



ASSESSMENT and
QUALIFICATIONS
ALLIANCE

Mark scheme

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GCE

Chemistry

Unit CHM1

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SECTION A

Answer all questions in the spaces provided.

- 1 (a) The mass of one mole of ^1H atoms is 1.0078 g and that of one ^1H atom is 1.6734×10^{-24} g. Use these data to calculate a value for the Avogadro constant accurate to five significant figures. Show your working.

$$L = \frac{1.0078}{1.6734 \times 10^{-24}} \text{ (1) } \text{ or } \frac{\text{mass of 1 mol}}{\text{mass of 1 atom}} \text{ (must show working)}$$

$$= 6.0225 \times 10^{23} \text{ (1) } \text{ (ignore wrong units)}$$

(2 marks)

(n.b. answer only scores 1)

- (b) How does the number of atoms in one mole of argon compare with the number of molecules in one mole of ammonia?

equal (1) (or same or 1:1)

(1 mark)

- (c) A sample of ammonia gas occupied a volume of 0.0352 m^3 at 298 K and 98.0 kPa. Calculate the number of moles of ammonia in the sample. (The gas constant $R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$)

$$PV = nRT \text{ (or } n = \frac{PV}{RT} \text{) (1)}$$

$$= \frac{98000 \times 0.0352}{8.31 \times 298} \text{ (1)}$$

$$= 1.39 \text{ (1) (allow 1.390 to 1.395)}$$

(3 marks)

ignore units even if incorrect
answer = 1.4 loses last mark

- (d) A solution containing 0.732 mol of ammonia was made up to 250 cm³ in a volumetric flask by adding water. Calculate the concentration of ammonia in this final solution and state the appropriate units.

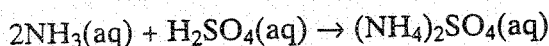
$$\frac{0.732 \times 1000}{250} = 2.93 \quad \text{mol dm}^{-3} \quad \text{or} \quad \begin{cases} \text{M} \\ \text{mol/dm}^3 \\ \text{mol l}^{-1} \text{ etc} \end{cases}$$

(1) (1)

(allow 2.928 to 2.93)

(note unit mark tied to correct answer but allow unit mark only if answer = 2.9 or 3) (2 marks)

- (e) A different solution of ammonia was reacted with sulphuric acid as shown in the equation below.



In a titration, 25.0 cm³ of a 1.24 mol dm⁻³ solution of sulphuric acid required 30.8 cm³ of this ammonia solution for complete reaction.

- (i) Calculate the concentration of ammonia in this solution.

if use $m_1v_1 = m_2v_2$ scores 3 if ans correct else zero
CE if $\times 2$ not used

$$\text{moles H}_2\text{SO}_4 = \frac{25}{1000} \times 1.24 = 0.0310 \quad (1)$$

$$\text{moles NH}_3 \text{ in } 30.8 \text{ cm}^3 = 0.0310 \times 2 = 0.0620 \quad (1) \quad \text{mark is for } \times 2$$

$$\text{moles NH}_3 \text{ in } 1 \text{ dm}^3 = \frac{0.0620 \times 1000}{30.8} = 2.01 \quad (1) \quad \text{allow to } 2.015$$

(mol dm⁻³)

- (ii) Calculate the mass of ammonium sulphate in the solution at the end of this titration.

wrong formula for $(\text{NH}_4)_2\text{SO}_4$
CE = 0

if moles of $(\text{NH}_4)_2\text{SO}_4$ not clear CE.

no units OK
wrong units lose last mark
allow conseq on
wrong moles in part if clear $\text{H}_2\text{SO}_4 = (\text{NH}_4)_2\text{SO}_4$
wrong units loses mark

$$\text{moles } (\text{NH}_4)_2\text{SO}_4 = \text{moles H}_2\text{SO}_4 = 0.0310 \quad (1)$$

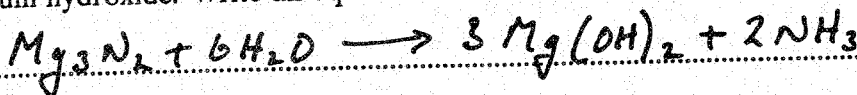
$$M_r (\text{NH}_4)_2\text{SO}_4 = 132.1 \quad (1) \quad \text{(allow 132)}$$

$$\text{mass} = \text{moles} \times M_r = 0.0310 \times 132.1 = 4.10 \quad (1) \quad (\text{g})$$

(allow 4.09 - 4.1 - 4.11)

(6 marks)

- (f) The reaction of magnesium nitride, Mg₃N₂, with water produces ammonia and magnesium hydroxide. Write an equation for this reaction.

