AQA

ASSESSMENT and QUALIFICATIONS ALLIANCE

Mark scheme January 2002

GCE

Chemistry

Unit CHM1

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SECTION A

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

1 (a) Define the term *atomic number* of an element.

number of protons in one (or nucleus) atom (1)

(1 mark)

[allow protons & electrons
do not allow protons + electrons or electrons]

(b) Give the symbol, including the mass number and atomic number, for an atom of an element which contains 12 neutrons and 11 electrons.

$^{23}_{11}Na$ (1) (1) (or Na^{23}_{11} or Na + unambiguous statement of mass no. & at. no. (1)) *(2 marks)*

(c) In terms of s and p sub-levels, give the electronic configuration of an aluminium atom.

$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^1$ (1)

(1 mark)

(allow $Ne\ 3s^2 3p^1$)

(d) How many neutrons are there in one ^{27}Al atom?

14 (1)

(1 mark)

(e) Define the term *relative atomic mass* of an element. (or isotope)

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

[reference to mass number not mass CE = 0]

(2 marks)

(or stated in moles
or compared with $\frac{1}{12}$ of a ^{12}C atom) or relative to ^{12}C taken as 12

(f) Parts (i) to (iv) below refer to the operation of a mass spectrometer.

(i) Name the device used to ionise atoms in a mass spectrometer.

electron gun (1)

(ii) Why is it necessary to ionise atoms before acceleration? or electric field

(particles must be charged (ions) before attraction to a charged plate (1)
(or only ions can be attracted by an electric field
or accelerated)

(or converse if not charged not attracted to electric field)

(iii) What deflects the ions?

magnetic field (or magnet) (1)

(iv) What is adjusted in order to direct ions of different mass to charge ratio onto the detector?

magnetic field (1) (or accelerating potential / strength of magnet)

allow magnet

(4 marks)

(g) A meteorite was found to contain three isotopes of element X. A mass spectrometer gave the following information about these isotopes.

m/z	24.0	25.0	26.0
Relative abundance	64.2	20.3	15.5

(i) Calculate the relative atomic mass of X.

(1) — mark for any m/z × rel.ab.

$$\frac{24.0 \times 64.2 + 25.0 \times 20.3 + 26.0 \times 15.5}{100}$$ (1)

if numerator is correct but 100 has AE conseq AE-1

= 24.5 (1) (allow 24.5 to 24.52)

ignore units

if AE on 100 allow conseq correct answer provided numerator is correct

(ii) Using the Periodic Table, suggest the most likely identity of element X.

magnesium (1) (or Mg) (allow conseq on wrong Ar)

(iii) Suggest **one** reason why the relative atomic mass of X. given in the Periodic Table, differs from your answer to part (g)(i).

abundance of isotopes is different (1) (or diff isotopes)

(5 marks)

TOTAL

16

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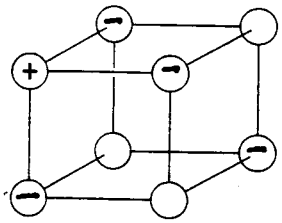
2 (a) The diagram below represents a part of the structure of sodium chloride. The ionic charge is shown on the centre of only one of the ions.



(1)

(i) On the diagram, mark the charges on the four negative ions.

(ii) What change occurs to the motion of the ions in sodium chloride when it is heated from room temperature to a temperature below its melting point?

vibrate faster (1) (or bigger amplitude or more) not start to vibrate or other type of motion esp. translation ignore rotation

(2 marks)

(b) Sodium chloride can be formed by reacting sodium with chlorine.

(i) Write an equation for this reaction. (if NA penalise once)

$Na + \frac{1}{2}Cl_2 \rightarrow NaCl$ (1) or Na^+Cl^- (or $2Na + Cl_2 \rightarrow 2NaCl$ ignore s.s. even if wrong)

(ii) A chloride ion has one more electron than a chlorine atom. In the formation of sodium chloride, from where does this electron come?

from sodium (1)

(2 marks)

(allow from sodium ion) also from the metal)

(c) In some ionic compounds the chloride ions are polarised.

