THE KENYA NATIONAL EXAMINATIONS COUNCIL
Kenya Certificate of Secondary Education

233/1 — CHEMISTRY — Paper 1

(THEORY)

Mar. 2021 – 2 hours

Ex No 1363

Name ... Index Number ...

Candidate's Signature ..... Date .....

233/1

Instructions to Candidates

(a) *Write your name and index number in the spaces provided above.*
(b) *Sign and write the date of examination in the spaces provided above.*
(c) *Answer **all** the questions in the spaces provided in the question paper.*
(d) ***Non-programmable** silent electronic calculators and KNEC mathematical tables may be used.*
(e) *All working **must** be clearly shown where necessary.*
(f) ***This paper consists of 16 printed pages.***
(g) ***Candidates should check the question paper to ascertain that all the pages are printed as indicated and that no questions are missing.***
(h) ***Candidates should answer the questions in English.***

For Examiner's Use Only

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16

17	18	19	20	21	22	23	24	25	26	27	28	Grand Total

1. Element A has mass number 40 and 21 neutrons.

(a) Write the electron arrangement of element **A**. (1 mark)

No of electrons 40−21 = 19 ½

Electron arrangement 2.8.8.1 ½

Accept 2 8 8 1 / 2 8 8 2 1 / 2 8 8 2 : 1

(b) Give the formula of the compound formed when element **A** reacts with sulphur. (S = 16.0) (1 mark)

A_2S OR SA_2 OR K_2S OR SK_2

2. Study the setup in **Figure 1** and then answer the questions that follow.

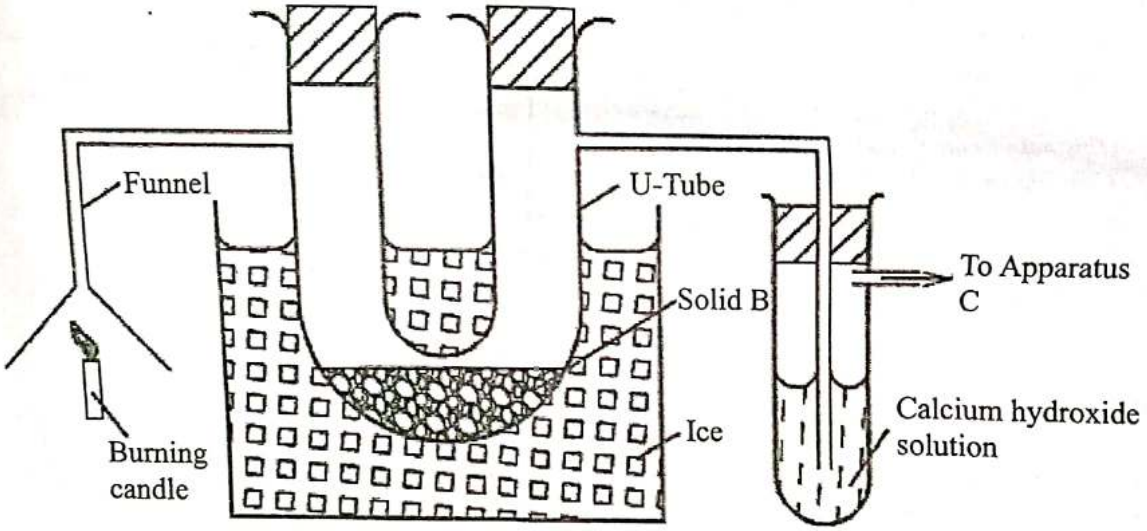


Figure 1

(a) At the end of the experiment, solid **B** changed from white to blue. Explain. (1 mark)

Solid B becomes hydrated hence turns from white to blue ✓

OR

Burning candle produces water ½ which combines with solid B to make it hydrated ½.

