REPUBLIC OF RWANDA

Chemistry III

025

07th Nov 2001   8.30am-11.30am

NATIONAL EXAMINATIONS COUNCIL

P.O.BOX 3817 KIGALI

ORDINARY LEVEL NATIONAL EXAMINATION 2001/2002
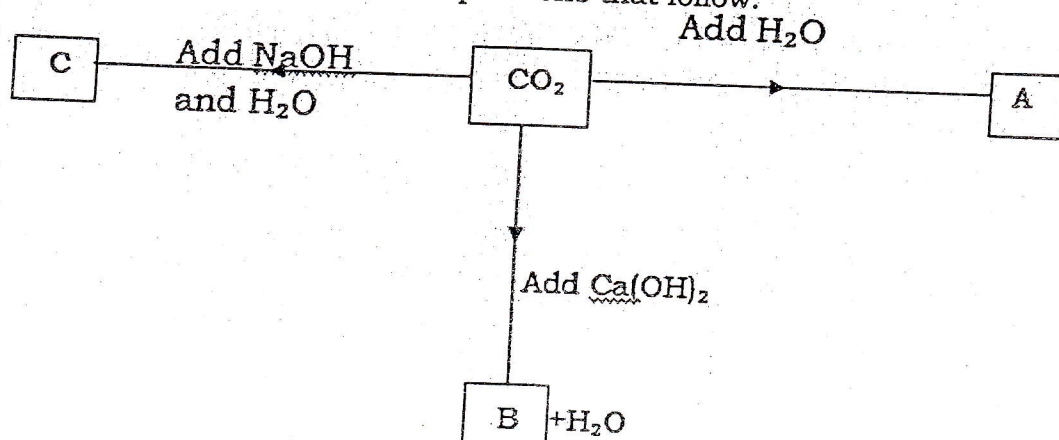
SUBJECT   : CHEMISTRY III

LEVEL   : ORDINARY LEVEL

TIME   : 3 HOURS

INSTRUCTIONS:

- This paper consists of THREE Sections A, B and C.
- Answer ALL the 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.

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

$$\boxed{C} \xleftarrow{\text{Add NaOH and } H_2O} \boxed{CO_2} \xrightarrow{\text{Add } H_2O} \boxed{A}$$

$$\boxed{CO_2} \xrightarrow{\text{Add Ca(OH)}_2} \boxed{B} + H_2O$$

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 substance C from CO_2. **(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 Irons during electrolysis of dilute sodium chloride solution (Nacl)
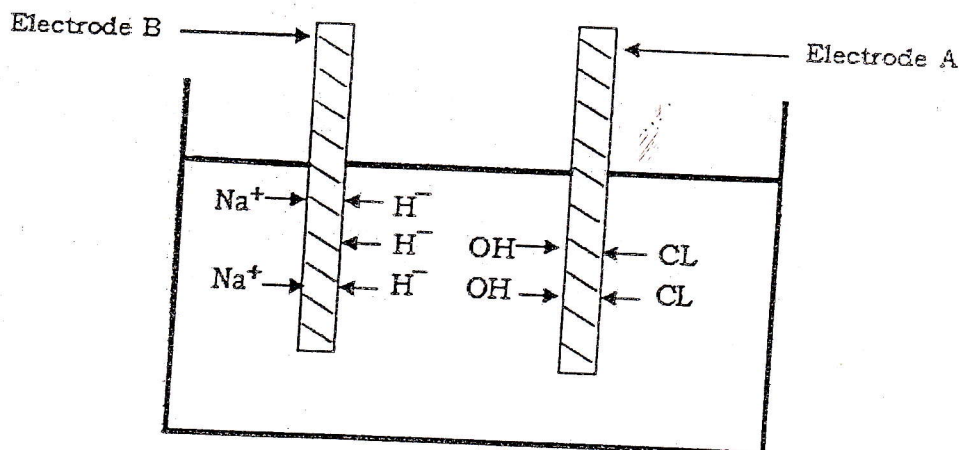
a) Which of the electrode A and B is the anode? **(1 mark)**

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 suplhuric 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 $2CuFeS_2 + 5O_2 \longrightarrow 2Cu + 4SO_2 + 2FeSiO_3$