(i) What is a polarised chloride ion?

not spherical (or distorted) (1) or charge uneven

(or diagram) or $Cl^{\delta-}$

(do not allow if describe Cl^- in a polarised covalent compound)

(ii) What feature of a cation causes a chloride ion to become polarised?

high charge/size ratio (1)

allow also high charge density

or high charge

or small size

(2 marks)

(d) (i) What is a covalent bond?

shared (1) electron pair (1)

(ii) What property of the atoms joined by a covalent bond causes the bond to be polar?

difference in electronegativity (1)

(3 marks)

LEAVE MARGINS BLANK

TOTAL

9

TURN OVER FOR THE NEXT QUESTION

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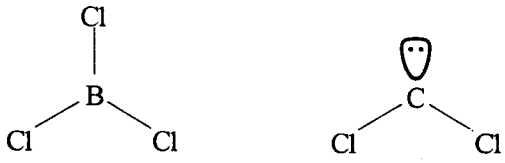
3 (a) The shape of the molecule BCl_3 and that of the unstable molecule CCl_2 are shown below.



(i) Why is each bond angle exactly 120° in BCl_3?

3 (bonding) pairs of electrons (1) allow 3 bonds

repel equally (1) (or as much as possible)
or get as far apart as possible

(ii) Predict the bond angle in CCl_2 and explain why this angle is different from that in BCl_3

Predicted bond angle 118° (allow 117-119°) (1)

allow Exp. if ∠ < 118° (no) but C.E. = 0 if ∠ ≥ 120°

Explanation lone pair (1)

repels more than bonding pair (1)

(5 marks)

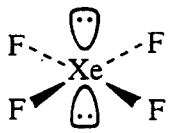
(b) Give the name which describes the shape of molecules having bond angles of 109° 28'. Give an example of one such molecule.

Name of shape tetrahedral (1)

Example CH_4 etc (1) allow a correct ion

(2 marks)

(c) The shape of the XeF_4 molecule is shown below.



(i) State the bond angle in XeF_4

90° (1)

(ii) Suggest why the lone pairs of electrons are opposite each other in this molecule.

lone pairs (or they) repel {more than bonding pairs (1) / or most}

(so are) as far apart as possible (1)

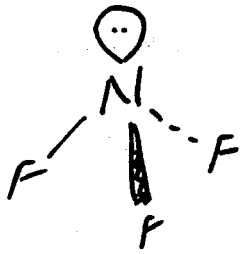
mark independently

(iii) Name the shape of this molecule, given that the shape describes the positions of the Xe and F atoms only.

square planar (1) (allow square)

(4 marks)

(d) Draw a sketch of the NF_3 molecule. Indicate in your sketch any lone pairs of electrons on nitrogen.



3 bonds + 1 lone pair (1)

correct shape (1)

(only give this mark if first mark also given

(penalise sticks (ie N—) once but N must be shown)

(2 marks)

TOTAL

13

TURN OVER FOR THE NEXT QUESTION

LEAVE MARGINS BLANK

4 (a) State the meaning of the term *electronegativity*.

{ability / power (of an atom) to attract} {or electrons or -ve charge / electron density (1)} in a covalent bond (1) or shared pair

if 'remove an electron' lose first mark

(2 marks)

(b) State and explain the trend in electronegativity values across Period 3 from sodium to chlorine.

Trend increases (1)

Explanation nuclear charge (no of protons) increases (1)

electrons in same shell (1)

[or similar shielding / or atoms similar/ size or smaller]

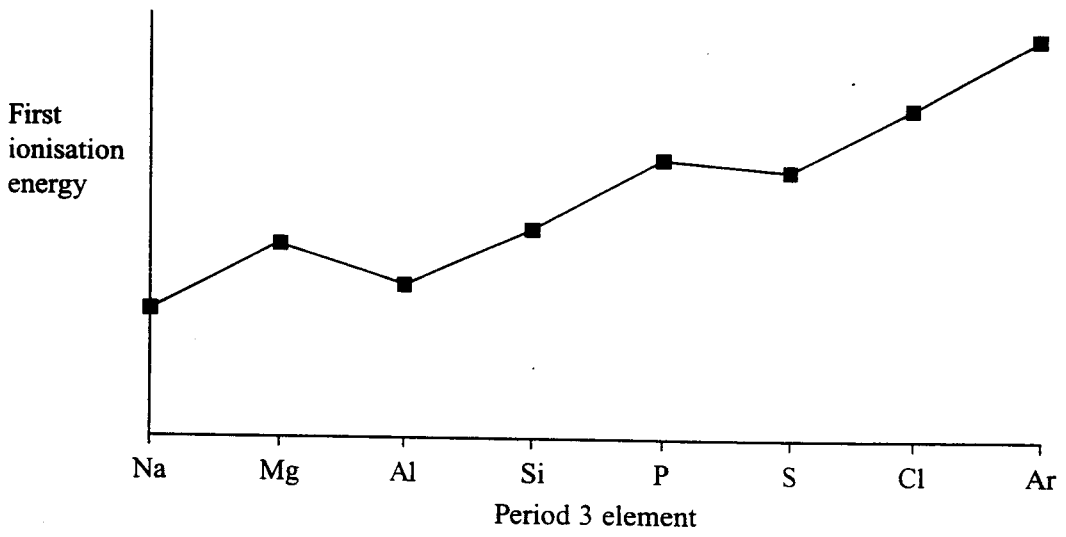
(3 marks)

