AQA

ASSESSMENT and QUALIFICATIONS ALLIANCE

# Mark scheme June 2003

## GCE

## Chemistry

## Unit CHM1



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## SECTION A

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

**1** (a) (i) Complete the electronic configuration of aluminium.

$1s^2$ $2s^2\ 2p^6\ 3s^2\ 3p^1$ *[Allow subscripted electron numbers]* *(1)*

(ii) State the block in the Periodic Table to which aluminium belongs.

*p (block)* *[Allow upper or lower case 's' and 'p' in (a)(i) and (a)(ii)]* *(1)*

***(2 marks)***

(b) Describe the bonding in metals.

*Lattice of metal / +ve ions / cations / atoms* *Not +ve nuclei/centres* *(1)*

*[Accept regular array/close packed/tightly packed/uniformly arranged]*

*(Surrounded by) delocalised electrons* *(1)*

*Note: Description as a 'giant ionic lattice' = CE* ***(2 marks)***

(c) Explain why the melting point of magnesium is higher than that of sodium.

*Greater nuclear or ionic charge or more protons* *(1)*

*Smaller atoms/ions* *[Accept greater charge density for either M1 or M2]* *(1)*

*More delocalised electrons / e⁻ in sea of e⁻ /free e⁻* *(1)*

*Stronger attraction between ions and delocalised/free electrons etc.* *[Max 3]* *(1)*

*Note: 'intermolecular attraction/forces' or covalent molecules = CE* ***(3 marks)***

(d) Explain how metals conduct electricity.

*(Delocalised) electrons* *(1)*

*Move / flow in a given direction (idea of moving non-randomly)*

*or under the influence of applied pd.* ***QoL mark*** *(1)*

*[Allow 'flow through metal']* ***(2 marks)***

*Not: 'carry the charge'; 'along the layers'; 'move through the metal'*

*(c) Notes [Accept stronger 'electrostatic attraction' if phrase described elsewhere]*
*[Ignore references to m/z values]*
*[If Mg or Na compared to Al, rather than each other, then: Max 2]*
*[If reference to 'ionic bonding, then: Max 2]*
*[Treat description that is effectively one for Ionisation Energy as a 'contradiction']*

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**2** (a) Give the relative charge and relative mass of an electron.

*Relative charge* -1 (1)

*Relative mass* ≤ 1 /1800 or ≤ 5.55 × $10^{-4}$ [accept zero / negligible] (1)

*(2 marks)*

(b) Isotopes of chromium include $^{54}Cr$ and $^{52}Cr$

(i) Give the number of protons present in an atom of $^{54}Cr$

*Protons = 24* (1)

(ii) Deduce the number of neutrons present in an atom of $^{52}Cr$

*Neutrons = 28* (1)

(iii) Apart from the relative mass of each isotope, what else would need to be known for the relative atomic mass of chromium to be calculated?

*Need (relative) abundance or peak height or intensity / amount / number / % / fraction of each element.* [Not: 'ratio of each isotope'] (1) *(3 marks)*

(c) In order to obtain a mass spectrum of a gaseous sample of chromium, the sample must first be ionised.

(i) Give **two** reasons why it is necessary to ionise the chromium atoms in the sample.

*Reason 1* To allow particles to be accelerated / deflected /detected **or** to count

*Reason 2* charged particles **or** to generate a current in the detector [**any 2**] (2)
[Not: 'to allow m/z to be measured']

(ii) State what is adjusted so that each of the isotopes of chromium can be detected in turn.

Magnetic field or electric field or electromagnet (1)

(iii) Explain how the adjustment given in part (c)(ii) enables the isotopes of chromium to be separated.

Deflection depends on mass or m/z (1)

*(4 marks)*

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(d) (i) State what is meant by the term *empirical formula.*

*(simplest) ratio of atoms of each element in compound* (1)

(ii) A chromium compound contains 28.4% of sodium and 32.1% of chromium by mass, the remainder being oxygen.
Calculate the empirical formula of this compound.

*% oxygen = 39.5%* (1)

*Na 28.4/23* *Cr 32.1/52* *O 39.5/16* (1)

*= 1.23* *= 0.617* *= 2.47*

*(2:1:4) so empirical formula = $Na_2CrO_4$* (1)

***(4 marks)***

*[If % oxygen not calculated, only M2 available; if $A_r$ values wrong, only M1 available]*

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**TURN OVER FOR THE NEXT QUESTION**

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3 (a) A sample of ethanol vapour, $C_2H_5OH$ ($M_r = 46.0$), was maintained at a pressure of 100 kPa and at a temperature of 366 K.