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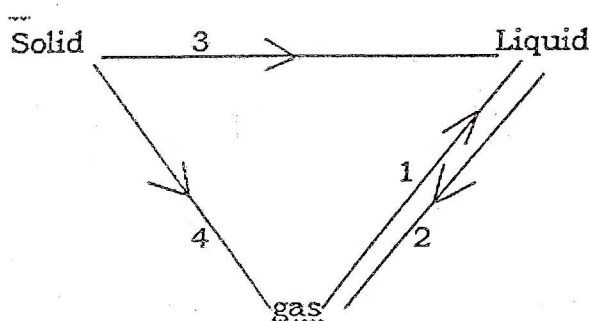
a) Name changes or processes 1, 2, 3 and 4. (2 marks)

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 (30 MARKS)

Answer three questions in this section.

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.

Reactants

Products

| Iron oxide |

| X |

| Y |

| Air |

Blast Furnace
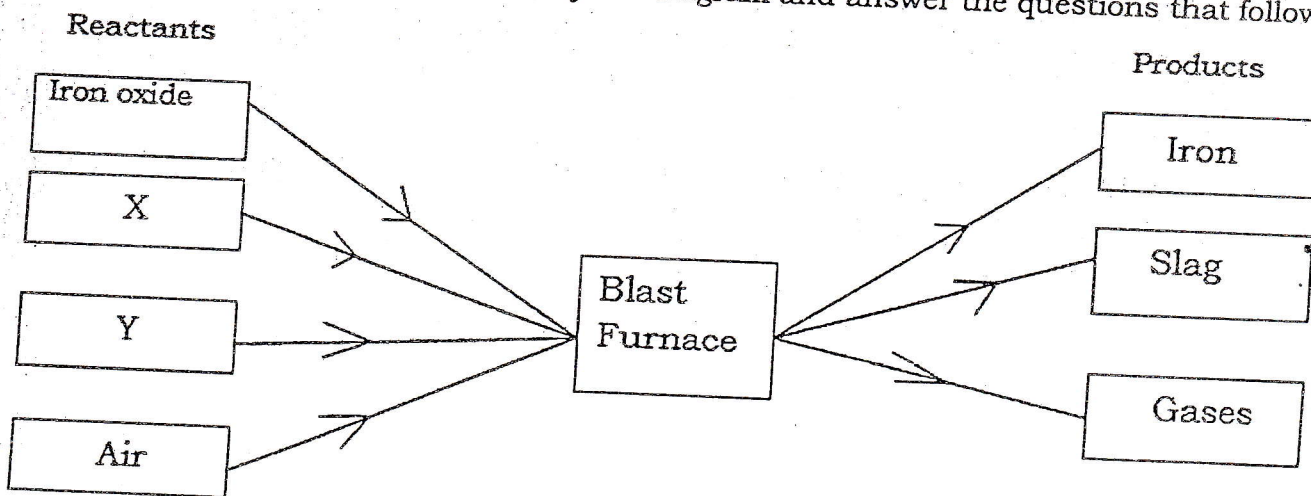
| Iron |

| Slag |

| Gases |

a) Name substances X and Y.

(2 marks)

