why do we add the acid from a burette into a conical flask dropwise while approaching the end of the titration? **(1 mark)**

12. A senior three student passed 140 cm^3 of air over heated copper metal until there was no further change. The remaining volume of air was 115 cm^3.
    a) State the main gas in the 115 cm^3 of the remaining air. **(1 mark)**

    b) Why did the volume of air decreases? **(1 mark)**

c) Calculate the percentage by volume of oxygen in the 140 cm^3 of air. **(2 marks)**

d) Is the air used polluted or not? Give a reason. **(2 marks)**

SECTION B: ATTEMPT ONLY THREE (3) QUESTIONS (30 marks)

13. In an experiment, ammonia gas was prepared by heating ammonium chloride (NH_4Cl) with Calcium hydroxide [$Ca(OH)_2$]. After drying, 120 cm^3 of ammonia gas were collected at room temperature and pressure.

a) Is Calcium hydroxide a base or an acid? Justify your answer. **(2 marks)**

b) Ammonia gas is dried using calcium oxide and not concentrated sulphuric acid. Explain. **(2 marks)**

c) Write a chemical equation of the reaction between Calcium hydroxide and ammonium chloride. **(2 marks)**

d) Calculate the mass of ammonium chloride required to produce 120 cm^3 of ammonia. (RAM: N = 14, H = 1, Cl = 35.5, molar gas volume = 22.4 dm^3 per mole). **(2 marks)**

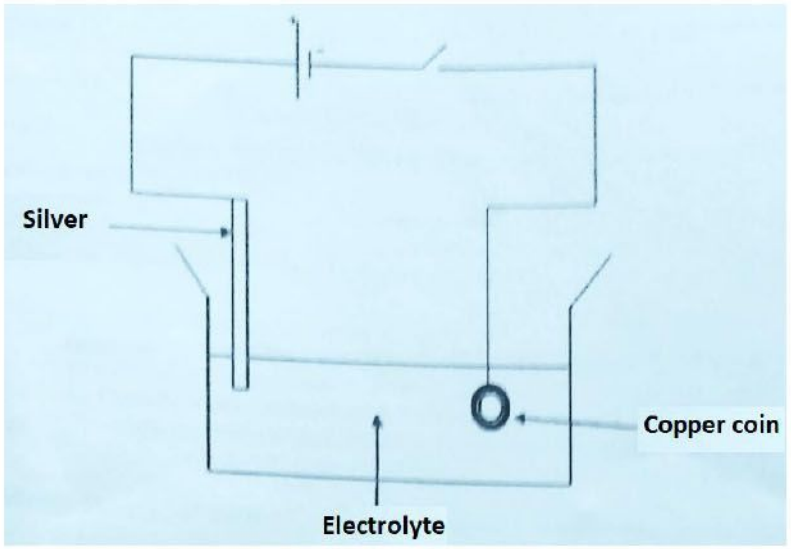
e) The solubility of calcium chloride salt at 30°C is 40, what amount of water is required to make a saturated solution of 80g of solute? **(2 marks)**

14. a) Burning is one way of managing wastes. Discuss 3 negative impacts of this practice on the environment. **(3 marks)**

c) Outline 3 dangers of materials that do not rot when dumped. **(3 marks)**

c) **Reuse, Recycling, Disposal** and **Minimization** are the steps of effective waste management. Discuss these 4 steps. **(4 marks)**

15. Study the diagram below and answer the questions that follow:



a) Name a suitable electrolyte that could have been used. **(1 mark)**

b) What name is given to the negative electrode? **(1 mark)**

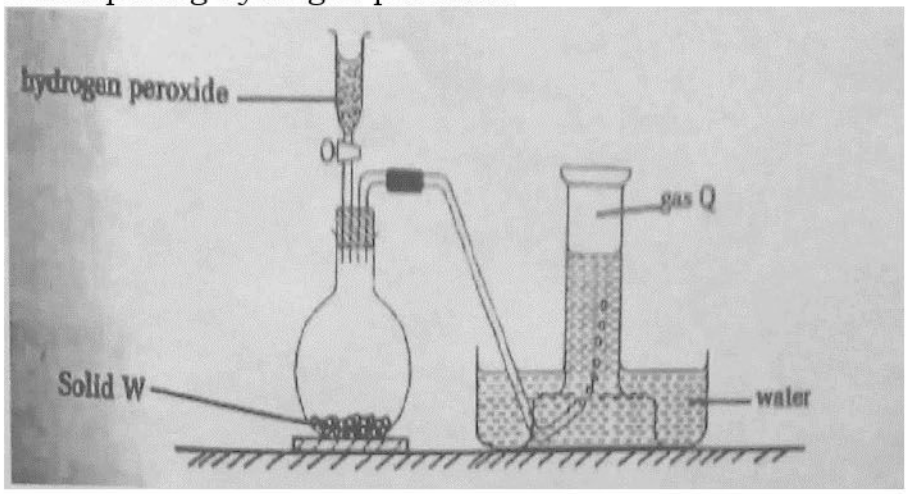
c) Give an ionic equation for the reaction which occurred on the surface of the copper coin. **(2 marks)**

d) What happened to the mass of the silver electrode? Explain your answer. **(2 marks)**

e) State the name of particles responsible for conduction of electricity in:
(i) The electrolyte. **(1 mark)**
(ii) The external wire connecting the electrodes. **(1 mark)**

f) The original mass of the copper coin used was **12.8 g**. Calculate the number of moles of copper in the coin. (Cu = 64) **(2 marks)**

16. Study the diagram representing the preparation and collection of gas Q by decomposing hydrogen peroxide.



a) Identify W and Q. **(2 marks)**

b) Give the chemical equations of decomposition of hydrogen peroxide, including states of the reactants in the flask. **(2 marks)**

c) Write the chemical equation when:

(i) Burning Sulphur in gas Q. **(1 mark)**

(ii) Burning magnesium in gas Q. **(1 mark)**

(iii) The products in (c) (i) and (c) (ii) were dissolved separately in water and the resulting solution tested with litmus solution. Determine the colour change of litmus solution in each solution. **(2 marks)**

(iv) Explain the reasons of that change in colour in (c) (iii) with a chemical equation. **(2 marks)**

SECTION C: THIS QUESTION IS COMPULSORY (15 marks)

17. A sample of air was bubbled into two wash bottles containing soda lime and concentrated sulphuric acid respectively, and finely collected in a gas syringe.

a) (i) State the role of soda lime in this experimental set up. **(1 mark)**

(ii) Suggest a reason for passing the air sample through concentrated sulphuric acid. **(1 mark)**

b) $80cm^3$ of the gas was collected in the syringe and it was passed over heated copper fillings in a combustion tube very many times until no further change occurred. On cooling to initial temperature, the volume of the gas did reduce to $63.2cm^3$.