(b) The other product of the burning candle formed a white precipitate with the calcium hydroxide solution. Write an equation for the reaction. (1 mark)

$CO_{2(g)} + Ca(OH)_{2(aq)} \longrightarrow CaCO_{3(s)} + H_2O_{(l)}$

(Wrong state — Penalise symbols ½)

(c) State the role of apparatus C. (1 mark)

To suck the gaseous product from the system

OR Accept — to pull
— pumping the products
— Remove the products

Rej: to push

3. (a) State and explain the factors that are considered when collecting a gas by displacement of:

(i) air; (1 mark)

Density of the gas ✓½

If the gas is lighter than air — upward delivery or downward displacement of air ✓½.

OR

If the gas is denser than air — downward delivery

Accept either of the explanation without stating

Correct Explanation without stating

(ii) water. (1 mark)

Solubility in water

If the gas is insoluble or slightly soluble in water

(b) Other than collecting a gas by displacement of air or water, state another method that can be used to collect a gas. (1 mark)

— gas syringe
— Solidification — SO_2
— Condensation
— freezing
— Collection over mercury.
— Liquidfraction

4. (a) Carbon(II) oxide was passed over 4.1 g of heated oxide of copper in a combustion tube until there was no further change. The mass of the final substance was found to be 3.29 g. Complete **Table 1** and determine the empirical formula of the oxide.

(Cu = 64.0; O = 16.0)

Table 1

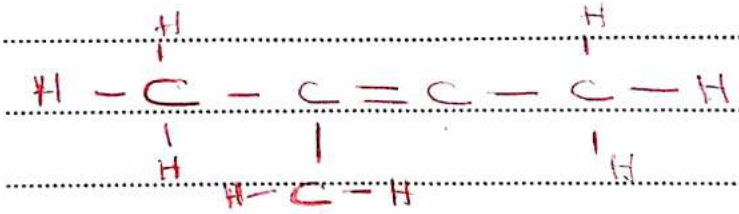
Element	Cu	O
Mass (g)	3.29	0.81 ✓ ½
Number of Moles	$\frac{3.29}{64}$ 0.051 ✓ ½	$\frac{0.81}{16}$ 0.051 ✓ ½
	mole ratio 1	1

Empirical formula ..... CuO ✓ ½ ..... (2 marks)

(b) State the property of carbon(II) oxide that was demonstrated in the experiment. (1 mark)

..... Reducing agent / reducing property .....

5. (a) Draw the structural formula of 2-methylbut-2-ene. (1 mark)



(b) Bromine water was added to 2-methylbut-2-ene.

(i) State the observation made. (1 mark)

..... Bromine water is decolourised / orange/brown/yellow bromine turns to colourless .....

(ii) Name the type of the reaction that took place. (1 mark)

..... Addition Rxn .....

6. Table 2 shows pH values of solutions of compounds **D, E, F** and **G**.

Table 2

Compound	D	E	F	G
pH value of solution	2	5	7	13

(a) State which one of the compounds is likely to be:

(i) sodium chloride; (1 mark) (½ mark)

F or PH 7

(ii) ammonium nitrate. (1 mark) (½ mark)

E or PH 5

(b) Select *two* compounds that can be used to illustrate the amphoteric nature of an oxide. (1 mark)

Marked independently → ½ ½ ½ ½

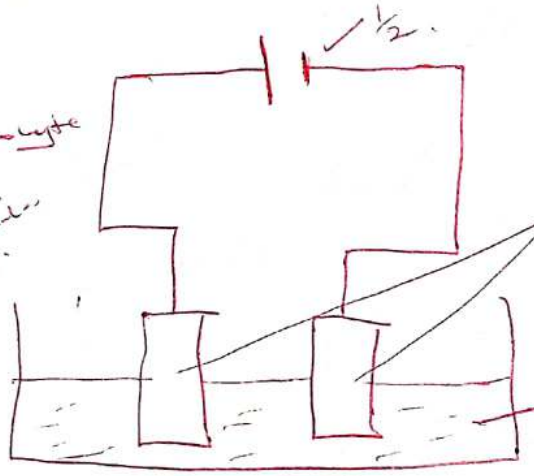
D and G or 2 and 13

(c) Give a reason for the answer in (b). (1 mark)

Amphoteric oxides react with both strong acids/acids and alkalis.

OR Amphoteric oxide behave as acids or bases.

