# Chemistry I

# 002

04/11/2014 8.30AM – 11.30AM

REB
Rwanda Education Board

ORDINARY LEVEL NATIONAL EXAMINATION 2014

SUBJECT : CHEMISTRY I

DURATION : 3 HOURS

INSTRUCTIONS:

1) Do not open this paper until you are told to do so.
2) This paper consists of **THREE** Sections A, B and C.
   1) Answer **ALL** the questions in section A. **(55 marks)**
   2) Answer **THREE** questions in section B. **(30 marks)**
   3) 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.**

**SECTION A: ATTEMPT ALL QUESTIONS. (55 marks)**

1. One of the types of bonding is "metallic".
   a) Draw a labeled 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:
   a) Melting point b) Fluid. **(4 marks)**

3. The equation for the reaction between aqueous lead II nitrate and aqueous potassium iodide is shown below:

   $Pb(NO_3)_{2(aq)} + 2KI_{(aq)} \longrightarrow PbI_{2(s)} + 2KNO_{3(aq)}$

   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. **(2 marks)**
   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 color 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 the 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 100cm³ 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 20cm³ of 2M HCl. (2 moles per litre) solution. **(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.

$2\,Cu(NO_3)_{2(s)} \longrightarrow 2CuO_{(s)} + 4NO_{2(g)} + O_{2(g)}$

(1 mole of a gas occupies 24dm³ at room temperature and pressure;
Atomic mass: Cu = 63.5, N = 14, O =16).

## SECTION B: ATTEMPT ANY THREE QUESTIONS. (30 marks)

16. A student pours (titrates) 30ml of a 0.1 M aqueous sodium hydroxide from a burette into a beaker containing 25 cm³ of a 0.1M 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) Dilute 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 labeled diagram for the preparation of ammonia gas in the laboratory. **(4 marks)**

b) Write a balanced equation of reaction between ammonium chloride and calcium hydroxide. **(2 marks)**

c) By giving an 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 60g $mol^{-1}$. 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: $C_{(s)} + H_2O_{(g)} \longrightarrow CO_{(g)} + H_{2(g)}$

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 mol of a gas occupies 24$dm^3$ 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 unlabeled. It is known that one is chlorine and the other is hydrogen chlorine. 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. a) 25 $cm^3$ of a 0.12M sodium hydroxide solution was neutralized 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:

$H_2X + 2NaOH \longrightarrow Na_2X + 2H_2O$

b) Mention 2 uses of sulphur. **(2 marks)**

c) Write an equation of reaction between chlorine gas a phosphorous. **(2 marks)**

d) Briefly explain the reason why a mixture of 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 unsaturated hydrocarbon that contains 4 carbon atoms. **(1 mark)**

b) Magnesium reacts with oxygen in air to form magnesium oxide.

$2Mg + O_2 \longrightarrow 2MgO$

If the yield (MgO produced) of the reaction is 100%, calculate the mass of magnesium oxide formed when 6g 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. **(2 marks)**
(ii) Mention two uses of pentane on a large scale. **(2 marks)**

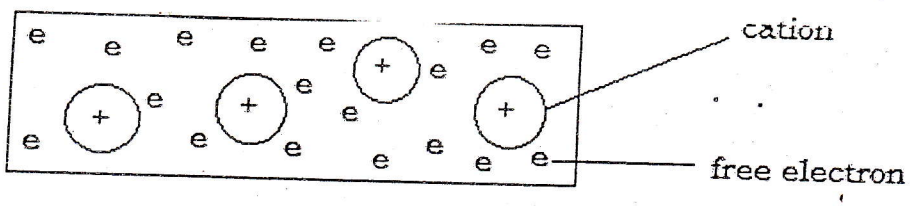
d) Write the name of a hydrocarbon derivative that can cause an environment hazard in the atmospheric ozone layer. **(1 mark)**

**END**

**CHEMISTRY III 2014**

**SECTION A**

1. a) Metallic bonding



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.