(i) State what was observed in the combustion tube. **(1 mark)**

(ii) What is the purpose of copper fillings? **(1 mark)**

(iii) Calculate the volume change of the gas in the syringe. **(1 mark)**

(iv) Determine the percentage change in the volume of the gas. **(2 marks)**

c) What is the composition of residual gas in the syringe? **(1 mark)**

d) 20 grams of sulphur burn completely in air to form Sulfur Dioxide.

(i) Write the chemical equation of combustion reaction of Sulfur. **(1 mark)**

(ii) State the limiting reactant. Support your answer. **(2 marks)**

(iii) Calculate the mass of SO_2 produced. **(2 marks)**

(iv) Explain how dioxide produced by burning Sulfur, can pollute atmospheric air. (Equation not required). **(2 marks)**

MARKING SCHEME OF ORDINARY LEVEL CHEMISTRY NATIONAL EXAMINATION 2021-2022

SECTION A: Answer all questions

1) a)
   (i) In acidic solution: the solution becomes colourless.
   (ii) In basic solution: the solution turns pink.

   b) Students must know and understand the procedure before starting the experiment.
   Always use small amounts of chemicals.
   Clean all the apparatus before leaving the experiment.

2)
   a) Decantation/decanting
   b) Immiscible liquids such as water and oil.
   c) Liquid oil forms the upper layer because it is less dense than water.
   d) Petrol and water.
      Benzene and water

3) Air can be liquefied by cooling it cooling it to about – 200˚C. The boiling point of oxygen is – 180˚C and the boiling point of nitrogen is – 196˚C.

   a) Nitrogen gas will be separated first from liquid air because its boiling point is lower than that of the other components of the air.

   b) Nitrogen is used in the manufacture of fertilizers.
   It is used in the Haber process to manufacture ammonia gas.
   Because of its inert nature at low temperature, it is pumped into the ships' tanks that transport crude oil to remove traces of oxygen. This prevents dangerous explosions that could occur from crude oil vapours.
   It is used to freeze substances (coolant)due to its low boiling point of -196°C. It can be used to store body tissues that are required to last for a long period of time.

   c) One industrial use of oxygen: supports combustion; used in oxyacetylene flame for welding.
   It is used in hospitals by patients with breathing difficulties and also when an anaesthetic is being administered to patients.
   Liquid oxygen is used in burning of fuels to propel rockets.

4)

Substance	Number of Protons	Number of Neutrons	Number of Electrons
W	9	9	10
X	11	11	11
Y	12	12	10
Z	16	17	16

a) Which one(s) of the particles is/are:
i) A cation: Y
ii) An anion: W
iii) Neutral: Z and X

b) The electronic configuration of X: 2: 8: 1

c) i) The valency of X is 1.
ii) It has one electron on the outermost shell.

5)

Element	Formula of oxide	Class of oxide
Sodium	Na_2O	Basic oxide
Aluminium	Al_2O_3	Amphoteric oxide
Sulphur	SO	Acidic oxide
Carbon	CO_2	Acidic oxide

6) Aluminium is a metal of group IIIa of the periodic table.

a) 2:8:3

b) $2Al\,(s) + 3Cl_2\,(g) \rightarrow 2AlCl_3\,(s)$

c) Mass of aluminium = 34g

Mm of aluminium = 27g/mole
Number of moles of Al $n = \frac{m}{Mm} = \frac{34}{27} = 1.259\ mole$
From the equation, 2 moles of aluminium produce 2 moles of aluminium chloride (ratio is 1:1)

Mm of aluminium chloride = 27 + (35.5 x 3) = 133.5 g/mole
Number of moles of chloride $n = \frac{m}{Mm} = \frac{39}{71} = 0.54\ mole$
From the equation 3 moles of Cl_2 reacts with 2moles of $AlCl_3$
i.e mole ratio is 3:2
n of moles of $AlCl_3 = \frac{0.54mol \times 2}{3} = 0.36mol$

0.36 mole of aluminium will react with 0.54 mole of chlorine to produce 0.36 mole of aluminium chloride
mass of $AlCl_3$ = $0.36mol \times 133.5 gmol^{-1}$=48.06g of $AlCl_3$

Hence the mass of $AlCl_3$ is 48.06g from Cl_2 as a limiting reactant.

7)

a) This is because of free delocalized electrons in the solid structure of aluminium and in molten state of aluminium chloride whereas the solid structure of aluminium chloride the ions are in fixed position.
b) Which particles are responsible for the conduction of electricity in:
   (i) Free delocalized electrons
   (ii) Mobile ions

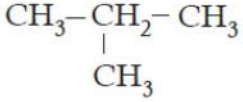
8)

a) Ca is more reactive than Mg because the reactivity of metals increases as you go down the group.
b) Cl is more reactive than S because the reactivity of non –metals increases as you go right the period and of course Cl is more electronegative than sulphur (S).

9) An ionic bond is formed by the transfer of electrons from a metallic atom to a non-metal atom so that there is attraction between ions of opposite charges. One atom of Mg loses 2 electrons and each of the two atoms of Cl gain one electron. Mg becomes Mg^{2+} and 2Cl becomes $2Cl^-$. They attract each other.

