AQA

ASSESSMENT and QUALIFICATIONS ALLIANCE

Mark scheme January 2003

GCE

Chemistry

Unit CHM1

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SECTION A

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

1 (a) Complete the following table.

Particle	Relative charge	Relative mass
Proton	+1 or 1+	1 (1)
Neutron	0 or no charge or neutral or zero	1 Not -1 (1)
Electron	−1 or 1−	$\frac{1}{1800}$ to $\frac{1}{2000}$ or negligible or zero or 5.0×10^{-4} to 5.6×10^{-4} (1)

if 'g' in mass column - wrong penalise once

(3 marks)

(b) An atom of element **Z** has two more protons and two more neutrons than an atom of $^{34}_{16}S$. Give the symbol, including mass number and atomic number, for this atom of **Z**.

$^{38}_{18}Ar$ allow numbers before or after Ar

(1) (1)

(2 marks)

(c) Complete the electronic configurations for the sulphur atom, **S**, and the sulphide ion, S^{2-}.

if use sub-scripts penalise once

S $1s^2$ $2s^2$ $2p^6$ $3s^2$ $3p^4$ (1) Allow upper case letters

S^{2-} $1s^2$ $2s^2$ $2p^6$ $3s^2$ $3p^6$ (1)

(2 marks)

(d) State the block in the Periodic Table in which sulphur is placed and explain your answer.

Block P (1)

Explanation Highest energy or outer orbital is (3) P (1)

or outer electron
valency electron } in (3)P

NOT 2p etc.

(2 marks)

LEAVE MARGIN BLANK

(e) Sodium sulphide, Na_2S, is a high melting point solid which conducts electricity when molten. Carbon disulphide, CS_2, is a liquid which does not conduct electricity.

(i) Deduce the type of bonding present in Na_2S and that present in CS_2

Bonding in Na_2S Ionic (1) Ignore other words such as dative / polar / coordinate

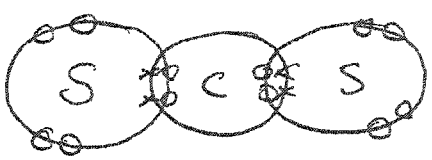
Bonding in CS_2 Covalent (1)

(ii) By reference to all the atoms involved explain, in terms of electrons, how Na_2S is formed from its atoms.

Clear indication of electron transfer from Na to S (1)

QoL (Correct english) 1 e^- from each (of 2) Na atoms or 2 e^- from 2 Na atoms (1)

(iii) Draw a diagram, including all the outer electrons, to represent the bonding present in CS_2



allow all •s or all ×s.

Correct covalent bonds (1)

All correct including lone pairs (1)

(M2 tied to M1)

Not separate e⁻s in S. – 2 L.P.

(iv) When heated with steam, CS_2 reacts to form hydrogen sulphide, H_2S, and carbon dioxide.
Write an equation for this reaction.

$CS_2 + 2H_2O \longrightarrow CO_2 + 2H_2S$ (1)

(7 marks)

Ignore state symbols even if wrong

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TURN OVER FOR THE NEXT QUESTION

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2 (a) Calculate the concentration, in mol dm^{-3}, of the solution formed when 19.6 g of hydrogen chloride, HCl, are dissolved in water and the volume made up to 250 cm^3.

M_1 mass / M_r ie $\frac{19.6}{36.5}$ only — moles HCl = $\frac{19.6}{36.5}$ (1) (= 0.537)

M_2 ×4 — Concentration = 0.537 / 0.25 (1)

M_3 conc. — = 2.15 (mol dm^{-3}) conseq on (1)

A.E. lose 1 mark

min 2 d.p. 2.14 → 2.15

ignore wrong units

in correct M_r

(3 marks)

(b) The carbonate of metal **M** has the formula M_2CO_3. The equation for the reaction of this carbonate with hydrochloric acid is given below.

$$M_2CO_3 + 2HCl \longrightarrow 2MCl + CO_2 + H_2O$$

A sample of M_2CO_3, of mass 0.394 g, required the addition of 21.7 cm^3 of a 0.263 mol dm^{-3} solution of hydrochloric acid for complete reaction.