b) The chemical reaction for the formation of iron is

$$Fe_2O_{3(s)} + CO_{(g)} \longrightarrow 2Fe_{(s)} + 3CO_{2(g)}$$

From the above equation, identify which substance is a reducing agent and which substance is an oxidizing agent.
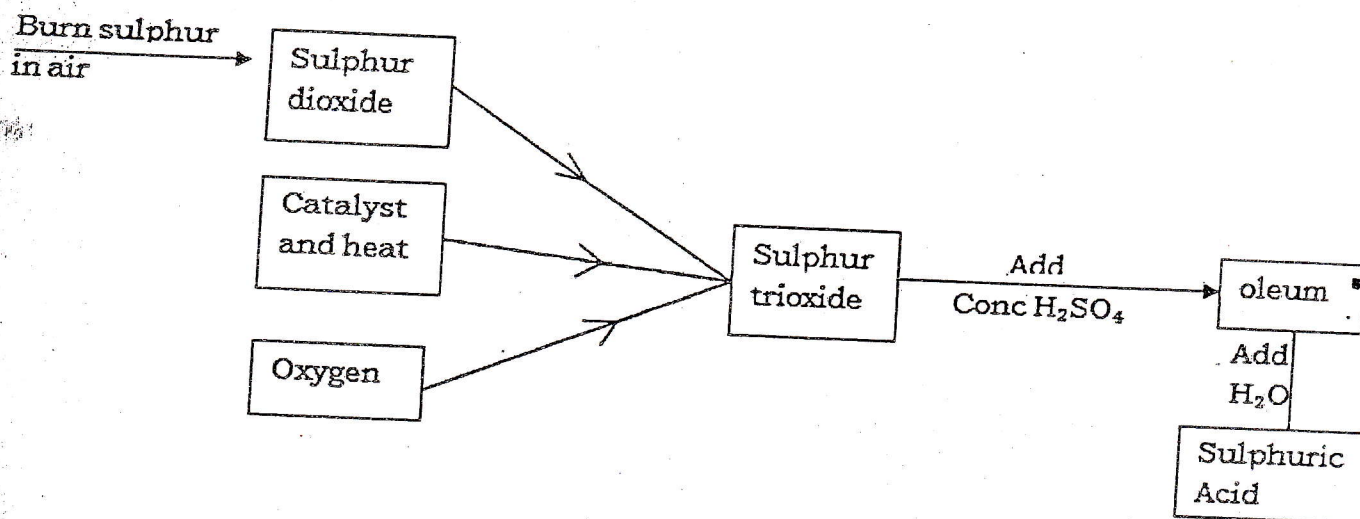
(2 marks)

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.

Burn sulphur in air

| Sulphur dioxide |

| Catalyst and heat |

| Oxygen |

Sulphur trioxide

Add Conc H_2SO_4

| oleum |

Add H_2O

| Sulphuric Acid |

a) Write a balanced equation for the formation of sulphur tioxide from oxygen and sulphur dioxide.

(2 marks)

b) Starting with 50cm³ of sulphur dioxide and 50cm³ of oxygen,

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

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 starting with zinc powder and copper II sulphate solution. **(2 marks)**

18. a) Explain how you would obtain a pure sample of zinc sulphate and a pure sample of copper powder. **(2 marks)**

b) Write an ionic equation from the following chemical reaction. **(2 marks)**

$$ZnSO_{4(aq)} + Bacl_{2(aq)} \longrightarrow Zncl_{2(aq)} + BaSO_4.$$

19. a) With the aid of a well labeled 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. (MgO_2) **(1 mark)**

SECTION C: (15 marks)

Answer only one question from this section.

20. To determine the concentration of a solution of sulphuric acid, 25cm³ of sulphuric acid was added to 2ml 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:

$$2KOH_{(aq)} + H_2SO_{4(aq)} \longrightarrow K_2SO_{4(aq)} + 2H_2O.$$

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

    d) Calculate the concentration of sulphuric acid in g/dm³.   **(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 H₂(cm³)	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.

    d) Why is the volume of H_2 = 0cm³ 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.   **(1 mark)**

        (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) $Zn(NO_3)_{2(aq)}$ and $Fe(NO_3)_{3(aq)}$

    b) $Nacl_{(aq)}$ and $Na_2CO_{4(aq)}$

    c) Ethane and Ethanol

    d) SO_2 and CL_2 gases,

    e) $Pb(NO_3)_2$ and $CU(NO_3)_{2(S)}$ **(3 marks each)**

END.

SECTION A

Answer to question 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) $4Na + O_2 \longrightarrow 2Na_2O$

Answer to question 2

a) Calcium carbonate

b) $CaCO_3 \longrightarrow CaO + CO_2$

Rmm of $CaCO_3$ = 40 + 12 + 16 × 3 = 100

Rmm of CaO = 40 + 16 = 56.

From the equation: 100g $CaCO_3 \longrightarrow$ 56g of CaO

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

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

Answer to question 3

3. a)

Name	Chemical formula	Approximate percentage in air
Nitrogen	N_2	78
Carbondioxide	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.

Answer to question 4.