10)

a) CH_3-CH_2-CH_2-CH_3: n-butane



2-methylpropane

b) $C_4H_{10} + Cl_2 \rightarrow C_4H_9Cl + HCl$

11)

a) B

b) Thymolphthalein acts as an indicator to show the end- point of the reaction by a rapid colour change

c) This will show you the exact volume needed to end up the titration following the colour change of an indicator

12)

a) Nitrogen

b) The volume decreases because the volume of oxygen gas reacted with copper to form a black copper (II) Oxide.

c) Volume of oxygen reacted=140cm^3 - 115cm^3 = 25cm^3

$$\% \text{ of oxygen} = \frac{25 \times 100}{140} = 17.86\%$$

d) The air is polluted because there is a shortage percentage composition of oxygen which is normally 21%

SECTION B: ATTEMPT ONLY THREE (3) QUESTIONS (30 marks)

13) a) Calcium hydroxide is a base since it dissociates to give hydroxide ions (OH^-) and turns the litmus paper blue.

b) Ammonia gas is dried using calcium oxide and not concentrated sulphuric acid because concentratedH_2SO_4 reacts with ammonia

c) $2NH_4Cl(s) + Ca(OH)_2(aq) \rightarrow CaCl_{2(s)} + 2H_20_{(l)} + 2NH_{3(g)}$

d) Volume of ammonia =120cm3
Molar gas volume=22.4dm^3=22400cm^3

Mm of NH_4Cl = 14 + 4 + 35.5 = 53.5gmol^{-1}

From the equation 2moles of NH_3 are produced from 2moles of NH_4Cl
Number of moles of ammonia $n = \frac{V}{Molar\ Volume} = \frac{120}{22400} = 0.0053\ mole$

0.0053 *mole* of NH_3 will be produced from 0.0053 *mole* of NH_4Cl

Mass of NH_4Cl = n x Mm = 0.0053 x 53.5 = 0.286 g

e) Mass of solute (calcium chloride) = 80g

solubility at 30°C = 40

mass of solvent(water) =?

$$\text{Solubility} = \frac{mass\ of\ solute}{mass\ of\ solvent} \times 100$$

$$\text{Hence mass of solvent} = \frac{mass\ of\ solute}{solubility} \times 100$$

$$= \frac{80g}{40g/l} \times 100 = 200\ l \text{ of water}$$

14) a) Burning wastes in outdoor can cause a wildfire that burn out vegetation, animals and their shelters.

Burning wastes releases in the atmosphere some gases such as SO_2 responsible for acidic rain which can destroy monuments, vegetation, and roof tops of houses.
Burning wastes on the soil destroys the soil structure such as alteration of the PH of the soil.
Burning of waste cause air pollution responsible for respiratory diseases

b) Blockage of water ways

Destroys the soil structure that leads to poor soils that cannot support growth of crops.

Surface water contamination when dumped into water etc

c) **Reuse**: Re-using means using a material that has been used before for another purpose.

Recycling involves reprocessing materials that are regarded as wastes as wastes into useful products.

Disposal refers to dumping of wastes in specific places called landfills.
Minimization: this is the way of encouraging people to use alternative products preferably biodegradable ones.

15)

a) $AgNO_3$ Solution

b) Cathode

c) $Ag^+_{(aq)} + e^- \rightarrow Ag(s)$

d)at the anode $Ag_{(s)} - e^- \rightarrow Ag^+_{(aq)}$ silver dissolves and the mass of anode decreases.

e) i) Free ions
ii) Free electrons

f) m of copper coin=12.8g

Mm of Cu = 64

n of moles=$\frac{m}{Mm}=\frac{12.8g}{64gmol-1}$ = 0.2mol

16)

a) W = MnO_2 (manganese (IV) Oxide

Q = Oxygen (O_2)

b) $2H_2O_2\,(aq) \rightarrow H_2O(l) + O_{2(g)}$

c) i) $S(s) + O_2(g) \rightarrow SO_2(g)$

ii) $Mg(S)+O_{2(g)} \rightarrow 2MgO(s)$

iii) When SO_2 is dissolved in water, the solution formed is acidic, hence it turns litmus paper Red.

When MgO is dissolved in water, the solution formed is basic, hence it turns the litmus paper Blue

iv) $SO_2\ (g) + H_2O(l) \rightarrow H_2SO_3$ (Sulphurous acid)

$MgO(s) + H_2O(l) \rightarrow Mg(OH)_2$

SECTION C: THIS QUESTION IS COMPULSORY (15 marks)

17)

a) i) The role of soda lime is to absorb any impurities that may be present in the syringe.

ii) A reason for passing the air sample through concentrated sulphuric acid is to dry the air as conc.H_2SO_4 is a drying agent

b) i) The black colour of copper (II) oxide is observed

ii) The purpose of copper fillings is to react with oxygen while conducting an experiment of the percentage determination of oxygen in air (copper fillings are reagents)

iii) Initial volume = $80cm^3$

Remaining volume = $63.2\ cm^3$

Volume change = $80cm^3 - 63.2\ cm^3 = 16.8cm^3$

iv) % change = $\frac{16.8}{80} \times 100 = 21\%$

c) Other gases such as nitrogen, carbon dioxide, argon…
Their composition = $\frac{63.2}{80} \times 100 = 79\%$

d) i) $S + O_2 \rightarrow SO_2$

ii) The limiting reagent is oxygen because the combustion of sulphur depends on the availability of Oxygen.

iii) m of sulphur = 20g

Mm of sulphur = 32gmol-1

n sulphur = $\frac{20}{32} = 0.626mol$

mole ratio S:SO_2 is 1:1

Hence moles of SO_2 =0.625mol

Mm of SO_2 = 32 + (16)2 = 64gmol-1

Mass of SO_2 = 0.625mol × 64gmol-1 = 40g of SO_2

iv) Burning sulphur produce sulphur dioxide in the air, which is a pollutant of air to the fact that it combines with rain water to produce acidic rain which is harmful to plants, 'monuments, house rooftops and can cause the death of aquatic animals.

Chemistry I

001

28/07/2023 08:30 AM – 11:30 AM

NESA NATIONAL EXAMINATION AND SCHOOL INSPECTION AUTHORITY

ORDINARY LEVEL NATIONAL EXAMINATIONS, 2022-2023

SUBJECT: CHEMISTRY I

DURATION: 3 HOURS

INSTRUCTIONS:

1) Write your names and index number on the answer booklet as they appear on your registration form and **DO NOT** write your names and index number on additional answer sheets of paper if provided.
2) **DO NOT** open this paper until you are told to do so.
3) This paper consists of **three** sections **A**, **B** and **C**

SECTION A: Attempt **ALL** questions.	**(55 marks)**
SECTION B: Attempt any **THREE** questions.	**(30 marks)**
SECTION C: Attempt any **ONE** question.	**(15 marks)**

4) **You do not need the periodic Table.**
5) Silent non-programmable calculators may be used.
6) Use only a **blue** or **black pen** for answering and a **pencil for drawing**.