(i) Calculate the number of moles of hydrochloric acid used.

$\frac{21.7}{1000} \times 0.263$ = 5.7(1) × 10^{-3} (mol) (1)

5.7 → 5.71 × 10^{-3}

(ii) Calculate the number of moles of M_2CO_3 in 0.394 g.

conseq $\frac{5.71 \times 10^{-3}}{2}$ = 2.85 × 10^{-3} (mol) (1)

(iii) Calculate the relative molecular mass of M_2CO_3

Conseq $\frac{0.394}{2.85 \times 10^{-3}}$ = 138 (1)

(iv) Deduce the relative atomic mass of **M** and hence suggest its identity.

Relative atomic mass of M 138 − 60 = 78 (1)

$\frac{78}{2}$ = 39 (1)

Conseq *Identity of M* Potassium or K or K^+ (1)

(6 marks)

if 78 = M_r

M = Selenium

LEAVE MARGIN BLANK

3 When a sample of liquid, **X**, of mass 0.406 g was vaporised, the vapour was found to occupy a volume of 2.34×10^{-4} m^3 at a pressure of 110 kPa and a temperature of 473 K.

(a) Give the name of the equation $pV = nRT$.

Ideal gas equation (1)
law.

(1 mark)

(b) Use the equation $pV = nRT$ to calculate the number of moles of **X** in the sample and hence deduce the relative molecular mass of **X**.
(The gas constant $R = 8.31$ J K^{-1} mol^{-1})

Moles of X $n = \frac{pV}{RT}$ (1) $= \frac{110000 \times 2.34 \times 10^{-4}}{8.31 \times 473}$

if wrote $n = \frac{RT}{PV}$ zero here can't come M_r $= 6.55 \times 10^{-3}$ (1) $6.5 \times 10^{-3} \rightarrow 6.6 \times 10^{-3}$

ignore units min 2 sig figs

Relative molecular mass of X $M_r = \frac{m}{n}$ (1)

$= 62$ (1) consequential

$61.5 \rightarrow 62.5$ *(4 marks)*

(c) Compound **X**, which contains carbon, hydrogen and oxygen only, has 38.7% carbon and 9.68% hydrogen by mass. Calculate the empirical formula of **X**.

% Oxygen $= 51.6(2)$ (1)

if no % O or wrong A_r used then max 1

C $= \frac{38.7}{12}$ H $= \frac{9.68}{1}$ O $= \frac{51.6(2)}{16}$ (1)

$= 3.23$ $= 9.68$ $= 3.23$

1 : 3 : 1 $\therefore$ CH_3O (1)

correct empirical formula earns all 3 marks *(3 marks)*

(d) Using your answers to parts (b) and (c) above, deduce the molecular formula of **X**.

$\left(\frac{62}{31} \times CH_3O\right) = C_2H_6O_2$ (1)

(1 mark)

9

Turn over

4 (a) The boiling point of H_2O is 373 K and that of H_2S is 212 K.

(i) Name the strongest type of intermolecular attraction present in water.

Hydrogen bonding (1)

(ii) Name the strongest type of intermolecular attraction present in hydrogen sulphide. (must be 2 dipoles 1)

London forces / dispersion forces

Van der Waal or dipole-dipole (1) or temporary dipole-dipole

accept permanent dipole interaction

(iii) Explain why the boiling point of water is so much higher than that of hydrogen sulphide.

H-bonding is stronger (1)

more energy or higher temp needed (1)

"H-bonding needs more energy to break" (2) *(4 marks)*

To score M2 must have reasonable attempt at M1

(b) Define the term *electronegativity*.