(i) State the ideal gas equation.

*$pV = nRT$* (1)

(ii) Use the ideal gas equation to calculate the volume, in $cm^3$, that 1.36 g of ethanol vapour would occupy under these conditions.
(The gas constant $R = 8.31\,J\,K^{-1}\,mol^{-1}$)

*Moles ethanol = n = 1.36/46 (= 0.0296 mol)* (1)

*$V = nRT/p = \frac{0.0296 \times 8.31 \times 366}{100000}$ [if $V = p/nRT$ lose M3 and M4]* (1)

*$= 8.996 \times 10^{-4}$ ($m^3$)* (1)

*= 899 (900) $cm^3$ [range = 895 – 905]* (1)

*[If final answer = 0.899 award (2 + M1); if = 0.899 $dm^3$ or if = 912 award (3 + M1)]*

*[Note: If 1.36 or 46 or 46/1.36 used as number of moles (n), then M2 and M4 not available]*
*[Note: If pressure = 100 then, unless answer = 0.899 $dm^3$, deduct M3 and mark consequentially]* **(5 marks)**

(b) Magnesium nitride reacts with water to form magnesium hydroxide and ammonia.

(i) Balance the equation, given below, for the reaction between magnesium nitride and water. (1)

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

(ii) Calculate the number of moles, and hence the number of molecules, of $NH_3$ in 0.263 g of ammonia gas.
(The Avogadro constant $L = 6.02 \times 10^{23}\ mol^{-1}$)

*Moles $NH_3$ = $\frac{0.263}{17}$ (= 0.0155 mol)* (1)

*Number of molecules of $NH_3$ = 0.0155 × $6.02 \times 10^{23}$ [mark conseq]* (1)

*= $9.31 \times 10^{21}$ [range $9.2 \times 10^{21}$ to $9.4 \times 10^{21}$] [Conseq (min 2 sig fig)]* (1)

**(4 marks)**

(c) Sodium carbonate is manufactured in a two-stage process as shown by the equations below.

$$NaCl + NH_3 + CO_2 + H_2O \rightarrow NaHCO_3 + NH_4Cl$$

$$2NaHCO_3 \rightarrow Na_2CO_3 + H_2O + CO_2$$

Calculate the maximum mass of sodium carbonate which could be obtained from 800 g of sodium chloride.

*Moles NaCl = 800/58.5 (= 13.68)* *(1)*

*Moles $NaHCO_3$ = 13.68* *(1)*

*Moles $Na_2CO_3$ = 13.68/2 = 6.84* *(1)*

*Mass $Na_2CO_3$ = 6.84 × 106 = 725 g [range = 724 – 727]* *(1)*

*[1450 g (range 1448 – 1454) is worth 3 marks]*

***(4 marks)***

*[Accept any valid calculation method, e.g. reacting masses or calculations via the mass of sodium present. Also, candidates may deduce a direct 2:1 ratio for NaCl:$Na_2CO_3$]*

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**TURN OVER FOR THE NEXT QUESTION**

**4** (a) Both HF and HCl are molecules having a polar covalent bond. Their boiling points are 293 K and 188 K respectively.

(i) State which property of the atoms involved causes a bond to be polar.

*Electronegativity (difference) or suitable description* (1)

*[Accept 'F and Cl are highly electronegative] Not: 'both atoms are highly electronegative'*

(ii) Explain, in terms of the intermolecular forces present in each compound, why HF has a higher boiling point than HCl.

*HF = hydrogen bonding* (1)

*HCl = (permanent) dipole-dipole bonding* **or** *van der Waals'* (1)

*Hydrogen bonding stronger / is the strongest IMF* (1)

*[Accept a statement that HF must have the stronger IMF, even if no IMFs identified.]*

*[The explanation* ***must*** *be based clearly on* ***intermolecular*** *forces/attractions]*

*Note: if the explanation is clearly intramolecular = CE* ***(4 marks)***

(b) When aluminium chloride reacts with chloride ions, as shown by the equation below, a co-ordinate bond is formed.

$$AlCl_3 + Cl^- \rightarrow AlCl_4^-$$

Explain how this co-ordinate bond is formed.