7. Draw a labelled diagram of the setup of apparatus that can be used to electrolyse lead(II) bromide. (3 marks)



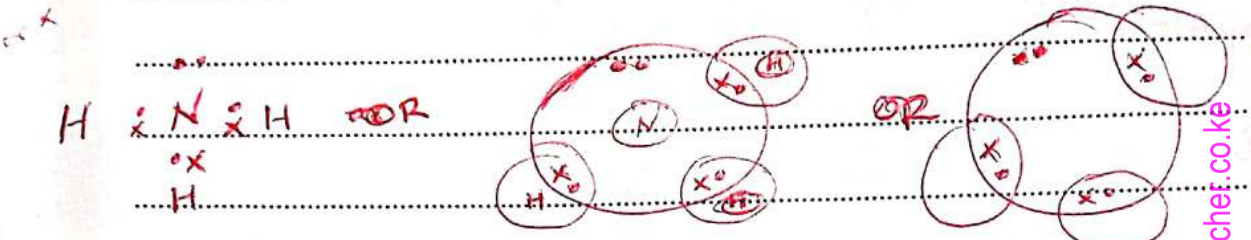
Reconcability.
- Electrodes are above the electrolyte
- cells
- Heat
- Anodes and cathodes correctly labelled.

8. (a) State the difference between a covalent bond and a dative covalent bond. (1 mark)

In covalent shared electrons are contributed by both species/atoms while in dative, the shared electrons are from one of the atoms or species.

(b) Using dots (•) and crosses (x) to represent electrons, draw a diagram to show the bonding in ammonia. (1 mark)

Accept ½ if only one pair



(c) Using the diagram in (b), state ***one*** property that makes ammonia react with hydrogen ion. (1 mark)

- Nitrogen in ammonia contain a lone pair of electrons ✓ OR
- presence of lone pair of electrons / unshared pair of e-

9. **Figure 2** shows a reaction scheme starting with copper turnings. Study it and answer the questions that follow.

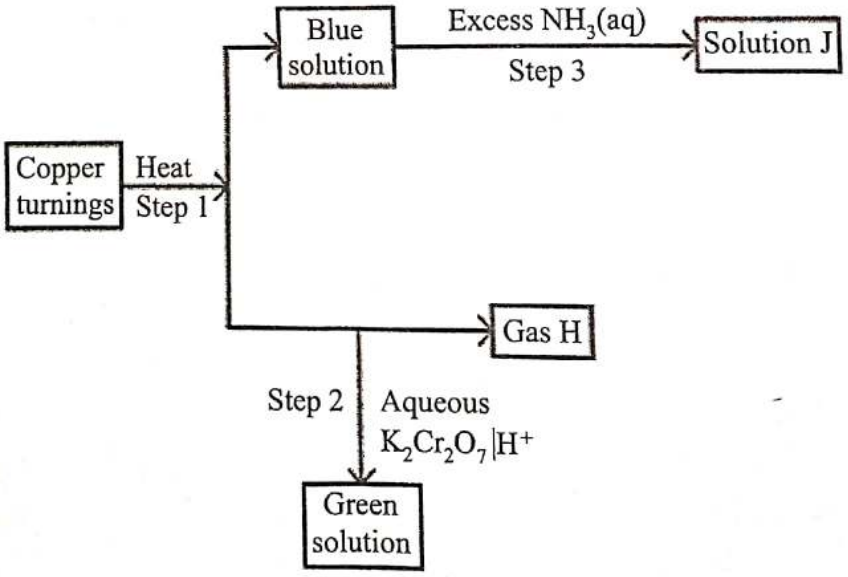


Figure 2

(a) State the reagent that is added in step 1. (1 mark)

Rej. dilute or $H_2SO_4(aq)$.

Conc. Sulphuric(VI) acid Conc. H_2SO_4 or Sulphuric(VI) acid

(b) Identify gas H ..... (1 mark)

SO_2 or Sulphur(IV) oxide

(c) Write the formula of the complex ion in solution J. (1 mark)

$[Cu(NH_3)_4]^{2+}$ 2+

10. When chlorine is bubbled through hot concentrated sodium hydroxide solution, sodium chlorate(V), sodium chloride and water are formed.