(c) What is meant by the term *first ionisation energy*? (heat / enthalpy) energy for removal of one electron (1) from a gaseous atom (1) (can score in an equation) or 1 mol of e^-

(must have first mark to score second)

(2 marks)

(d) The diagram below shows the variation in first ionisation energy across Period 3.



(i) What is the maximum number of electrons that can be accommodated in an s sub-level?

2 (1)

(ii) What evidence from the diagram supports your answer to part (d)(i)?

Two elements (or Na, Mg) before the drop (in energy) to Al (1)

(iii) What evidence from the diagram supports the fact that the 3p sub-level is higher in energy than the 3s?

ionisation energy of Al < that for Mg (1)

(iv) What evidence from the diagram supports the fact that no more than three unpaired electrons can be accommodated in the 3p sub-level?

fall in energy from P to S (1) (or discontinuity in trend)
from Al to P there are 3 additional electrons (1)
or 3 elements

(5 marks)

for second mark idea of block of 3 elements

TOTAL

12

TURN OVER FOR THE NEXT QUESTION

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5 (a) (i) Describe the bonding in a metal.

positive ions (1) confusion with -ve ions or ionic lattice C.E = 0

(attract) delocalised electrons (1)

(or sea of / or free / or mobile)

can be brought forward from (a)(i)

(ii) Explain why magnesium has a higher melting point than sodium.

metallic bonding stronger scores 1 mark (only given if no other marks awarded

more protons (1) (or Mg^{2+} more charge than Na^+)

attracts delocalised (or bonding) electrons more strongly (1)

(or more delocalised electrons (1))

attract +ve ions more (1)

(4 marks)

(b) Why do diamond and graphite both have high melting points?

macromolecular (1) or giant molecule etc

covalent (1)

strong covalent bonds (1)

(or bonds require much energy to break)

(3 marks)

(c) Why is graphite a good conductor of electricity?

delocalised electrons (1)

(or free or sea of / or mobile)

(1 mark)

(d) Why is graphite soft?

planes (1)

(weak (bonds / forces) between planes (1)

or v.d.W forces between planes

(2 marks)

TOTAL

10

SECTION B

Answer **both** questions in the spaces provided on pages 12 to 16 of this booklet.

6 *Begin your answer to Question 6 on a new page.*

(a) A small sample of barium metal was added to water in a flask. When the reaction had ceased, the contents of the flask were treated with a small amount of dilute aqueous sodium sulphate.
Describe all that you would observe and write equations, with state symbols, for the reactions that occur.
(8 marks)

(b) Dilute sodium hydroxide solution was added dropwise until in excess to separate dilute aqueous solutions of beryllium chloride, magnesium chloride and barium chloride. Describe what you would observe in each case and account for your observations.
(8 marks)

(c) (i) A naturally occurring compound of calcium contains by mass 23.29% of calcium, 18.64% of sulphur and 2.32% of hydrogen, the remainder being oxygen. Determine the empirical formula of this compound.

(ii) For any compound, what is the relationship between empirical and molecular formula? What additional information is required to determine a molecular formula from an empirical formula?
(5 marks)

7 *Begin your answer to Question 7 on a new page.*

The chloride of an element **Z** reacts with water according to the following equation.

$$ZCl_4(l) + 2H_2O(l) \longrightarrow ZO_2(s) + 4HCl(aq)$$

A 1.304 g sample of ZCl_4 was added to water. The solid ZO_2 was removed by filtration and the resulting solution was made up to 250 cm^3 in a volumetric flask. A 25.0 cm^3 portion of this solution was titrated against a 0.112 mol dm^{-3} solution of sodium hydroxide, of which 21.7 cm^3 were required to reach the end point.