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) $2Na + 2H_2O \longrightarrow 2NaOH_{(aq)} + H_{2(g)}$
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.
- Its 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 so supports combustion.

7. a) Mass of metal M = 6.4g
Mass of oxygen = 8g – 6.4 = 1.6g

| M | : | O |
|---|---|---|
| $\frac{6.4}{64}$ | : | $\frac{1.6}{16}$ |
| $\frac{0.1}{0.1}$ | : | $\frac{0.1}{0.1}$ |
| 1 | : | 1 |

∴ Empirical formula of the metal oxide is MO

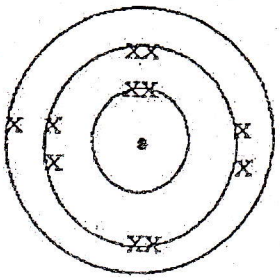
b) $MO_{(S)} + H_{2(g)} \longrightarrow M_{(S)} + H_2O_{(l)}$

8. a) Name: Calcium oxide (quick lime), Carbon dioxide (carbonic gas)
Or chemical formula: CaO, $CO_2$
Or $CaCO_{3(S)} \xrightarrow{\Delta} CaO + CO_2$

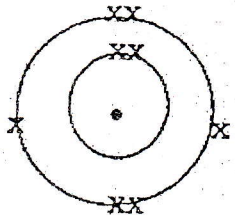
b) $NaO_{(S)} + H_2O_{(l)} \longrightarrow NaOH_{(aq)}$

9.

a) Sodium



b) Oxygen



**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
- Transparent as thin sheet
- Not lustrous (not shiny)
- Non-metals form acidic oxides
- They have a low density
- They do not ring when hit
- Not attracted by magnets
- ionize by gaining electrons
- High electronegativity
- They form covalent bonds
- non- electrolytes

**11. a)** $FeS + 2HCl \longrightarrow H_2S + FeCl_2$

**b)** Displacement reaction:
$Zn_{(S)} + ZnSO_{4(aq)} + Cu_{(S)}$

**13. a)** $3H_{2(g)} + N_{2(g)} \rightleftharpoons 2NH_{3(g)}$

**b)** Fe, $CO_2O_3$, $Fe_2O_3$, $Fe_3O_4$

**14. a)** Number of moles $= \frac{Mass}{Molar\ mass}$

Molar mass of NaCl = 23 + 35.5 = 58.5g

Number of moles $= \frac{12}{58.5} = 0.205$mole

Concentration $= \frac{number\ of\ moles}{volume\ (l)}$

Morality of NaCl $= \frac{0.205\ mole}{0.1l}$

= 2.05mole/litre

**12. a)** Ions at anode: $SO_4^{2-}$ , $OH^-$

**b)** ions at cathode: $H^+$

**15.** $2\,Cu(NO_3)_{2(s)} \longrightarrow 2CuO_{(s)} + 4NO_{2(g)} + O_{2(g)}$

Molar mass of $Cu(NO_3)_2$ :
$= 63.6 + 2(14 + 13 \times 16) = 187.5$g/mol

Number of moles in 42g $= \frac{42}{187.5}$
= 0.224 moles

According to the equation:

1 mole of $Cu(NO_3)_2$ produces 2 moles of $NO_2$

So number of moles of $NO_2$
$= 2 \times 0.224 = 0.448$ mole

Volume $= 0.448 \times 24 = 10.752 dm^3$

**14. b)** Morality $= \frac{number\ of\ moles}{volume\ (l)}$

Number of moles = morality × volume (l) $\Leftrightarrow 20cm^3 = 20 \times 10^{-3} l = 0.02l$

Number of moles $= \frac{2\ mole}{l}\ 0.02l = 0.04$ mole

**SECTION B**

**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)** $H^+ + OH^- \longrightarrow H_2O$ OR $H_3O^+ + OH^- \longrightarrow 2H_2O$