Tendency / ability or element Power of an atom to attract or withdraw e⁻ density or electrons (1)

in / from a covalent bond (1)

Not reference to 'an electron' for M1 *(2 marks)*

"Ability of an atom to gain and retain electrons in a covalent bond" 1 mark

(c) State and explain the trend in electronegativity down Group II from Be to Ba.

max 1 if trend wrong

Trend Decreases (1)

Explanation Increased radius or size or shells (1) increased shielding (1)

Weaker attraction between nucleus and bonding pair (1)

Any 2 out of 3 in explanation *(3 marks)*

(d) (i) Give the type of bonding present in $BeCl_2$

Not 'ionic with covalent character'

Covalent (1) (ignore other words such as dative, coordinate, polar)

(ii) Give the type of bonding present in $BaCl_2$

Ionic (1)

(iii) Explain why the type of bonding is different in these two compounds.

Greater) electronegativity difference in $BaCl_2$ or more charge separation or reduced charge density on barium cation, Ba^{2+} or Ba^{2+} reduced polarising (1) *(3 marks)*

LEAVE MARGIN BLANK

(e) (i) Explain what is meant by the term *amphoteric*. Write **two** equations involving $Be(OH)_2$ to illustrate your answer.

any example must be correct substance accept Be

Explanation Reacts with acids and bases / alkalis. (Neutralises) or Dissolves in " " " or Behaves as acid and base (1)

accept equations with any acid/base

Equation 1 $Be(OH)_2 + 2H^+ \rightarrow Be^{2+} + 2H_2O$ (1)

Do not accept coordination number other than 4.

Equation 2 $Be(OH)_2 + 2OH^- \rightarrow Be(OH)_4^{2-}$ (1)

(ii) In what way is this behaviour of $Be(OH)_2$ atypical of the behaviour of Group II metal hydroxides?

Others do not react with or dissolve in base/alkali

or others not amphoteric (1)

(4 marks)

or others only or always basic

or others only react with acids

'only' or implied from context

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TURN OVER FOR THE NEXT QUESTION

LEAVE MARGIN BLANK

5 There is a general trend in the values of the first ionisation energies of the elements Na to Ar. The first ionisation energies of the elements Al and S deviate from this trend.

(a) Write an equation, including state symbols, to represent the process for which the energy change is the first ionisation energy of Na.

'=' or electron not essential

$Na_{(g)} \rightarrow Na^+_{(g)} + e^-$ equation (1)

or $Na_{(g)} + e^- \rightarrow Na^-_{(g)} + 2e^-$ state symbols (1) *(2 marks)*

ignore state symbols on electrons

(b) State and explain the general trend in the values of the first ionisation energies of the elements Na to Ar.

Trend Increases (1)

Explanation Increased nuclear charge or proton number (1)

Stronger attraction (between nucleus and (outer) e^-) (1)

trend only on M2 if M3 correct ✓ can

(3 marks)

(c) State how, and explain why, the values of the first ionisation energies of the elements Al and S deviate from the general trend.

How the values deviate from the trend (Both values) too low (1)

Explanation for Al e^- removed from (3) p (1)

mark independently e^- or orbital is higher in energy or better shielded than (3) s (1)

allow e^- is further away

or p electron is shielded by 3s electrons

Explanation for S e^- removed from (3) p electron pair (1)

repulsion between paired e^- (reduces energy required) (1)

(5 marks)

10

If deviation wrong allow M2 and M4

if M3 and/or M5 right ✓ can

If used 'd' rather than 'p' orbital - lose M2 & M4 but may get M3, M5 (explanation marks)

Section B

Q6

(a) *Ionisation*

not bombard

High speed or high energy electrons or electron gun not beam / stream of electrons (1)

Knocks out(outer) electron (1)

Accept + ion later in question to clarify charge of ion

Forming positive ion – could be from $Ti \rightarrow Ti^+ + e^-$ (1)

($Ti + e^- \rightarrow Ti^+ + 2e^-$ *worth 2 marks) Ignore state symbols*

Acceleration (1)