SECTION A: Attempt all questions from this section. (55 marks)

1. Air is essentially a mixture of gases and it can be polluted. Read carefully the following statements and answer with True (T) or False (F).
   a) Carbon monoxide is an air pollutant which causes acidic rain. **(1 mark)**
   b) Catalytic converters are control devices which are added to automobiles and they increase air pollution. **(1 mark)**
   c) Chlorofluorocarbons, CFCs, are responsible for ozone layer depletion. **(1 mark)**

2. In daily life, we use many substances that scientists call acids and bases.
   a) What is an acid-base indicator? **(1 mark)**
   b) Fill in the blanks with a missing correct term:
      (i) The vinegar used in salad dressing contains..... **(1 mark)**
      (ii) When milk turns sour, it contains ..... **(1 mark)**

3. In chemistry, salts can be soluble, slightly soluble or insoluble.
   a) Define the term "solubility" of a salt. **(1 mark)**
   b) Ammonium carbonate, $(NH_4)_2CO_3(s)$ decomposes on heating and gives off three products. Write a balanced equation. **(2 marks)**
   c) The solubility of a salt **AX** in water, is 90 at 20°C and 105 at 40°C. Explain. **(1 mark)**

4. Alkanes are saturated hydrocarbons obtained from crude oil.
   a) What is meant by saturated hydrocarbon? **(1 mark)**
   b) State the process by which components of alkanes are obtained from crude oil. **(1 mark)**
   c) On which physical property the process in (b) above is based? **(1 mark)**
   d) Give the IUPAC name for a non-branched saturated hydrocarbon with four (4) carbon atoms. **(1 mark)**

5. Ensuring laboratory safety is the responsibility of everyone working in the laboratory. Choose a correct answer about the safety rules of a laboratory and provide a short explanation to support your choice.
   a) In a laboratory you are allowed to eat and drink only: **(2 marks)**
      (i) If you are very hungry.
      (ii) If you have washed your hands well
      (iii) If the food is healthy and can be digested fast and easily.
      (iv) If the food has been covered well to avoid contamination.
      (v) None of the above.

   b) In case of acid splashes onto your skin while working in a laboratory, immediately apply: **(2 marks)**
      (i) Oil or lotion.
      (ii) Soap to wash out acids.
      (iii) A strong base to neutralize the acid.

(iv) Plenty of clean water.

6. The conversion of reactants into products in a chemical reaction is often accompanied by some features (characteristics) which can be observed easily.
   a) State any two characteristics of chemical reactions. **(2 marks)**
   b) What type of reaction is the reaction below and which of the characteristics of chemical reactions does it exhibit? **(2 marks)**
   $AgNO_3$ (aq) + NaCl (aq) → AgCl (s) + $NaNO_3$ (aq)

7. Under certain conditions, alkenes can be converted into alcohols and vice-versa.
   a) Write the reaction equation, with all conditions, to show the product formed when propan-1-ol is heated with sulphuric acid at 170°C. **(2 marks)**
   b) Both ethanol and butane are organic compounds. The molecular weight of butane (58) is higher than the molecular weight of ethanol (46), but the boiling point of ethanol (351K) is higher than the point of butane (272K). Explain such a difference. **(2 marks)**

8. Carbon dioxide is a colorless, odorless gas produced by burning carbon or burning organic compounds and by respiration. It is naturally present in air.
   a) State one environmental problem caused by the increase of carbon dioxide in the atmosphere. **(1 mark)**
   b) Describe any one process or phenomenon that acts to remove carbon dioxide from the atmosphere. **(3 marks)**

9. Carboxylic acids can be obtained by oxidation of alcohols.
   a) Give the IUPAC name or chemical formula of an alcohol which can be used to prepare ethanoic acid. **(1 mark)**
   b) Write the equation of preparation of ethanoic acid by oxidation of the alcohol in (a) above. **(1 mark)**
   c) State any three uses of ethanoic acid. **(3 marks)**

10. In a laboratory, oxygen can be prepared by carrying out decomposition of potassium chlorate in the presence of manganese (IV) oxide as depicted in figure 1.

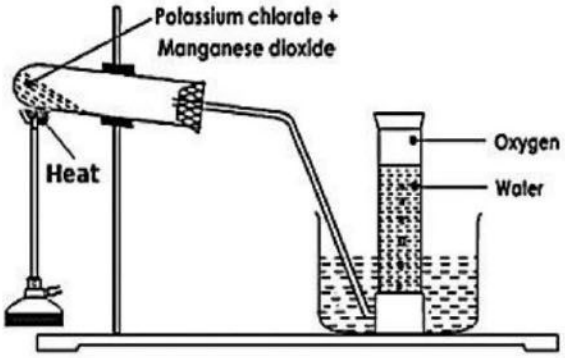


Figure 1

a) Give the chemical formula of manganese (IV) oxide and explain its role in this reaction. **(2 marks)**

b) Oxygen exists in two forms known as allotropes.

(i) Define the term "allotropes". **(1 mark)**

(ii) One of the allotropes of oxygen plays a big role in protecting living things on earth. Give the name or chemical formula for this allotrope. **(1 mark)**

11. A few crystals of lead (II) nitrate were heated strongly. There was formation of a solid residue and two different gases.

a) Write a well-balanced chemical equation for the reaction which occurs. **(1 mark)**

b) The solid residue dissolves in dilute nitric acid to give a colourless solution **Y**, which in turn reacts with potassium iodide solution, KI (aq), to form a yellow precipitate **Z**.

(i) Write the reaction equation of solid residue and dilute nitric acid and identify **Y**. **(2 marks)**

(ii) Give the ionic equation between **Y** and iodine ions to form **Z**. **(2 marks)**

12. A dilute solution of hydrochloric acid, HCl (aq) reacts with magnesium ribbons and magnesium powder in two different reactions as follows:

Reaction 1: HCl (aq) reacts with magnesium ribbons
Reaction 2: HCl (aq) reacts with magnesium powder

a) Write the reaction equation between HCl (aq) and magnesium metal with all the states for chemicals. **(2 marks)**

b) State the main factor which affects the rates of the two reactions above. **(1 mark)**

c) Compare the reaction (1) with the reaction (2) in terms of rate and amount of products formed. **(2 marks)**

13. When phosphorous burns in air, a bright yellow flame is observed and white fumes of phosphorous (V) oxide are produced.

a) Write a balanced chemical equation for this reaction. **(2 marks)**

b) Air is a mixture of gases in proportions: 78%, 21% and 1% of nitrogen, oxygen and other trace gases, respectively. Given that 133.5 dm^3 of air was required to burn phosphorous completely.