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

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

c) Two ways of speeding up the decomposition are:
   i) Increasing the concentration of hydrogen peroxide.

   i) Increasing the concentration of hydrogen peroxide.

   ii) Using manganese (iv) oxide as a catalyst.

Answer to question 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: Decreaseing the amount of Ammonia produced.
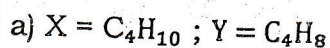
Answer to question 6

a) A $\longrightarrow$ Carbonic acid, H_2CO_3

B $\longrightarrow$ Calcium carbonate, $CaCO_3$

C $\longrightarrow$ Sodium hydrogen carbonate, $NaHCO_3$

b) $2NaOH + H_2O + CO_2 \longrightarrow Na_2CO_3 + 2H_2O$
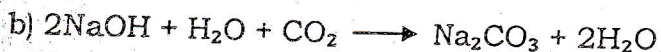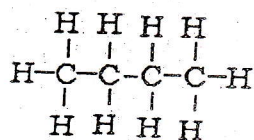
Answer to question 8

a) Anode is A

b) Hydrogen is formed at B.

$2H^+ + 2e \longrightarrow H_2$

c) The main product is oxygen, it is tested using a glowing splint, it re-lights a glowing splint.
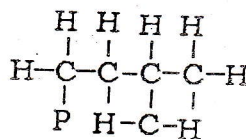
Answer to question 9

a) Calcium

b) Copper

c) Calcium resets 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.

Answer to question 7

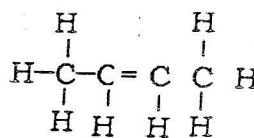a) $X = C_4H_{10}$; $Y = C_4H_8$

Structural formula of X
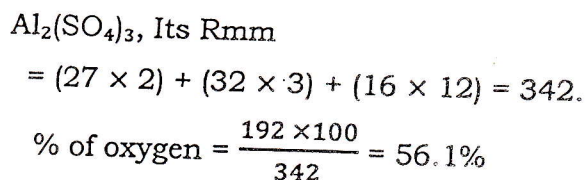

Butane

2-methy propane

b)

But-2-ene

Answer to question 10

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

b) First find Rmm of $CuFeS_2$

$= 63.5 + 56 + 32 \times 2 = 183.5g$

$(2 \times 183.5)g$ of $CuFeS_2 \longrightarrow \dfrac{2 \times 63.5}{2 \times 183.5} \times 36.7$

$= 12.7g.$

Answer to question 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
It has shape	No shape

Answer to question 12

$Al_2(SO_4)_3$, Its Rmm

$= (27 \times 2) + (32 \times 3) + (16 \times 12) = 342.$

% of oxygen $= \dfrac{192 \times 100}{342} = 56.1\%$

Answer to question 13.

a) methanol

b) water

c) C_2H_5OH or CH_3-CH_2-OH

Answer to question 14.	b)
a)	Molecular formula $(C_2H_6O)_n = 92$

Answer to question 14.

a)

C	H	O	% for oxygen = 100 – (52.1 + 13)
$\frac{52.17}{12}$	$\frac{13}{1}$	$\frac{34.83}{16}$	% for oxygen = 34.83
4.3475	13	2.1769	

Divide by the smallest $\quad \frac{1.3475}{2.1769} \quad \frac{13}{2.1769} \quad \frac{2.1769}{2.1769}$

$\qquad\qquad\qquad\qquad\quad 2 \qquad\quad 6 \qquad\quad 1$

Empirical formula is C_2H_6O

b)

Molecular formula $(C_2H_6O)_n = 92$

$(12\times2+1\times 6+16)_n = 92$

$46n = 92$

$n = \frac{92}{46} = 2$

Molecular formula $(C_2H_6O)_2$

$= C_4H_2O_2$

SECTION B

Answer to question 15

a) X $\longrightarrow$ Coke (carbon)

Y $\longrightarrow$ lime stone

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

$Fe_2O_3 \longrightarrow$ oxidizing agent

$CO \longrightarrow$ 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, transport.

Answer to question 16

a) $2SO_2 + O_2 \longrightarrow 2SO_3$

b) i) From the equation:

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

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

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

$50cm^3$ of SO_2 + $25cm^3$ of $O_2 \longrightarrow 50cm^3$ of SO_3.

b) ii) Volume of O_2 that remained unreacted:

= 50 – 25 = $25cm^3$

c) Catalyst, V_2O_5

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

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

e) - Acid rain which:

Increases soil acidity

dissolves minerals away (soil infertility destroys stone works of buildings.