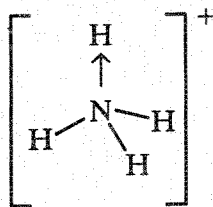


(2 marks)

formulae (1)

balanced equation (1)

- 2 (a) An ammonium ion, made by the reaction between an ammonia molecule and a hydrogen ion, can be represented as shown in the diagram below.



- (i) Name the type of bond represented in the diagram by N—H

covalent (1)

- (ii) Name the type of bond represented in the diagram by N→H

co-ordinate (1) (or dative)

- (iii) In terms of electrons, explain why an arrow is used to represent this N→H bond.

{ both electrons come from nitrogen (1)
or two
or pair

- (iv) In terms of electron pairs, explain why the bond angles in the NH_4^+ ion are all $109^\circ 28'$

4 { bonding electron pairs (1)

repel equally (1) or are identical

as far apart as possible (1) (or to position of minimum repulsion)

tetrahedron (1)

(7 marks)

- (b) Define the term electronegativity.

power (ability) of an { element atom to attract { electron pair electrons an electron electron density (1)
in a covalent bond (1)

(2 marks)

allow attract from
withdraw in

do not allow remove from
allow withdraw from

(c) A bond between nitrogen and hydrogen can be represented as $\overset{\delta-}{\text{N}}-\overset{\delta+}{\text{H}}$

(i) In this representation, what is the meaning of the symbol $\delta+$?

electron deficient (1) or (small) slight positive charge

(ii) From this bond representation, what can be deduced about the electronegativity of hydrogen relative to that of nitrogen?

H < N (1)

(2 marks)

TURN OVER FOR THE NEXT QUESTION

- 3 The table below shows some values of melting points and some heat energies needed for melting.

Substance	I ₂	NaCl	HF	HCl	HI
Melting point/K	387	1074	190	158	222
Heat energy for melting /kJ mol ⁻¹	7.9	28.9	3.9	2.0	2.9

- (a) Name **three** types of intermolecular force.

Force 1 van der Waals' (1) or London dispersion temporary dipole

Force 2 dipole - dipole (1)

Force 3 hydrogen bonding (1) (3 marks)

- (b) (i) Describe the bonding in a crystal of iodine. :

..... covalent between atoms (1) (or within a molecule)

..... van der Waals' between molecules (1)

- (ii) Name the crystal type which describes an iodine crystal.

..... molecular (1)

- (iii) Explain why heat energy is required to melt an iodine crystal.

..... { bonds forces between molecules must be broken (loosened) (1)

..... { or v.d.W. forces (4 marks)

..... or intermolecular forces

..... mention of ions CE = 0

(c) In terms of the intermolecular forces involved, suggest why

- (i) hydrogen fluoride requires more heat energy for melting than does hydrogen chloride,

H-bonding in HF (1)
 (dipole-dipole in HCl (1) (or v.d.w)
 H-bonding is stronger than (dipole-dipole (1)
 (or H-bonding is strongest) } or v.d.w
 intermolecular force - 3rd mark

- (ii) hydrogen iodide requires more heat energy for melting than does hydrogen chloride.

HI bigger molecule than HCl (1) or { heavier
 more e's
 more electron shells
 bigger Mr
 more polarisable

Therefore the forces between HI molecules are stronger (1)

9h mark (look for unambiguous statement using correct terminology) (5 marks)

- (d) (i) Explain why the heat energy required to melt sodium chloride is large.

ionic (1)
 strong forces between ions (1) (or lots of energy required to break bonds)

- (ii) The heat energy needed to vaporise one mole of sodium chloride (171 kJ mol^{-1}) is much greater than the heat energy required to melt one mole of sodium chloride. Explain why this is so.

all bonds must be broken (1) (mention of molecules etc $CE=0$)

(3 marks)

(e) In terms of its structure and bonding, suggest why graphite has a very high melting point.

macromolecular (1) or giant molecule/lattice
 or correct diagram

strong covalent bonds (1) (or lots of energy required to break bonds)

(2 marks)

- 4 (a) State the trend in atomic radius down Group II from Be to Ba and give a reason for this trend.

Trend increases (1) (wrong trend CE = 0 and in (b))

Reason more electron shells (1)
..... (or implies more shells/subshells/levels) (2 marks)

- (b) State and explain the trend in melting points of the elements down Group II from Be to Ba.

Trend decreases (1)

Explanation metallic bonds weaker (1) (or weaker attraction between ions & delocalised electrons) (or nuclei)

..... atoms (ions) larger (1) (this mark only scored if previous mark given)

(CE if mention molecules, intermolecular forces, ionic bonding) (3 marks)

- (c) State the trend in reactivity with water of the elements down Group II from Be to Ba. Write an equation for the reaction of magnesium with steam and an equation for the reaction of strontium with water.