(i) Find the volume, in dm^3, of oxygen which reacted. **(1 mark)**

(ii) Deduce the amount, in grams, of oxygen which reacted. **(1 mark)**

(iii) Calculate the amount, in grams, of phosphorous (V) oxide produced. **(2 marks)**
(Atomic mass: P = 31, O = 16; molar gas volume = 22.4 dm^3/mole)

SECTION B: ATTEMPT ONLY THREE (3) QUESTIONS (30 marks)

14. During a laboratory investigation, a student was given a sample that was a mixture of 3.0 grams of NaCl (aq) and 4.0 grams of sand, which was mostly SiO_2 (s). The purpose of the investigation was to separate and recover the compounds in the sample. In the first step, a student placed the sample in a 250 ml flask. Secondly, 50 grams of distilled water were added to the flask, and the content was thoroughly stirred.
The mixture in the flask was then separated, using the equipment represented by the diagram in the figure 2 below.

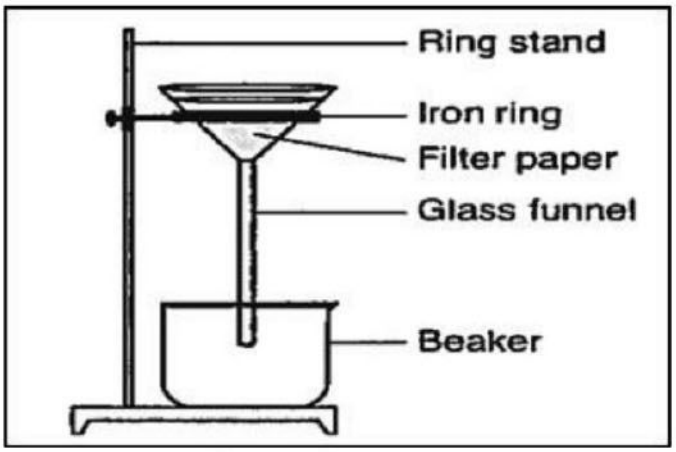


Figure 2

(a) Name the technique used to separate the above mixture. **(1 mark)**

(b) Explain, in terms of solubility, why the mixture in the flask remains heterogeneous even after thorough stirring. **(2 marks)**

(c) State and describe the process which can be used to remove water from the mixture that passes through the filter and collect it in the beaker. **(2 marks)**

(d) Differentiate between a mixture and a compound (at least two differences). **(2 marks)**

(e) Calculate the percentage of NaCl, sand and water in the mixture NaCl-SiO_2-water. **(3 marks)**

15. During electrolysis two points called electrodes are involved: One which allows the current to enter the electrolyte and another which allows the current to leave the electrolyte.
    a) Name the electrode which allows the current to enter the electrolyte. Give its polarity. **(2 marks)**
    b) Name the electrode which allows the current to leave the electrolyte. Give its polarity. **(2 marks)**
    c) State any two applications of electrolysis. **(2 marks)**
    d) Consider electrolysis of dilute sodium chloride, NaCl (aq) using graphite electrodes.
        (i) Show all the ions present in the solution. **(2 marks)**
        (ii) Which product is obtained at the negative electrode? **(2 marks)**

16. Plastic carrier bags and single-use plastic have been identified to negatively impact the environment. This is one of the major reasons which pushed the Government of Rwanda to take a decision of banning such materials (plastic carry bags and single-use plastics).
    a) Define the term "waste material". **(1 mark)**
    b) Differentiate between a biodegradable and a non-biodegradable waste, with one supporting example in each case. **(3 marks)**
    c) State and explain the impact of these plastic carry bags and single-use plastics on environment; soil, water (lakes, oceans), air and health. **(4 marks)**
    d) Formulate any two alternative solutions of materials which can be used in place of plastic carry bags and single-use plastics with less or no impact to the environment. **(2 marks)**

17. The most common laboratory method for preparation of chlorine is to heat manganese (IV) oxide with concentrated hydrochloric acid according to experimental set up shown by figure 3 below.

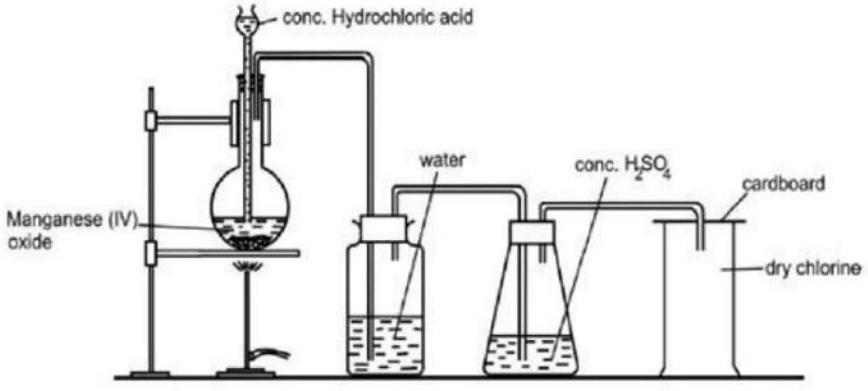


Figure 3

    a) Write a balanced chemical equation between manganese (IV) oxide and concentrated hydrochloric acid. **(2 marks)**
    b) Explain the role of water and sulphuric acid in this experiment. **(2 marks)**
    c) Name the method used to collect chlorine gas. **(1 mark)**

d) Justify the choice of collecting chlorine gas by the method named in (c) above. **(2 marks)**

e) Outline any three uses of chlorine and its compounds. **(3 marks)**

18. a) On analysis, a compound **P** gave the following percentage composition:

Na = 43.4%, C = 11.3%, O = 45.3%

(i) Define the term empirical of a substance. **(1 mark)**

(ii) Calculate the empirical formula of **P**. **(4 marks)**

(iii) If **P** has a molecular mass of 106, deduce the molecular formula. **(2 marks)**

b) (i) State the Boyle's law. **(1 mark)**

(ii) A certain mass of gas occupies 48 mL at a pressure of 720 mm of Hg. What is the volume when the pressure is increased to 960 mm of Hg? (Temperature remains constant) **(2 marks)**

SECTION C: ATTEMPT ANY ONE (1) QUESTION (15 marks)

19. Crystals of zinc sulphate were prepared using the method described below.

Excess zinc carbonate was mixed with aqueous sulphuric acid in a beaker.