(a) Write an equation for the reaction. (1 mark)

$3Cl_2(g) + 6NaOH(aq) \rightarrow NaClO_3(aq) + 5NaCl(aq) + 3H_2O(l)$

(b) Sodium chlorate(V) and sodium chloride have different solubilities in water. Name a method that can be used to separate the salts. (1 mark)

Fractional crystallisation

(c) Give *one* use of sodium chlorate(V). (1 mark)

- Herbicides
- Mnf of dyes
- Bleaching agent
- In fireworks and explosives/matches
- Treatment of sewage

11. Excess dilute hydrochloric acid was added to an alloy of copper and zinc in a beaker.

(a) State the observations made. (2 marks)

fizzing / effervescence / production of gas bubbles ✓1

Colourless solution formed ✓½

Brown residue/solid ✓½

(b) Excess aqueous sodium hydroxide was added to 2 cm^3 of the solution obtained in the reaction. Write an ionic equation for the reaction that occurred. (1 mark)

$Zn^{2+}(aq) + 4OH^-(aq) \rightarrow [Zn(OH)_4]^{2-}(aq)$

OR

$Zn(OH)_2(s) + 2OH^-(aq) \rightarrow [Zn(OH)_4]^{2-}(aq)$

12. Study the information in **Table 3** and answer the questions that follow. The elements belong to the same chemical family. (The letters are not actual symbols of the elements).

Table 3

Element	Atomic radius (nm)	Ionic radius (nm)	Ionisation energy kJ/mol
L	0.157	0.095	494
K	0.203	0.133	418
M	0.123	0.060	519
N	0.235	0.169	376

(a) Classify the elements as either metals or non-metals. Give a reason. (1 mark)

Metals ✓ ½ Ionic radius is smaller than corresponding atomic radius / vice versa ✓ ½

(b) (i) Identify the element which is

I. least reactive M. ½ ..... (½ mark)

II. most reactive N ½ ..... (½ mark)

(ii) Give a reason for the answer in b (i). (1 mark)

The more the ionization energy the less the reactive or the less the ionization energy the more the reactive / OR use atomic radius to explain.

13. Nitrogen(IV) oxide is prepared by heating lead(II) nitrate.

(a) Write an equation for the reaction. (1 mark)

$2Pb(NO_3)_{2(s)} \xrightarrow{Heat} 2PbO_{(s)} + 4NO_{2(g)} + O_{2(g)}$

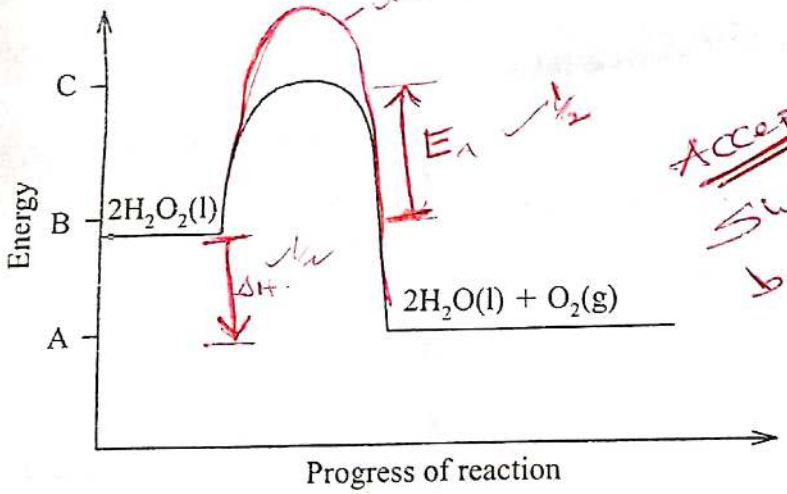
(b) At room temperature, nitrogen(IV) oxide exists as an equilibrium mixture with dinitrogen tetraoxide.

