ASSESSMENT and QUALIFICATIONS ALLIANCE

Mark scheme June 2002

GCE

Chemistry

Unit CHM1

SECTION A

Answer **all** questions in the spaces provided.

1 (a) The mass of one mole of ^{1}H atoms is 1.0078 g and that of one ^{1}H 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.

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

$= 6.0225 \times 10^{23}$ (1) (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 $R = 8.31\,J\,K^{-1}\,mol^{-1}$)

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

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

$= 1.39$ (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 cm^3 in a volumetric flask by adding water. Calculate the concentration of ammonia in this final solution and state the appropriate units.

$\frac{0.732 \times 1000}{250} = 2.93$ (1) $mol\ dm^{-3}$ (1) or { M, mol/dm^3, mol l^{-1} etc }

(allow 2.928 to 2.93)

(2 marks)

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

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

$$2NH_3(aq) + H_2SO_4(aq) \rightarrow (NH_4)_2SO_4(aq)$$

In a titration, 25.0 cm^3 of a 1.24 mol dm^{-3} solution of sulphuric acid required 30.8 cm^3 of this ammonia solution for complete reaction.

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

moles $H_2SO_4 = \frac{25}{1000} \times 1.24 = 0.0310$ (1)

moles NH_3 in 30.8 cm^3 = 0.0310 × 2 = 0.0620 (1) mark is for × 2

moles NH_3 in 1 dm^3 = $\frac{0.0620 \times 1000}{30.8}$ = 2.01 (1) ($mol\ dm^{-3}$) allow 2.010 to 2.015

no units OK

wrong units lose last mark.

if use $m_1v_1 = m_2v_2$ scores 3 if ans correct else zero

(CE if ×2 not used)

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

moles $(NH_4)_2SO_4$ = moles H_2SO_4 = 0.0310 (1) allow conseq on wrong moles in part i if clear $H_2SO_4 = (NH_4)_2SO_4$

M_r $(NH_4)_2SO_4$ = 132.1 (1) (allow 132)

mass = moles × M_r = 0.0310 × 132.1 = 4.10 (1) (g) wrong units loses mark

(allow 4.09 – 4.1 – 4.11)

(6 marks)

wrong formula for $(NH_4)_2SO_4$ CE = 0

if moles of $(NH_4)_2SO_4$ not clear CE.

(f) The reaction of magnesium nitride, Mg_3N_2, with water produces ammonia and magnesium hydroxide. Write an equation for this reaction.

$Mg_3N_2 + 6H_2O \longrightarrow 3Mg(OH)_2 + 2NH_3$

(2 marks)

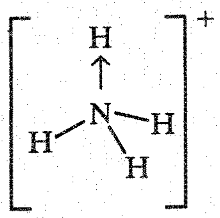
formulae (1)

balanced equation (1)

16

Turn over ▶

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 / or two / or pair} come from nitrogen (1)

(iv) In terms of electron pairs, explain why the bond angles in the NH_4^+ ion are all 109° 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 $\overset{\delta-}{N}—\overset{\delta+}{H}$

(i) In this representation, what is the meaning of the symbol δ+ ?

electron deficient (1) or {small / slight / partial} 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)

11

TURN OVER FOR THE NEXT QUESTION

Turn over ▶

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

or intermolecular forces

(4 marks)

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 (or V-d W) (1)

(or H-bonding is strongest 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)

(5 marks)

QL mark (Look for unambiguous statement using correct terminology)

(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)

17

Turn over ▶

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 / sub shells / 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)........

.... (3 marks)

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

(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

LEAVE MARGIN BLANK

(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+} 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)

(3 marks)

(do not allow if $BeCl_2$ ionic)

16

TURN OVER FOR SECTION B

Turn over ▶

LEAVE MARGIN BLANK

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

HM1	for June 2002
	J E Bentham

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 negligable or $\frac{1}{1800}$ to $\frac{1}{2000}$
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) 7

(b) $\frac{\text{average (1) mass of \{isotopes / an atom}}{\text{mass of 1 atom of } ^{12}C}$ × 12 (1) (or $\frac{\text{mass of 1 mol of atoms}}{\text{mass of 1 atom of } ^{12}C}$ × 12 or in words)
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, Ar 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 7

max 2 for e.g. if only isotopes

(14)

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

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

E if — end wrong

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 / or shared} electrons (1)

conductivity

13

(16)

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}