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) One isotope of sodium has a relative mass of 23.

(i) Define, in terms of the fundamental particles present, the meaning of the term *isotopes*.

Atoms with the same number of protons / proton number *NOT same atomic number* (1)

with different numbers of neutrons *NOT different mass number / fewer neutrons* (1)

(ii) Explain why isotopes of the same element have the same chemical properties.

Chemical properties depend on the number or amount of (outer) electrons

OR isotopes have the same electron configuration / same number of e⁻ (1)

(iii) Calculate the mass, in grams, of a single atom of this isotope of sodium.
(The Avogadro constant, L, is 6.023×10^{23} mol^{-1})

23/6.023 × 10²³ *(1)* *CE = 0 if inverted or multiplied*

tied to M1 3.8(2)× 10⁻²³ *[2-5 sig figs]* *(1)*

(5 marks)

(b) Give the electronic configuration, showing all sub-levels, for a sodium atom.

1s² 2s² 2p⁶ 3s¹ *(1)* *[accept subscripted figures]*

(1 mark)

(c) Explain why chromium is placed in the d block in the Periodic Table.

Q of L *Highest energy e⁻ / outer e⁻s / last e⁻ in (3)d sub-shell OR d sub-shell being filled / is incomplete* (1)

OR highest energy sub-shell is (3)d *NOT transition element / e⁻ configuration ends at 3d*

(1 mark)

(d) An atom has half as many protons as an atom of ^{28}Si and also has six fewer neutrons than an atom of ^{28}Si. Give the symbol, including the mass number and the atomic number, of this atom.

$^{15}_{7}N$ *N correct symbol* *(1)* *allow* N^{15}_{7}

Mass number = 15 AND atomic number = 7 *(1)* *(2 marks)*

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2 A gaseous sample of chromium can be analysed in a mass spectrometer. Before deflection, the chromium atoms are ionised and then accelerated.

(a) Describe briefly how positive ions are formed from gaseous chromium atoms in a mass spectrometer.

High speed electrons OR electrons from an electron gun (1)

Knocks out an (outer-shell) electron (on the chromium atom) (1)

[Accept $Cr(g) + e^- \rightarrow Cr^+(g) + 2e^-$*]*

NOT e⁻ gun alone / beam of e⁻ / bombardment with e⁻

(2 marks)

(b) What is used in a mass spectrometer to accelerate the positive ions?

Electric field OR (attraction to) –ve plate OR electrostatic attraction (1)

OR (repelled by) +ve plate OR charged plate

NOT high p.d. / electromagnetic field / electric plates

(1 mark)

(c) What is used in a mass spectrometer to deflect the positive ions?

Magnet OR magnetic field OR electromagnet (1)

(1 mark)

(d) The mass spectrum of a sample of chromium shows four peaks. Use the data below to calculate the relative atomic mass of chromium in the sample. Give your answer to two decimal places.

m/z	50	52	53	54
Relative abundance/%	4.3	83.8	9.5	2.4

$A_r = (50 \times 0.043) + (52 \times 0.838) + (53 \times 0.095) + (54 \times 0.024)$ (1)

52.06 OR 52.05 (1)

Mark consequentially on transcription, or addition of %, error

(2 marks)

6

3 (a) The equation for the reaction between magnesium carbonate and hydrochloric acid is given below.

$$MgCO_3 + 2HCl \longrightarrow MgCl_2 + H_2O + CO_2$$

When 75.0 cm^3 of 0.500 mol dm^{-3} hydrochloric acid were added to 1.25 g of impure $MgCO_3$ some acid was left unreacted. This unreacted acid required 21.6 cm^3 of a 0.500 mol dm^{-3} solution of sodium hydroxide for complete reaction.

(i) Calculate the number of moles of HCl in 75.0 cm^3 of 0.500 mol dm^{-3} hydrochloric acid.

$75.0 \times 10^{-3} \times 0.500 = 0.0375$ (mol) accept 0.037 or 0.038 (1)

(ii) Calculate the number of moles of NaOH used to neutralise the unreacted HCl.

$21.6 \times 10^{-3} \times 0.500 = 0.0108$ (mol) accept 0.011 (1)

[If both (i) and (ii) answers wrong, allow ONE process mark for both correct processes]

(iii) Show that the number of moles of HCl which reacted with the $MgCO_3$ in the sample was 0.0267

0.0375 - 0.0108 = 0.0267 (mol) (1) NOT conseq – must use figures shown

(iv) Calculate the number of moles and the mass of $MgCO_3$ in the sample, and hence deduce the percentage by mass of $MgCO_3$ in the sample.