$2NO_2(g) \rightleftharpoons N_2O_4(g)$; Δ is −ve
(brown) (pale yellow)

State the observation made when the mixture is placed in an ice-bath. Give a reason. (2 marks)

Mixture turns yellow / Yellow colour intensifies ✓1
- Decrease in temp, forward is favoured / more N_2O_4 is formed since the rxn is exothermic ✓½ ✓½

14. **Figure 3** shows an energy level diagram for the decomposition of hydrogen peroxide using a catalyst.



Uncatalysed ✓1
Accept ΔH and E_A shown on the diagram but penalise ½.

Figure 3

(a) Using the energy values **A**, **B** and **C**, write an expression for:

(i) ΔH of the reaction; (1 mark)

$\Delta H = A - B$ ✓1
OR Diagram drawn ½

(ii) activation energy. (1 mark)

$E_A = C - B$ ✓1

(b) On the same axis, sketch a curve that would be obtained if the reaction was carried out without a catalyst. (1 mark)

15. Sodium carbonate is prepared on large scale by the Solvay process. The equation for the main reaction that takes place in the carbonator is:

$$NaCl(aq) + NH_3(g) + CO_2(g) + H_2O(l) \rightarrow NH_4Cl(aq) + NaHCO_3(s)$$

(a) Describe how the sodium carbonate is obtained from the products of the carbonator. (1½ marks)

✓½.
The products are filtered to obtain $NaHCO_3$ as a residue.
— The residue is heated to obtain Na_2CO_3 ✓1
OR
The products are filtered then dried ✓1.

(b) One of the by-products of the Solvay process is calcium chloride. Explain how the calcium chloride is formed in this process. (1½ marks)

Calcium carbonate decomposes to form CaO and CO_2
— CaO reacts with water and then NH_4Cl to form $CaCl_2$.
OK. Use of equations correctly.

16. Methane reacts with bromine as shown in the following equation.

$$CH_4(g) + Br_2(g) \rightarrow CH_3Br(g) + HBr(g)$$

Using the bond energies in **Table 4**, calculate the enthalpy change, ΔH for the reaction.

Table 4

Bond	Bond energy (kJ mol^{-1})
C – H	412
C – Br	276
Br – Br	193
H – Br	366

(3 marks)

Bonds broken
C–H
Br–Br
Energy absorbed
412 + 193
= 605 kJ

Bond formed
C–Br
H–Br
Energy released
276 + 366
= 642 kJ

ΔH = 605 − 642
= −37 kJ/m

OR

B.B
(4 × 412) + 193
= +1841

B.F
(3 × −412) + −276 + −305
= −1878

ΔH = 1841 + −1878
= −37 kJ/m

17. Some compounds such as CFCs and DDT are regarded as environmental pollutants. Give the complete names of:

(a) CFCs; (1 mark)

Chlorofluorocarbons

(b) DDT. (1 mark)

Dichlorodiphenyltrichloroethane.

18. Use the information in **Table 5** to answer the questions that follow.

Table 5

Liquid	Boiling point (°C)	Miscibility with water
Propanone	56	Miscible
Octane	126	Immiscible
Water	100	–

(a) State the method that can be used to separate propanone and water. (1 mark)

Fractional distillation / distillation

(b) Describe how a mixture of water and octane can be separated. (2 marks)

– Place the mixture on a separating funnel / dropping funnel / burette
– Run down the bottom layer
– Discard the interphase.

OR

– Use of a dropper
– Suck the top layer
– Suck the interphase and discard it

NB Penalise ½ if interphase is not discarded

$4P_{(s)} + 5O_{2(g)} \rightarrow 2P_2O_{5(s)}$

19. 6.2 g of phosphorus was reacted with excess oxygen to form phosphorus(V) oxide. Determine the mass of the oxide formed. (O = 16.0 ; P = 31.0) (2 marks)