Trend increases (1)

Equation for magnesium $Mg + H_2O \rightarrow MgO + H_2$ (1)

Equation for strontium $Sr + 2H_2O \rightarrow Sr(OH)_2 + H_2$ (1) (3 marks)

(ignore state symbols)

- (d) Sulphates of the Group II elements from Be to Ba have different solubilities. Give the formula of the least soluble of these sulphates and state one use that depends upon the insolubility of this sulphate.

Formula $BaSO_4$ (1)

Use test for sulphate ions (1) (2 marks)

or { pigment
for X-rays
barium meal
paint

(e) A solution contains ions of a Group II element, M. When aqueous sodium hydroxide is added a white precipitate forms. This precipitate dissolves in an excess of aqueous sodium hydroxide. Identify M and write ionic equations for the two reactions.

Identity of M Be (1) (allow Be^{2+})

Equation 1 $Be^{2+} + 2OH^- \rightarrow Be(OH)_2$ (1) (allow $+2NaOH \rightarrow +2Na^+$)

Equation 2 $Be(OH)_2 + 2OH^- \rightarrow [Be(OH)_4]^{2-}$ (1) (allow $+2NaOH \rightarrow +2Na^+$)
(3 marks)

(f) With the exception of beryllium chloride, Group II chlorides are classed as ionic. Explain why beryllium chloride is different by considering how a beryllium ion would interact with a chloride ion.

penalise
Be

$(Be^{2+} \text{ ion})$ has high ^{charge density} charge/size ratio (1) (or Be^{2+} ion is very small)
polarises (Cl^-) (1) (can score from diagram)
causes covalency (1) (or sharing of electrons)

(do not allow if $BeCl_2$ ionic) (3 marks)

TURN OVER FOR SECTION B

SECTION B

Answer **both** the questions below in the space provided on pages 10 to 16 of this booklet.

- 5 (a) State the relative charge and relative mass of a proton, of a neutron and of an electron. In terms of particles, explain the relationship between two isotopes of the same element. Explain why these isotopes have identical chemical properties. (7 marks)
- (b) Define the term *relative atomic mass*. An element exists as a mixture of three isotopes. Explain, in detail, how the relative atomic mass of this element can be calculated from data obtained from the mass spectrum of the element. (7 marks)
- 6 (a) Explain why certain elements in the Periodic Table are classified as p-block elements. Illustrate your answer with an example of a p-block element and give its electronic configuration. (3 marks)
- (b) Explain the meaning of the term *periodicity* as applied to the properties of rows of elements in the Periodic Table. Describe and explain the trends in atomic radius, in electronegativity and in conductivity for the elements sodium to argon. (13 marks)

END OF QUESTIONS

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MARK SCHEME

- (a) Proton: mass 1, charge +1 (1)
- Neutron: mass 1, charge 0 (1)
- Electron: mass 1/1840, charge -1 (1) (allow mass = 0 or negligible or 1/1800 to 1/2000)
- isotopes have the same number of protons (or atomic number) (1)
- different (number of neutrons) (1)
- isotopes have the same electronic configuration (1) (or same number of electrons)
- chemical properties depend on electrons (1)

b. (i) average (1) mass of ^{isotopes} an atom $\times 12$ (1) (or $\frac{\text{mass of 1 mol of atoms}}{\text{mass of 1 atom of } ^{12}\text{C}} \times 12$ or in words)

mass of 1 atom of ^{12}C

spectrum gives (relative) abundance (1) or % or amount

and m/z (1)

multiply m/z by relative abundance for each isotope (1) — allow instead of m/z {mass no, or actual value from example}

sum these values (1)

divide by the sum of the relative abundances (1) — only award this mark if previous 2 given (14)

- 6. (a) Elements in the p block have their outer electron(s) in p orbital(s) (1) {or levels or subshells}
- example of element (1)
- correct electronic configuration (1) 3

(b) (Trend in the properties of elements across a period or) Pattern in the change in the properties of a row of elements (1)

repeated in the next row (1) — or {element underneath (or in same group) has similar properties}

atomic radius

decreases across the row (1)

number of protons increases (1) (or nuclear charge increases)

more attraction for electrons in the same shell (1)

electronegativity

increases across the row (1)

number of protons increases (1) (or nuclear charge)

atomic radius decreases (1) (or shielding remains the same) (or electrons in same shell)

more attraction for bonding electrons (1)

conductivity {or shared}

decreases across row (1) (or significant drop from Al to Si)

Na-Al metals (1) (or metallic bonding or description of metallic bonding)

Two of Si-Ar non metals (1) (or molecular or covalent)

EITHER {electrons free to move (or delocalised) in metals} (1)

OR {electrons unable to move in non-metals} (1)