The mixture was warmed until the reaction stopped.

The mixture was filtered to remove the unreacted zinc carbonate.

The filtrate was evaporated until a small volume remained.

The remaining solution was left to cool to form crystals.

a) Write a balanced chemical equation for the reaction between zinc carbonate and sulphuric acid. **(2 marks)**

b) Why was the excess zinc carbonate used? **(1 mark)**

c) Why will a similar method not be suitable for preparing lead (II) sulphate? **(1 mark)**

d) A salt of zinc sulphate has the formula: $ZnSO_4.7H_2O.7H_2O$. How can you show with a chemical test that the compound contains water of crystallization? **(2 marks)**

e) Calculate the percentage by mass of water in $ZnSO_4.7H_2O$. **(3 marks)** (Zn = 65; S = 32; O = 16; H = 1)

f) The solubility of a solute at 30C is 40. What amount of water is required to make a saturated solution of 80 grams of the solute? **(2 marks)**

g) A reaction scheme involving an unknown salt XY (aq) is shown in the figure 4 below. **(4 marks)**

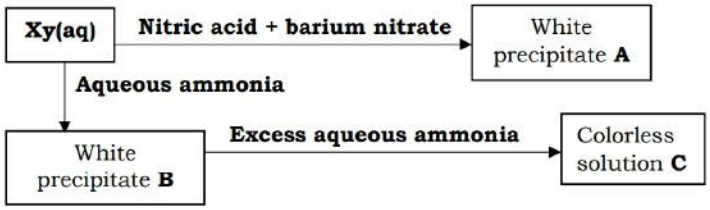


Figure 4

Give the names or chemical formulae for:

(i) Solutions XY and C.

(ii) Precipitates A and B.

20. Students carried out a titration experiment in a laboratory. During that titration, 20 cm^3 of sodium carbonate (Na_2CO_3) reacted completely with 0.15M hydrochloric acid (HCl) in excess, using phenolphthalein indicator. The table below has been used to record the volume of HCl used. (Na = 23, Cl = 35.5, C = 12, o = 16, H = 1, phenolphthalein indicator: colorless-pink)

Titration number	1st	2nd	3rd
Final burette reading (cm^3)	25.0	49.5	73.9
Initial burette reading (cm^3)	0.00	25.0	49.5
Volume of hydrochloric acid used (cm^3)	V1	V2	V3

a) State the expected colour change observed. **(1 mark)**

b) Find the average volume of HCl used. **(2 marks)**

c) Write a balanced chemical equation for the reaction that took place. **(2 marks)**

d) State any other observable change made as the reaction occurs. **(1 mark)**

e) Find:

(i) The mole ratio between Na_2CO_3: HCl. **(1 mark)**

(ii) The number of moles of hydrochloric acid used and deduce the moles of Na_2CO_3 reacted. **(2 marks)**

(iii) The concentration of sodium carbonate, in mol/dm^3. **(2 marks)**

(iv) The concentration of sodium carbonate, in g/dm^3. **(2 marks)**

-END-

MARKING SCHEME OF ORDINARY LEVEL CHEMISTRY NATIONAL EXAMINATION 2022-2023

SECTION A: Answer all questions

1) a) False
b) False
c) True

2) a) In daily life, we use many substances that scientists call acids and bases. An acid-base indicator is substance used to test if substance is base or an acid. It takes one colour in acidic solution and another in alkaline solution.
Or acid–base indicator is a substance that changes colour according to the pH of the solution
Accept any other correct definition and example of indicator.
b) (i) The vinegar used in salad dressing contains **acetic acid**
(ii) When milk turns sour, it contains **lactic acid**.

3) a) Solubility of a salt is the ability of a salt to be dissolved in a solvent at a particular temperature. **Or** it is the amount of solute in grams required to form a saturated solution in 100grs of solvent (water) at a particular temperature.

Or Solubility=$\frac{mass\ of\ solute}{mass\ of\ solvent} \times 100$ or Solubility = $\frac{mass\ of\ solute}{mass\ of\ solution} \times 100$

b) $(NH_4)_2CO_3$ (s) $\xrightarrow{heat}$ $2NH_3$ (g) + CO_2 (g) + H_2O (l)

c) The solubility of a salt increases as the temperature increases.
or Solubility is directly proportional temperature or solubility decreases with decreasing in temperature.

4) a) Saturated hydrocarbon: A compound which is made by carbons and hydrogen atoms only and single covalent bonds only.

b) Process: Fractional distillation

c) Difference in the boiling point or the component.
Accept boiling point or melting point or volatility.

d) CH_3-CH_2-CH_2-CH_3: n-Butane Accept also Butane

5) a) (v). Do not eat or drink while you are in the laboratory to prevent contamination.

b) (iv). Chemical spills (acid and base) on the body should be washed off with plenty water. Do not apply a base or an alkali.

6) a) 1. Evolution of a gas

2. Formation of a precipitate

3. Change in colour

4. Change in temperature

5. Change in state

Accept: Change in smell, disappearance of reactants, appearance of new products, effervescence/bubbles and light.

b) Type: Double displacement or precipitation reaction.

Characteristics: Formation of a precipitate

7) a) $CH_3\text{-}CH_2\text{-}CH_2OH(l) \xrightarrow{H_2SO_4\,;\,170°C} CH_3\text{-}CH{=}CH_{2(g)} + H_2O$

b) The boiling point of ethanol and butane are 351K (48°C) and 272 K:
Alcohols contain strong intermolecular forces called hydrogen bonds while alkanes contain week intermolecular forces called van der waals forces.

8) a) Greenhouse effect acidic rain.

b) One process or phenomenon:

Dissolution in water:

-Carbon dioxide dissolves in rivers and lakes to form week carbonic acid. The carbonic acid reacts with calcium carbonate and magnesium carbonate to form calcium hydrogen carbonate and magnesium hydrogen carbonate respectively.