Answer to question 17

a) 9 electrons

b) 2, 8, 8, 2.

c) Mg, Ca.

d) Mg_3

e) Mg, S, Al.

f)

$$H\bullet x\overset{\overset{\overset{H}{\underset{\scriptstyle x}{}}}{}}{\underset{\underset{\underset{H}{\underset{\scriptstyle x}{}}}{}}{C}}x\bullet H$$

Answer to question 18.

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

i.e $Zn_{(s)} + CuSO_{4(aq)} \longrightarrow ZnSO_{4(aq)} + Cu_{(s)}$

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

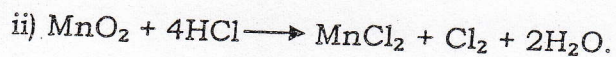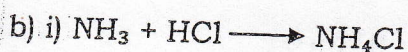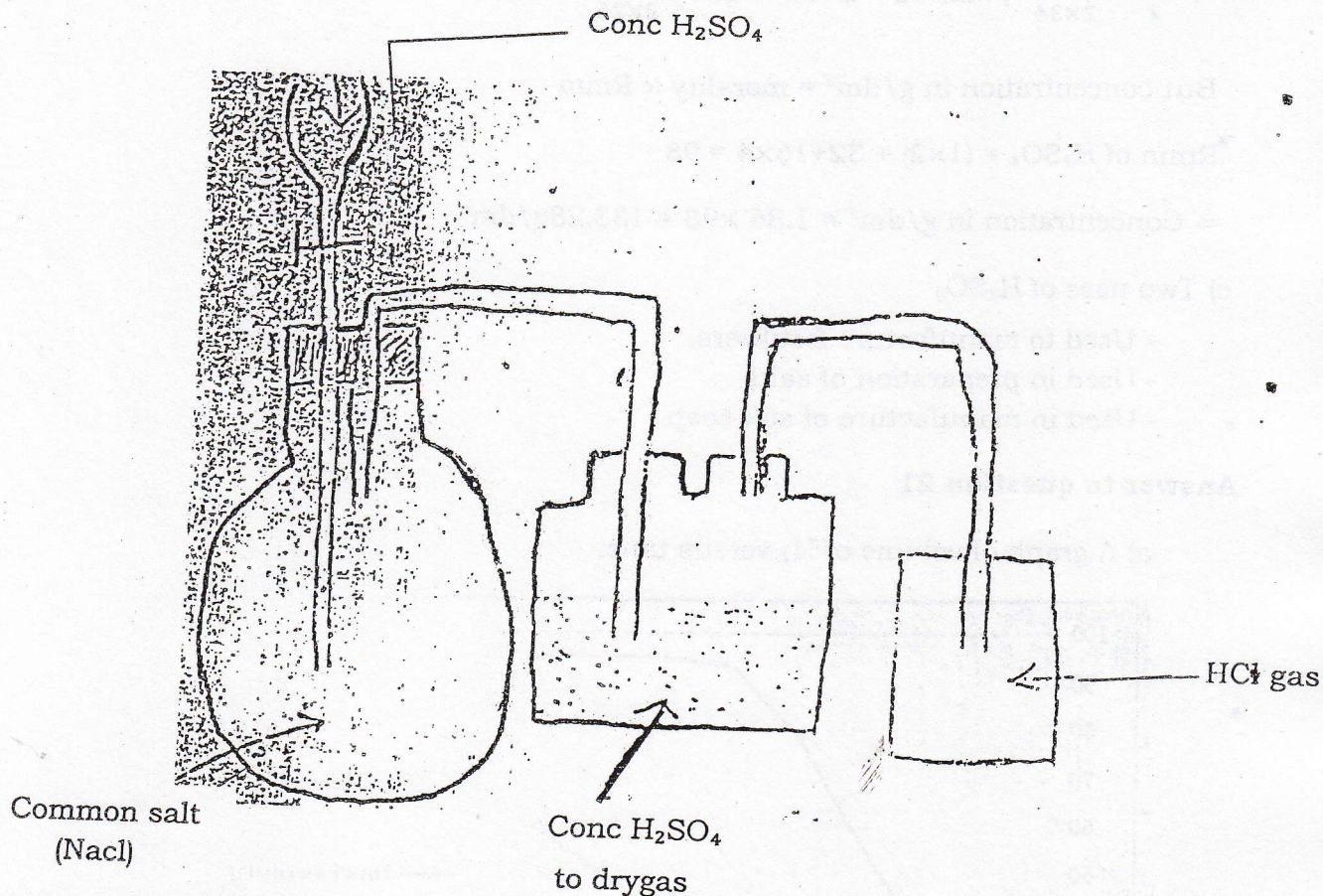b) $ZnSO_{4(aq)} + BaCl_{2(aq)} \longrightarrow BaSO_{4(s)} + ZnCl_{2(aq)}$