*Electron pair* **or** *lone pair donated* *Do not accept 'donation of electron(s)'* (1)

*From chloride ion to Al* **or** *$AlCl_3$* (1)

***(2 marks)***

*[M1 can be earned by a general explanation of coordinate bonding, even if the electron pair is said to come from Al. The second mark, M2, is for this specific bond]*

*[Ignore missing charge]*

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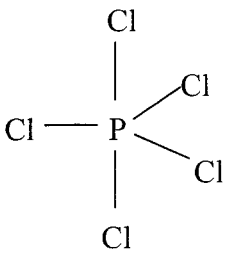
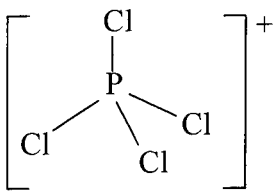
(c) Draw the shape of the $PCl_5$ molecule and of the $PCl_4^+$ ion. State the value(s) of the bond angles.

$PCl_5$




(1)

$PCl_4^+$




(1)

*$PCl_5$ shown as trigonal bipyramid*

*[Look for: ONE solid linear Cl-P-Cl bond]*

*Bond angle(s) ..... 90° and 120° (1)*

*$PCl_4^+$ shown as tetrahedral*

*NO solid linear Cl-P-Cl bonds]*

*Bond angle(s) ..... 109 or 109.5° (1)*

*(4 marks)*

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**TURN OVER FOR THE NEXT QUESTION**

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## SECTION B

Answer the question below in the space provided on pages 12 to 16 of this booklet.

**5** (a) The table below gives the melting point for each of the Period 3 elements Na – Ar.

| Element | Na | Mg | Al | Si | P | S | Cl | Ar |
|---|---|---|---|---|---|---|---|---|
| Melting point/K | 371 | 923 | 933 | 1680 | 317 | 392 | 172 | 84 |

In terms of structure and bonding, explain why silicon has a high melting point, and why the melting point of sulphur is higher than that of phosphorus. *(7 marks)*

(b) Draw a diagram to show the structure of sodium chloride. Explain, in terms of bonding, why sodium chloride has a high melting point. *(4 marks)*

(c) Give the conditions under which, if at all, beryllium and magnesium react with water. For any reaction that occurs, state **one** observation you would make and write an equation. *(4 marks)*

**END OF QUESTIONS**

*(a) Macromolecular **or** giant structure [Accept diamond shaped lattice] (1)*

*[Intermolecular forces / molecular lattice / comparison to graphite structure, ='con']*

*Held together by covalent bonds ['Giant covalent structure' earns both M1 and M2] (1)*

*(Much) energy needed to break bonds **Or** many bonds to be broken (1)*

*[mark tied to earning 'covalent' M2] If explanation is clearly of ionic bonding = CE*

*Van der Waal / temporary induced dipole-dipole / London / disperse forces (1)*

*Forces increase with size **or** with number of electrons **or** with surface area etc. (1)*

*[Description must be of the molecules of P and S]*

*$P_4$ **or** $M_r = 124$ (1) $S_8$ **or** $M_r = 256$ (1)*

*[If M6 (i.e. $P_4$) and M7 (i.e. $S_8$) are not attempted, allow S molecule bigger/ more surface area than P molecule for 1 mark]* **(7 marks)**

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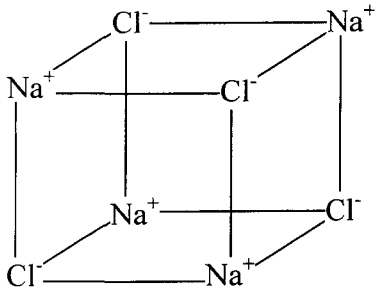
(b) *Diagram NaCl = cubic* *[Allow if 3 full faces shown correctly]* (1)

*Ions identified and placed properly* (1)




*[If diagram shows '+' and '-' signs rather than symbols for the ions, identification of the ions could be from the text]*

*(Bonding) identified in writing as being ionic* *[**Not** ionic molecule]* (1)

*Due to strong electrostatic attractions **or** similar description about attraction between oppositely charged ions.* ***QoL*** (1)

*[**Not just:** 'ionic bonds are strong' / 'need much energy to break bonding']* ***(4 marks)***

(c) *Be – no reaction with water or steam* *[**Not:** 'Be does not dissolve']* (1)

*Mg reacts **with steam*** ***or** reacts slowly with cold/hot water* (1)

*White solid **(not precipitate)** formed* *Bubbles* (1)

***or** Mg glows or burns (with bright white light)* *[Not: 'fizzes' or '**gas evolved**']*

$Mg + H_2O \rightarrow MgO + H_2$ $Mg + 2H_2O \rightarrow Mg(OH)_2 + H_2$ (1)

***(4 marks)***

*[Condition, equation and observation marks are tied. Candidates can't mix-and-match but, when both conditions quoted, select the higher scoring option]*

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