Photosynthesis: In this process green plants use carbon dioxide to make sugar using sunlight as source of energy

9) a) Ethanol/CH_3CH_2OH

b) $CH_3CH_2OH \xrightarrow{[K2Cr2O7]/H2SO4} CH_3COOH$

c) Ethanoic acid is used:

- in Production of vinegar in food processing industry
- In the production of synthetic fibres

- In the formation of esters which is used in the perfume- making process.

Or

- As solvent
- To make plastics, and detergents.

10) a) MnO_2. It plays the role of catalyst, to speed up the rate of reactions of decomposition of potassium chlorate.

b) i) Allotropes are different forms of the same element existing in the same physical state but with different physical properties.

- ii) Trioxygen or ozone / O_3

11) a) $2Pb(NO_3)_2\ (s) \xrightarrow{\Delta} 2PbO\ (s) + 4NO_2\ (g) + O_2\ (g)$

b) i) $PbO\ (s) + 2HNO_3\ (aq) \longrightarrow Pb(NO_3)_2\ (aq) + H_2O\ (l)$

ii) $Pb(NO_3)_2\ (aq) + 2KI\ (aq) \longrightarrow PbI_2\ (s) + 2KNO_3\ (aq)$

$Pb^{2+}(aq) + NO_3^-(aq) + 2K^+(aq) + 2I^-(aq) \longrightarrow PbI_2\ (s) + 2K^+(aq) + NO_3^-(aq)$

$Pb^{2+}(aq) + 2I^-(aq) \longrightarrow PbI_2\ (s)$

12) a) $2HCl\ (aq) + Mg\ (s) \xrightarrow{\Delta} MgCl_2\ (s) + H_2(g)$

b) The main factors is surface area of magnesium or Size of particles Mg.

c) Reaction 1: magnesium ribbon reacts slowly with HCl (aq) to produce magnesium chloride and release small amount of bubbles of hydrogen gas while in Reaction 2: magnesium powder reacts quickly forming magnesium chloride and a lot of bubbles of hydrogen gas.

13) a) $4P\ (s) + 5O_2\ (g) \longrightarrow 2P_2O_5\ (s)$

b) i) Volume of oxygen that reacted $= \frac{133.5\ dm^3 \times 21}{100} = 28.035\ dm^3$

ii) One mole of oxygen occupies a volume of 22.4 dm^3

Number of moles of oxygen $= \frac{28.035\ dm^3}{22.4\ dm^3/mole} = 1.25\ mole$

Mass of oxygen that reacted $= n \times Mm = 1.25\ mole \times \frac{32\ g}{mole} = 40\ g$

iii) 5 moles of oxygen are used to produce 2 moles of P_2O_5

1 mole of oxygen is used to produce $\frac{2}{5}$ moles of P_2O_5

1.25 mole of oxygen is used to produce $\frac{2\times1.25}{5}$ moles of $P_2O_5 = 0.5\ mole$

Mass of P_2O_5 is $= n \times Mm$

Molar mass of $P_2O_5 = 31 \times 2 + 16 \times 5 = 62 + 80 = 142\ g/mole$

Mass of P_2O_5 is $= n \times Mm = 0.5\ mole \times 142 \frac{g}{mole} = 71\ grams$

SECTION B: ATTEMPT ONLY THREE (3) QUESTIONS

14) a) Filtration **(1marks)**

b) Because,
- SiO_2 is a completely insoluble compound.
- Only NaCl solubilizes in water.
- SiO_2(s) remains solid in the NaCl solution.
- or simply sand is insoluble in water.

c) – The process is distillation.
– It is a separation technique that can be used to either increase the concentration of particular components in the mixture or to obtain (almost) pure component from the mixture.
- The process of distillation exploits the difference in the boiling point of the components in the liquid mixture by forcing one of them into a gaseous state.

d) Difference between compound and mixture

No	Differentiating property	Compound	Mixture
1	Definition	Compounds are substances which can be formed by chemically combining two or more elements.	Mixtures are substances that are formed by physically mixing two or more substances.
2	Composition Details	The chemical composition of the compounds is always fixed.	A mixture can have a variable composition of the substances forming it.
3	Nature	Compounds are always homogeneous in nature.	Mixture can either be homogeneous or heterogeneous in nature

4	Separation of constituents	The constituents of a compound can only be separated by be either chemical or electrochemical methods(like extraction)	Mixture can be separated into their constituents via physical separation methods such as filtration. Thus, separation of mixture is relatively easier than the separation of chemical compounds.
5	Properties	The properties of compounds are unique to themselves and need not necessarily reflect the properties of the constituents elements	The constituents of a mixture do not lose their properties and so, the properties of a mixture are generally the sum of the properties of its constituents.
6	Melting and boiling points	The melting and boiling points of a compound are always defined.	The melting and boiling points of a mixture are not defined.

e) Mass of the mixture NaCl-Sand (which is mostly SiO_2)-Water = 57g

$$\%\ of\ NaCl = \frac{3g}{57g} \times 100 = 5.26\ \%$$

$$\%\ of\ SiO_2 = \frac{4g}{57g} \times 100 = 7.02\ \%$$

$$\%\ of\ H_2O = \frac{50g}{57g} \times 100 = 87.72\ \%$$

15) a) Anode. It is positively charged.

b) Cathode. It is negatively charged.

c) Electroplating
Extraction of metals
Refining of metals

d) i) Ions present in the solution: Na^+, Cl^-, H^+, OH^-

e) Equation at cathode: $2H^+\ (aq) + 2e^- \longrightarrow H_2(g)$
Product at cathode: H_2 (g)

Equation at anode: $4OH^-\ (aq) \longrightarrow 2H_2O\ (l) + O_2(g) + 4e^-$

Product at anode: O_2 (g)

16) a) A waste is any unwanted or non-useful object or material.

b) A biodegradable waste is waste which can be broken down by microorganisms. Examples: peels of fruits, leaves of plants, remains of food. A non-biodegradable waste is a waste which cannot be broken down by microorganisms. Examples: glass, plastics.

c) Plastics accumulate in **the soil** causing the death of microorganisms which help in decomposition of substances. Plastics cause also soil pollution.
Water: plastics cause water pollution leading to the death of aquatic animals.
Air: the burning of plastics releases carbon dioxide gas in the atmosphere. Carbon dioxide is the leading cause of global warming.
Health: Causes respiratory diseases due to gases produced
Disruption of endocrines which results into many other health problems like infertility, obesity, prostate or breast cancer, thyroid problems and increased risk of cardiovascular disease.

d) Using biodegradable bags such as those made from papers; reuse and recycle of products; using containers mase from plant leaves.