ionically,

$Zn^{2+}_{(aq)} + SO^2_{(aq)} \div Ba^{2+}_{(aq)} + 2Cl^-_{(aq)} \longrightarrow BaSO_{4(s)} + Zn^{2-}_{(aq)} + 2Cl^-_{(aq)}$

ionic equation: $Ba^{2+}_{(aq)} + SO_4^{2-}_{(aq)} \longrightarrow BaSO_{4(s)}$

Answer to question 19.

a)

Conc H_2SO_4

Common salt
(Nacl)

Conc H_2SO_4
to drygas

HCl gas

b) i) $NH_3 + HCl \longrightarrow NH_4Cl$
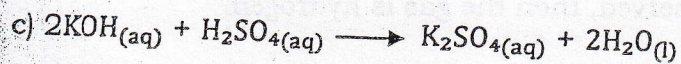
ii) $MnO_2 + 4HCl \longrightarrow MnCl_2 + Cl_2 + 2H_2O.$
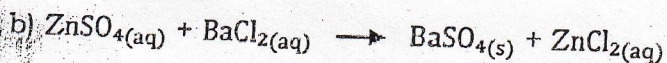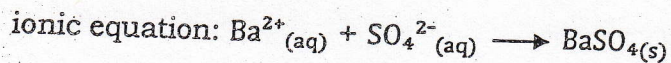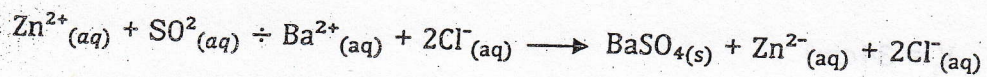
SECTION C

Answer to question 20

a) Burret, Pippet, Conical flask

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

c) $2KOH_{(aq)} + H_2SO_{4(aq)} \longrightarrow K_2SO_{4(aq)} + 2H_2O_{(l)}$

Number of moles of KOH $= \dfrac{2 \times 34}{1000} = \dfrac{68}{1000} = 0.068.$

d) Let, $M_a = 1$, $M_b = 2$

      $M_a = ?$, $M_b = 2$

      $V_a = 25cm^3$, $V_3 = 34cm^3$

$$\Rightarrow \frac{na}{nb} = \frac{Ma \times Va}{Mb \times Vb}$$

$$\Rightarrow \frac{1}{2} = \frac{Ma \times 25}{2 \times 34}; \; Ma \times 50 = 2 \times 34 \Rightarrow Ma = \frac{2 \times 34}{2 \times 25} = 1.36M.$$