Use this information to calculate the number of moles of HCl produced and hence the number of moles of ZCl_4 present in the sample. Calculate the relative molecular mass, M_r, of ZCl_4. From your answer deduce the relative atomic mass, A_r, of element **Z** and hence its identity.
(9 marks)

END OF QUESTIONS

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Q6

(a) Barium dissolves (1) (or forms a solution)
Gas evolved (1) (or hydrogen evolved) or bubbles gets hot (1) do not allow evolution of wrong gas
$Ba(s) + 2H_2O(l) \rightarrow Ba^{2+}(aq) + 2OH^-(aq)$ (or $Ba(OH)_2(aq)$) $+ H_2(g)$
Species all correct (1)
State symbols correct (1) (provided species correct)
Balanced equation (1)

White precipitate with sodium sulphate (1) (or white solid or suspension) or white cloudy or milky
$Ba^{2+}(aq) + SO_4^{2-}(aq) \rightarrow BaSO_4(s)$ (or $Ba(OH)_2(aq) + Na_2SO_4(aq) \rightarrow BaSO_4(s) + 2NaOH(aq)$)
State symbols (1)
Balanced equation (1) (mark obs of ppts independently /and in b)

max **8 marks**

(b) With $BeCl_2$ and NaOH get a white precipitate (1) (or solid etc)
because $Be(OH)_2$ is insoluble (1) (or white ppt is $Be(OH)_2$)
ppt is soluble in excess of the reagent (1)
Because $Be(OH)_2$ is amphoteric (or beryllium forms a complex ion $Be(OH)_4^{2-}$) (1)
(This is the quality of language mark so the terms must be used in a sentence)

Note can take marks for $Be(OH)_2(s)$, $Mg(OH)_2(s)$, $Ba(OH)_2(aq)$ from equations

With $MgCl_2$ get a white ppt (1)
Because $Mg(OH)_2$ is sparingly soluble (or insoluble) (1) (or white ppt is $Mg(OH)_2$)

With $BaCl_2$ no ppt formed (1) (or no reaction) (or remains in solution)
Because $Ba(OH)_2$ is soluble (1) (or all species are soluble)
Solubility of hydroxides increases down Group (1)

wrong formula for $M(OH)_2$ loses mark

max **8 marks**

(c) (i) %O = 55.75% (1)

Ca:S:O:H = $\frac{23.29}{40.1} : \frac{18.64}{32.1} : \frac{55.75}{16} : \frac{2.32}{1}$ (1) (allow 40, 32)

= 1 : 1 : 6 : 4 (if Oxygen omitted can score 2nd mark only)

therefore $CaSO_6H_4$ (1)

(ii) molecular formula = an integer (1) (or a number)
empirical formula

allow correct definitions as an alternative for the mark:
emp. form. The simplest ratio of atoms of each element in a compound
molec. form. The actual number of atoms of each element in a molecule

M_r (1) (or molar mass or RFM NOT molecular mass)

Q7 **5 marks** (if use 25 here only score first of first 4 marks)

range .00242 to .00244	moles NaOH used	= vol/1000 × conc **(1)** = 21.7/1000 × 0.112 = 0.00243 **(1)** (consider 0.0024 as an arithmetic error loses 1 mark)
	moles HCl in 25 cm^3	= 0.00243 **(1)** (or 1 mol HCl reacts with 1 mol NaOH)
	moles of HCl in 250 cm^3	= 0.0243 **(1)**
	moles ZCl_4	= 0.0243/4 = 0.006075 **(1)** (or 0.006076 or 0.006, mark is for /4)
	M_r	= mass/ no. moles **(1)** (method mark also 1.304/0.006075)
		= 214.7 **(1)** (or 0.006 gives 217) (allow 214 to 215)
	A_r	= 214.7 – 142 = 72.7 **(1)** (217 gives 75, 142 is 35.5 × 4)
	Therefore element is	**Germanium (1)** (allow conseq correct from A_r) (75 gives As)

9 marks

(if not /4, CE from there on but can score 2 independent marks for (mass/moles and identity of element) (method

(for candidates who use $m_1v_1 = m_2v_2$ and calculate [HCl] = 0·0972 allow 1st 3 marks
if 25 & 21·7 wrong way round only award 1/3)