Moles of $MgCO_3$ = 0.0267/2 = 0.01335 (mol) allow 0.0134 - 0.0133 (1)

Mass of $MgCO_3$ = 0.01335×84.3 [allow 84] (1) mark conseq on moles $MgCO_3$

= 1.125 g accept 1.13 g (1) mark conseq

Percentage of $MgCO_3$ = 1.125/1.25 × 100 (1) mark conseq (check for inversion)

= 90 % (1) mark conseq

range = 89.5 – 90.5% (8 marks)

If % expression inverted, lose M4 and M5

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(b) A compound contains 36.5 % of sodium and 25.5 % of sulphur by mass, the rest being oxygen.

(i) Use this information to show that the empirical formula of the compound is Na_2SO_3

% oxygen = 38.0 (1)

Na = 36.5/23 S = 25.5/32(.1) O = 38.0/16 (1)

= 1.587 = 0.794 = 2.375

= 2 :1:3 (1)

[If no % of oxygen Max 1 (allow M2 only)]

[If % for Na and S transposed,, or atomic numbers used, M1 only available]

(ii) When Na_2SO_3 is treated with an excess of hydrochloric acid, aqueous sodium chloride is formed and sulphur dioxide gas is evolved. Write an equation to represent this reaction.

$Na_2SO_3 + 2HCl \rightarrow 2NaCl + H_2O + SO_2$ *(1) allow multiples*

Allow $SO_3^{2-} + 2H^+ \rightarrow H_2O + SO_2$

(4 marks)

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TURN OVER FOR THE NEXT QUESTION

4 (a) Compound **A** is an oxide of sulphur. At 415 K, a gaseous sample of **A**, of mass 0.304 g, occupied a volume of 127 cm^3 at a pressure of 103 kPa.

State the ideal gas equation and use it to calculate the number of moles of **A** in the sample, and hence calculate the relative molecular mass of **A**.
(The gas constant $R = 8.31\,J\,K^{-1}\,mol^{-1}$)

Ideal gas equation ..... $pV = nRT$ (1) .....

Calculation ..... $n = pV/RT = \frac{103000 \times 127 \times 10^{-6}}{(8.31 \times 415)}$ (1) *mark for volume conversion* (1) *fully correct* .....

..... $= 3.79 \times 10^{-3}$ (mol) [range 3.79×10^{-3} to 3.8×10^{-3}] (1) .....

$M_r = m/n = .304/3.79 \times 10^{-3} = 80.1$ (range 80 – 80.3) min 2+ s.f. conseq (1) .....

[If 'V' wrong lose M2; 'p' wrong lose M3; 'inverted' lose M3 and M4] .....

(5 marks)

(b) The presence of sulphate ions in an aqueous solution can be shown by means of a simple chemical test.

(i) Identify a reagent you would use in this chemical test.

$BaCl_2$ or barium chloride allow barium nitrate/hydroxide/ethanoate (1) .....

Not Ba^{2+} but allow M2 and M3 as conseq [if reagent wrong, CE = 0]

(ii) State what you would observe if the test were positive.

White precipitate / solid / suspension (1) NOT cloudy/milky .....

(iii) Write an ionic equation for the reaction occurring when the test is positive.

$Ba^{2+} + SO_4^{2-} \rightarrow BaSO_4$ (1) .....

Do not allow spectator ions .....

(3 marks)

[If Ba^{2+} in (i), allow M2 and M3 only]
[If Ba in (i) allow M1 and M2 only]
[If no reagent offered in (i), allow M3, and, if M3 correct, allow M2]