But concentration in g/dm^3 = morality × Rmm

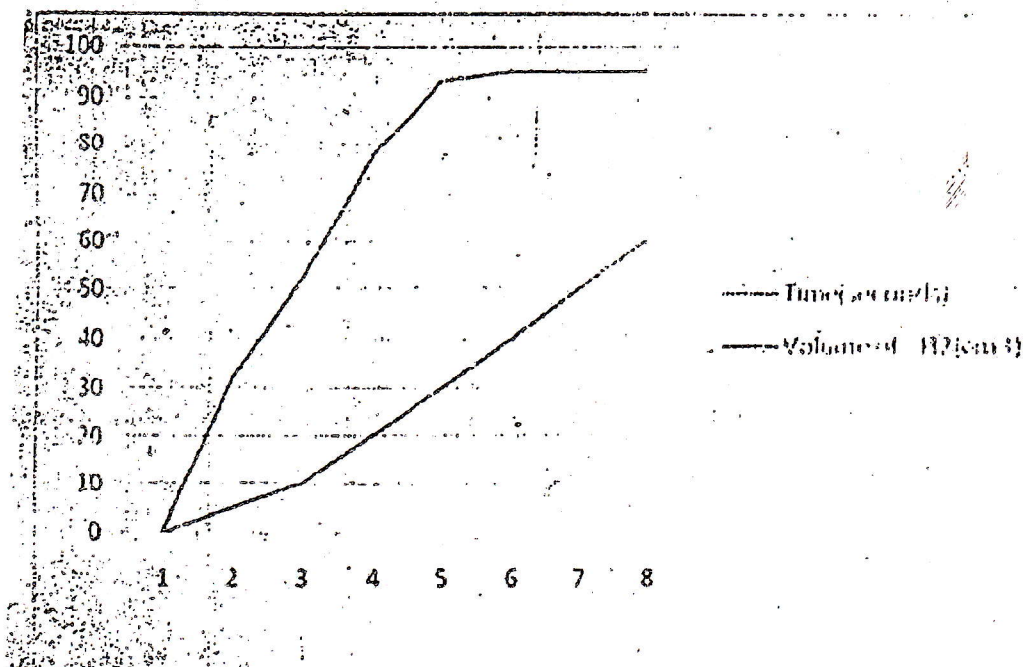Rmm of $H_2SO_4 = (1 \times 2) + 32 + 16 \times 4 = 98$

$\Rightarrow$ Concentration in $g/dm^3 = 1.36 \times 98 = 133.28 g/dm^3$

e) Two uses of H_2SO_4

    - Used to manufacture fertilizers.

    - Used in preparation of salts

    - Used in manufacture of soft soap

Answer to question 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.

Answer to question 22.

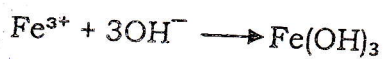To distinguish between each of the following substances.

a) $Zn(NO_3)_{2(aq)}$ and $Fe(NO_3)_{3(aq)}$

Reagent: Ammonia solution (NH_4OH)

With ZN^{2+}, a white ppt (precipitate) which dissolves in excess ammonia solution will be observed.
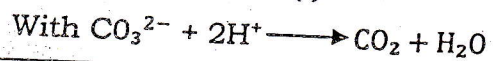
$$ZN^{2+} + 2OH^- \longrightarrow Zn(OH)_3$$

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

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

b) $Nacl_{(aq)}$ and $Na_2CO_{4(aq)}$

Reagent: Acidified silver nitrate solution.

With Cl^-, a white ppt observed,

$$Ag^+ + Cl^- \longrightarrow AgCl_{(s)}$$

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

c) Ethane and Ethanol

Reagent bromine water

Observations:

- With ethene: it decolorizes bromine water.
- With Ethanol: no observable change

d) SO_2 and CL_2 gases

Reagents: Acidified $KMnO_4$ or $K_2Cr_2O_2$

Using $KMnO_4$ (purple)

- With $SO_2 \longrightarrow$ the purple color of $KMnO_4$ turns to colorless.

- With Cl_2, no observable change.

Using $K_2Cr_2O_7$

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

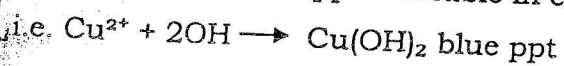- With $Cl_2 \longrightarrow$ no observable change.

e) $Pb(NO_3)_2$ and $CU(NO_3)_{2(S)}$

Reagents NaOH solution

Observations:

With Pb^{2+}, a white ppt soluble in excess NaOH solution to form a colorless solution.

$Pb^{2+} + 2OH \longrightarrow Pb(OH)_2$ white ppt

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

i.e. $Cu^{2+} + 2OH \longrightarrow Cu(OH)_2$ blue ppt

Or Reagent NH_3 (aq)

With $Pb^{2+} \longrightarrow$ a white ppt soluble in excess NaOH.

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

END.