By electric field or attraction to negative plate or electrostatic attraction (1)

not repelled by + plate allow - passed through positive & negative plates / oppositely charged plates

Deflection (1)

not just charged plates

By magnetic field or magnet or electromagnet (1)

Detection (1)

Idea that ions collected at detector and generate current (1)

Both ions have the same m/z value (of 24) or valid arguments in terms of the doubled charge on $^{48}Ti^{2+}$ *exactly counteracting its doubled mass* (1)

Deflected equally (so detected together) or deflection dependent on m/z value (1) *10 max*

can't get this from previous section

(b) *Differ in mass number or number of neutrons* (1)

Same proton/atomic number ignore references to electrons here (1)

Isotopes have the same chemical properties (1)

because *All have the same electron configuration or number of electrons or same number of valence electrons (so no chemical difference)* **This mark is tied to above mark** (1) *4*

or near miss [similar ele] in M3.

(c) *Mean mass of an atom* or isotope *[NOT mass of average atom]* (1)

Relative to 1/12 mass of ^{12}C *atom etc. or to* ^{12}C *taken as 12.000 or exactly 12* (1)

Isotope can be accepted

or $\frac{\text{mean (average) mass of an atom}}{\text{mass of one atom of } ^{12}C}$ (1) $\times 12$ (1)

Or $\frac{\text{mass of 1 mol of atoms}}{\text{mass of 1 mol of } ^{12}C}$ (1) $\times 12$ (1)

$A_r = (46 \times .0802) + (47 \times .0731) + (48 \times .7381) + (49 \times .0554) + (50 \times .0532)$ (1)

$= 47.93$ *answer to 2 d.p.* ~~range: 47.91 to 47.95~~ 47.92 is acceptable (1) *4*

[Must be 5 sets of values. Ignore transcription errors BUT DON'T ignore missing 100] *Total 18*

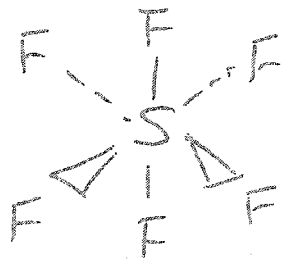
C.E. If missing isotope C.E.

Q7

(a) SF_6 shape shown as octahedral / square based bipyramid (1)

Bond angle = 90° or 180° and 90° (1)

Shape = octahedral [If lone pair shown then CE = 0/4] (1)



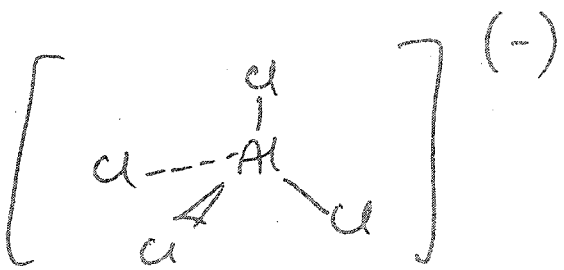
Wrong symbols - no diagram mark

Equal repulsion between 6 bonding or shared electron pairs QoL (1)

$AlCl_4^-$ shape shown as tetrahedral (1)

Bond angle = 109° to 109.5° (1)

Shape = tetrahedral [If lone pair shown then CE = 0/4] (1)



(Equal repulsion between) 4 bonding or shared electron pairs (1) 8

QoL may be awarded here also

Mark all points independently

Solvent has low bp or weak intermolecular forces or evaporates quickly (1)

(Solvent) needs energy to evaporate or valid reference to latent heat of vaporisation (1)

to overcome intermolecular forces

or evaporation is endothermic

or Higher energy or faster molecules more likely to escape so mean energy (and hence temperature) falls

Energy taken from the skin (and so it cools) (1)

Fragrance or perfume (molecules) slowly spreads (through the room) (1)

By random movement or diffusion (of the perfume/fragrance) (1) 4 max

Total 12