**c) i)** An acid is a substance that liberates $H^+$ ions Or it's a substance that accepts electrons.

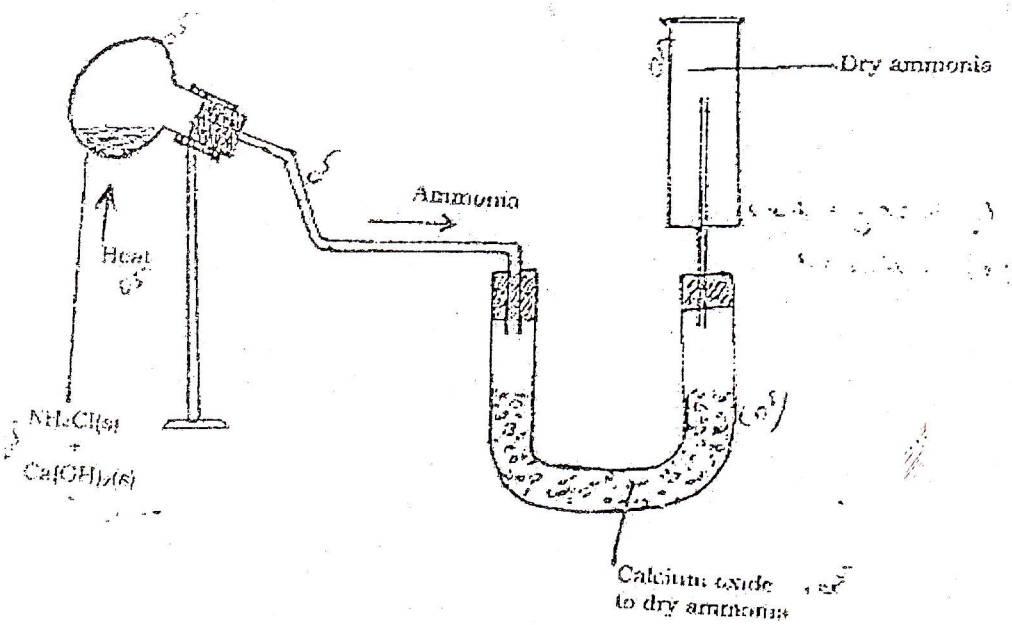
**ii)** A strong acid is that which dissociates completely to give $H^+$ ions while a weak acid dissociates partially to give few $H^+$ ions.

Or a weak 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

**d)** $Mg_{(S)} + H_2SO_4 \longrightarrow MgSO_{4(aq)} + H_{2(g)}$

**17. a)**




**b)** $Ca(OH)_{2(S)} + 2NH_4Cl_{(S)} \longrightarrow CaCl_{2(S)} + 2H_2O_{(l)} + 2NH_{3(g)}$

**c)** $Ca(HCO_3)_2 \xrightarrow{\text{heat}} CaCO_{3(S)} + H_2O_{(l)} + CO_{2(g)}$

Temporary hard water is heated so that $Ca(HCO_3)_2$ decomposes to get the precipitate $CaCO_3$ that 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 $MgSO_4$

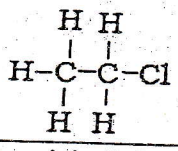
**18. a) i)** Homologous series is a series of compounds with the same general formula but varying by the length of the carbon chain.

**ii)** Alkane is a compound that is saturated constituting of carbon and hydrogen atoms only.

**b)** $2C_4H_{10} + 13O_2 \longrightarrow 8CO_2 + 10H_2O$ OR $C_4H_{10} + \frac{13}{2}O_2 \longrightarrow 4CO_2 + 5H_2O$

**c) i)** $C_2H_4 + HCl \longrightarrow CH_3CH_2Cl$

ii) Addition reaction



**19. a) i)** Empirical formula of the compound:

| C | : | H | : | O |
|---|---|---|---|---|
| $\frac{40}{12}$ | : | $\frac{6.67}{1}$ | : | $\frac{53.33}{16}$ |
| $\frac{3.33}{3.33}$ | : | $\frac{6.67}{3.33}$ | : | $\frac{3.33}{3.33}$ |
| 1 | : | 2 | : | 1 |