17. a) MnO_2 (s) + 4HCl $\xrightarrow{\Delta}$ $MnCl_2$ (aq) + Cl_2(g) + $2H_2O$ (l)

b) Role of water: to remove unreacted HCl fumes
Role of H_2SO_4 is to dry Chlorine gas)

c) Downward delivery or upward displacement.

d) Used downward delivery because Chlorine is denser than air and it is soluble in water.

e) 3 Uses of Chlorine:
- It is used in the treatment of water and sewage systems.
- It is used in the manufacture of hydrochloric acid.
- Manufacture of domestic bleaches
- Manufacture of weed killers such as Sodium Chlorate also used to make explosives, fireworks, matches and medicines such as throat lozenges
- Manufacture of germicides, fungicides and pesticides such as DDT
- Manufacture of Chlorofluorocarbons (CFC's) used to manufacture aerosol propellants and used in refrigerators as Freon) and air conditioning units due to their low boiling points.

- Compounds of chlorine such as Vinyl Chloride are used in making plastics water pipes, chairs, tables among other.

18) a) An **empirical formula** represents the simplest whole number ratio of various atoms present in a compound.

	Na	C	O
Percentage	43.3	11.3	45.3
Number of moles	$\frac{43.3}{23}$	$\frac{11.3}{12}$	$\frac{45.3}{16}$
Number of moles	1.88	0.94	2.83
Ratio	$\frac{1.88}{0.94}$	$\frac{0.94}{0.94}$	$\frac{2.83}{0.94}$
Ratio	2	1	3

The empirical formula is Na_2CO_3

iii) Molecular formula = 106

n(Na_2CO_3) = 106

$n(23 \times 2 + 12 + 16 \times 3) = 106$

$106n = 106$

$n = \frac{106}{106} = 1$

$MF = n(EF) = 1(Na_2CO_3) = Na_2CO_3$

b) i) Boyle's law: The temperature remaining constant, the volume of a given mass of gas is inversely proportional to the pressure applied to it.

ii) $P_1V_1 = P_2V_2$

$V_2 = \frac{P_1V_1}{P_2} = \frac{720\ mmHg \times 48\ ml}{960\ mmHg} = 36\ ml = 0.036\ l$

SECTION C: ATTEMPT ANY ONE (1) QUESTION

19) a) $ZnCO_3$ (s) + H_2SO_4 (aq) ⟶ $ZnSO_4$ (aq) + CO_2 (g) + H_2O (l)

b) The excess of zinc carbonate was used to make sure that all the sulphuric acid reacted.

c) A similar method is not suitable for preparing lead (II) sulphate because when dilute sulphuric acid reacts with lead (II) carbonate, an insoluble product of lead sulphate ($PbSO_4$) is formed and prevents the reaction from continuing taking place.

d) Water turns white anhydrous copper (II) sulphate blue
Water turns blue cobalt (II) chloride purple

e) The percentage by mass of water in $ZnSO_4.7H_2O$

Molar mass of $ZnSO_4.7H_2O$ = 65 + 32 + 16 x 4 + 7 (1 x 2 + 16) =
= 161 + 126 = 287 g/mole
Water occupies 126 g in $ZnSO_4.7H_2O$

The percentage by mass of water in $ZnSO_4.7H_2O = \frac{126g}{287g} \times 100 = 43.9\ \%$

f) $Solubility = \frac{Solute \times 100}{Solvent}$

$Weight\ of\ solvent = \frac{Solute \times 100}{Solubility} = \frac{80g \times 100}{40} = 200\ g$

g) i) XY is $ZnSO_4$ or zinc sulphate
C is $Zn[NH_3]_4(OH)_2$

ii) A = $BaSO_4$
B = $Zn(OH)_2$

20) a) The colour changes from pink to colourless

b) Average of HCl used
First volume V1 = 24.50 ml
Second volume V2 = 49.50 ml – 25.00 ml = 24.50 ml

Or

Third volume V3 = 73.90 ml – 49.50 ml = 24.40 ml

Average volume of HCl used= $\frac{V2+V3}{2} = \frac{24.5+24.4}{2} = 24.45\ ml = 0.02445 dm^3$

Or

Average volume of HCl used = $\frac{V1+V2+V3}{3} = \frac{25+24.5+24.4}{3} = 24.63\ ml$ =0.02463 dm^3

c) Na_2CO_3 (aq) + 2HCl (aq) ⟶ 2NaCl (aq) + CO_2 (g) + H_2O (l)

d) There is **effervescence** due to the carbon dioxide gas bubbling through the solution or only carbon dioxide gas.

e) (i) The mole ratio between Na_2CO_3 : HCl is 1 : 2

(ii) The number of moles of HCl used

$= M \times V = 0.15 \frac{mole}{dm^3} \times 0.02445\ dm^3 = 0.0036675\ mol$

2 moles of HCl react with one mole of Na_2CO_3

0.036675 mole of HCl will react with $\frac{0.036675}{2} = 0.00183375$ mole of Na_2CO_3

Number of moles of Na_2CO_3 = 0.00183375 mol of Na_2CO_3

iii) Volume of Na_2CO_3 used = $20.0\ cm^3 = 0.020\ dm^3$

Concentration of Na_2CO_3 in mole/dm^3 $= \frac{n}{V} = \frac{0.00183375\ mole}{0.020\ dm^3} = 0.091 \frac{mole}{dm^3}$

(iv) Concentration of Na_2CO_3 in gr/dm^3 $= M \times Mm$

where Mm of Na_2CO_3 = 23 x 2 + 16 x 3 = 46 + 12 + 48 = 106 gr/mole

The concentration of Na_2CO_3 in $g/dm^3 = 0.091\ mole/dm^3 \times 106 g/mol = 9.646\ g/dm^3$

f) Sketch: should display the main elements:

- Retort stand
- Burette (with the specific content indicated: HCl)
- Conical flask with the specific content indicated: Na_2CO_3 + phenolphthalein)

  Label/ (Burette or HCl , and conical flask or Erlenmeyer flask or beaker or Na_2CO_3)