Moles of P = $\frac{6.2}{31} = 0.2$ ✓½

Moles of $P_2O_5 = \frac{1}{2} \times 0.2 = 0.1$ mole

RFM of $P_2O_5 = (31 \times 2) + (16 \times 5) = 142$

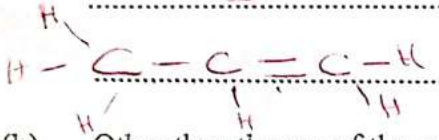
mass of $P_2O_5 = 142 \times 0.1 = 14.2$ g ✓ Final answer same

20. Compound **V** reacts with water as shown in the following equation.

$$V + H_2O \rightarrow CH_3CH_2CH_2OH$$

(a) Give the structural formula of compound **V**. (1 mark)

$CH_3CH=CH_2$ or CH_3CHCH_2 or



(b) Other than the use of the catalyst, name another condition necessary for this reaction. (1 mark)

Heat or Pressure of 60 – 70 atmosphere
Temp of 250 – 300°C.

Repeating

(c) This type of reaction is called hydrolysis or hydration. State another name that can be used to describe the reaction. (1 mark)

Addition or oxidation

21. Salts may be classified as soluble or insoluble.

(a) Select from the following list a pair of compounds that can be used to prepare a soluble and an insoluble salt.

HNO_3, $Pb(NO_3)_2$, KNO_3, BaO, NaCl

(i) Soluble salt (1 mark)

HNO_3 and BaO ✓

(ii) Insoluble salt (1 mark)

$Pb(NO_3)_2$ and NaCl ✓

(b) Describe how a soluble salt is obtained from its solution. (1 mark)

Heat / Boil ✓½

- Evaporate the mixture to saturation
- Allow to cool ✓½.
- Filter the residue

22. (a) State *one* factor that affects the preferential discharge of ions at the cathode. (1 mark)

- Nature of the electrode
- Concentration

- Position of the element in the reactivity series.
- position on the electrochemical series.

(b) Sodium sulphate was electrolysed using inert electrodes. Write the equation for the reaction that takes place at the:

(i) cathode; (1 mark)

$2H^+_{(aq)} + 2e^- \longrightarrow H_{2(g)}$ OR

$4H^+_{(aq)} + 4e^- \longrightarrow 2H_{2(g)}$

(ii) anode. (1 mark)

$4OH^-_{(aq)} \longrightarrow 2H_2O_{(l)} + O_{2(g)} + 4e^-$

23. Consider the following reaction.

$$H_2S + Cl_2 \rightarrow 2HCl + S$$

Determine the oxidation numbers of chlorine and sulphur in the reactants and products. (2 marks)

	Reactants	Products
Sulphur	−2 ✓½	0 ✓½
Chlorine	0 ✓½	−1 ✓½

24. (a) A volume of sulphur(IV) oxide gas diffused from an apparatus in 96 seconds.

Calculate the time taken by an equal volume of carbon(IV) oxide to diffuse under the same conditions. (C = 12.0 ; O = 16.0 ; S = 32.0) (1 mark)

RMM of SO_2 = 64 ✓½
RMM of CO_2 = 44

$\frac{r_{SO_2}}{t_{CO_2}} = \sqrt{\frac{64}{44}}$ ✓½

t_{CO_2} = 79.60 s

1½

(b) The rate of diffusion of neon was found to be 1.45 times faster than that of an equal volume of gas **X** at room temperature. Determine the relative formula mass of gas **X** (Ne = 20.0). (2 marks)

$\frac{R_{Ne}}{R_X} = 1.45$

$\sqrt{\frac{m_X}{20}} = 1.45$ ✓½

$m_X = 2.102 \times 20$ ✓½

$= 42.05 = 42$ ✓½

(1½)

25. Complete combustion of one mole of an alkanol, C_xH_yOH gave four moles of water. (C = 12.0, H = 1.0, O = 16.0)

$2C_xH_yOH + O_2 \rightarrow CO_2 + 4H_2O$.

Determine the:

(a) values of x and y

(i) x $2x = 2 \times 2$ ✓1 (1 mark)

C_2H_7OH

(ii) y $y = 7$ ✓1 (1 mark)

(b) number of moles of oxygen required for the complete combustion. (1 mark)

3 moles

26. Radioactive decay of $^{228}_{90}Th$ gives **X**, $^{224}_{88}Ra$ and gamma radiation.

(a) Identify **X** ..... (1 mark)

(b) Write a nuclear equation for the decay. (1 mark)

.....