Empirical formula is $CH_2O$

**ii)** Molecular formula of the compound:

$(CH^2O)_n = 60$

$12 + 2 + 16)n = 60$

$30n = 60$

$n = 2$

Molecular formula is $C_2H_4O_2$

**b) i)** $C_{(s)} + H_2O_{(g)} \longrightarrow CO_{(g)} + H_{2(g)}$

12g of C ⟶ 18g of $H_2O$

40g of C ⟶ x g of $H_2O$

$\frac{x}{40} = \frac{18}{12} \longrightarrow x = \frac{18}{12} \times 40$

x = 60g of $H_2O$

**ii)** Number of moles of $CO_{(g)}$ = number of moles of C = $\frac{40}{12}$

Volume of carbon monoxide = $\frac{40}{12} \times 24dm^3$

$= 80dm^3$

**c)** $2H_{2(g)} + O_{2(g)} \longrightarrow 2H_2O_{(g)}$

**20. a)** At low PH, the speed of corrosion is high, so the more acid the solution is, the more the rate of corrosion.

**b)** Carbon, nickel, manganese, aluminium, paint, oil, silver, chromium, zinc, tin, copper, enamel.

**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 color, blue litmus paper turns red

**d) i)** $2KI_{(aq)} + Cl_{2(g)} \longrightarrow I_{(S)} + 2KCl_{(aq)}$

**ii)** Displacement or oxidation or redox, substitution or reduction reaction.

**SECTION C:**

**21. a) i)** Number of moles of NaOH = $\frac{25}{1000} \times 0.12 = 0.003$ mole

**ii)** Equation: $H_2X + 2NaOH \longrightarrow Na_2X + 2H_2O$

Number of mole sof the dibasic acid = $\frac{1}{2} \times 0.003 = 0.0015$ mole

Morality of the cid $H_2X = \frac{number\ of\ moles}{Volume\ (l)} = \frac{0.0015}{0.003} = 0.05mole/l$

**iii)** Molar mass = $\frac{Mass}{Number\ of\ moles} = \frac{6.3g/l}{0.05mole/l} = 126g\ mol$

∴ Rmm = 126

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) $2P_{(S)} + 5Cl_{2(g)} \longrightarrow 2PCl_{5(g)}$
OR: $2P + 3Cl_2 \longrightarrow 2PCl_5$
$P_4 + 10Cl_2 \longrightarrow 4PCl_5$
$P_4 + 6Cl_2 \longrightarrow 4PCl_3$

a) The reaction between chlorine and hydrogen gas is very exothermic, so it releases a lot of energy to cause explosion

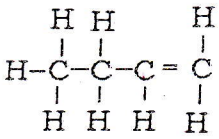
b) Chlorine reacts with materials to remove the coloring matter so that materials are not colored later. (changes the color of a material)

c) A brown solid of $FeCl_3$ is observed
$2Fe + 3Cl_2 \longrightarrow 2FeCl_3$

22. a) i) Functional group is a specific group of atoms or bonds within a molecule that is responsible for characteristic chemical reacts of the molecule.
Examples include: $CH_3CH_2\mathbf{OH}$ (group OH)
$CH_3\mathbf{COOH}$ (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 = 40g/mol

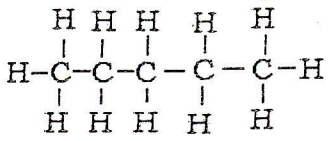
24g of Mg $\longrightarrow$ 40g of MgO

6g of Mg $\longrightarrow$ × g of MgO

$\frac{x}{6} = \frac{40}{24} \Rightarrow x = \frac{40}{24} \times 6$

Mass of Magnesium oxide (MgO) formed = 10g.

c) i) Molecular formula of pentane: $C_5H_{12}$ and the structural formula of pentane is:



ii) Two use of pentane:
Combustion in domestic cookers, To produce hydrogen gas when cracked, Use as fuel, Used as a solvent

d) Trichlorofluoromethane

**END**