(c) The half-life of $^{228}_{90}Th$ is 1.9 years. If after 5.7 years the mass of $^{228}_{90}Th$ was found to be 1.25 g. Determine the initial mass of the radioactive isotope. (~~1 mark~~) (2 marks)

No. of half life = 5.7 / 1.9 = 3

1st 2nd 3rd ✓1

1.25 → 2.5 → 5.0 → 10.0

10.0g ✓1

27. **Figure 4** shows part of the structure of a polymer.

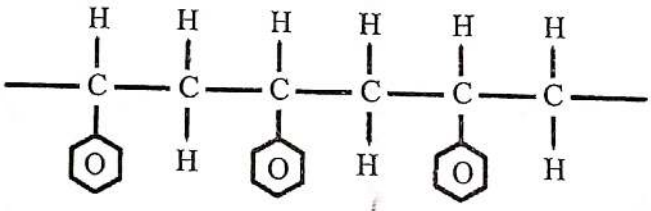
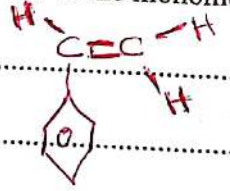


Figure 4

(a) Give the name of the polymer. (1 mark)

polyphenylethene or polystyrene.

(b) Draw the structure of the monomer used. (1 mark)



(c) Give ***one*** use of the polymer. (1 mark)

- Packaging materials
- Insulation
- Cutting boards.

28. **Figure 5** shows variation of number of outermost electrons **(a)** with atomic number of elements in the periodic table.

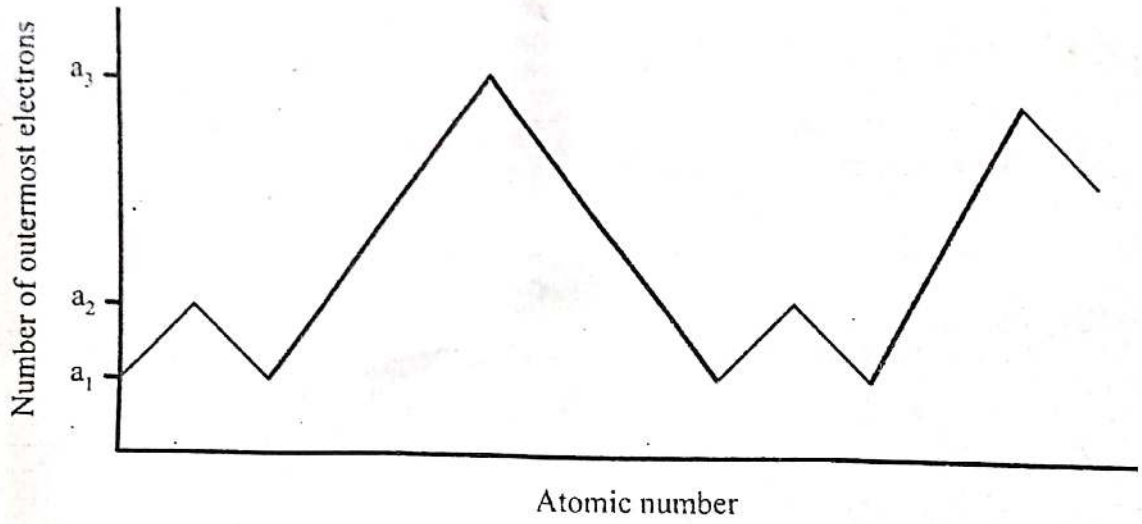


Figure 5

(a) Give the values of

(i) a_1 (1 mark)

1

(ii) a_3 (1 mark)

8

(b) State why elements with a_1 and a_2 outermost electrons do ***not*** react with each other. (1 mark)

- Have a tendency to loose electrons
- Both form positive ions
- Both of them are metals

THIS IS THE LAST PRINTED PAGE.