8

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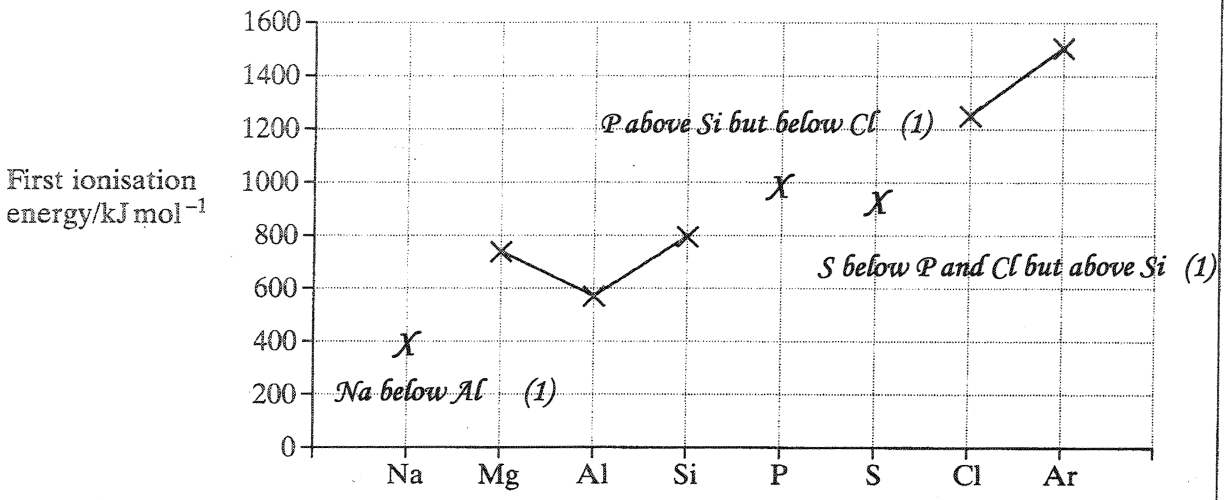
5 The diagram below shows the values of the first ionisation energies of some of the elements in Period 3.



(a) On the above diagram, use crosses to mark the approximate positions of the values of the first ionisation energies for the elements Na, P and S. Complete the diagram by joining the crosses. *(3 marks)*

(b) Explain the general increase in the values of the first ionisation energies of the elements Na–Ar.

Increased nuclear charge / proton number NOT increased atomic number (1)

Electrons enter same shell / energy level OR atoms get smaller OR same shielding (1)

Q of L *Stronger attraction between nucleus and (outer) electrons (1)*

(3 marks)

(c) In terms of the electron sub-levels involved, explain the position of aluminium and the position of sulphur in the diagram.

Explanation for aluminium *(third) electron in (3)p sub-shell (1)*

Sub-shell further away from nucleus OR of higher energy

OR extra shielding from (3)s (1)

Explanation for sulphur

Pair of electrons in (3)p orbital (1)

Repulsion between electrons [tied to reference to e⁻ pair in M3] (1)

[Penalise '2p' once only]

(4 marks)

6 (a) I_2 sublimes when heated / has low melting point AND graphite has (very) high melting point (1)

I_2 is (simple) molecular / I_2 / I-I (1)
CE = 0 if 'ionic' loses M2, M3, M4 Max 1 if I-I bond broken

Van der Waals forces / induced or temporary dipole-dipole / London forces (1)

Which are weak or easily overcome (so low melting point) (1)

Graphite is macromolecular / giant covalent / giant molecular / giant atomic / (1)
Diagram (min 3 correctly fused rings – ignore diagram unless no description offered)
CE = 0 if 'ionic' or 'metallic' loses M5, M6, M7

(Many) covalent bonds need to be broken 'covalent' may be inferred from structure (1)

Which takes much energy / bonds are strong (1)

Only graphite conducts [NOT just graphite is a better conductor] (1)

As it has delocalised / free / mobile electrons (1)

All e⁻ in iodine are used in bonding and lone pairs OR as it has no delocalised / free / mobile e⁻ (1) [Max 9]
[M9 and M10 tied to correct statements about graphite = conductor and iodine = non-conductor]

(b) Diagram Cl—Be—Cl (clearly linear) CE = 0 if lone pair(s) on Be, loses M1 and M2 (1)

(Equal) repulsion between 2 bonding pairs / bonds '2' may be inferred from a correct diag (1)
NOT repulsion between Cl atoms

Cl^- ion polarised by Be^{2+} / distorts e⁻ cloud (must be ions) / diag with correct charges (1)

Because of high charge density on Be^{2+} OR high charge/size ratio (1)
NOT just Be^{2+} is smaller. Treat higher m/z value as a contradiction

Electrons / electron cloud from Cl^- ion forms covalent bond (with Be)
/ electrons in new bond are from Cl^- ion (wtte) Accept a correct dot-and-cross diagram (1)
[Penalise missing charges or 'ions' once only for M3, M4 and M5]

$Be(OH)_2$ is amphoteric / description / dissolves in base NOT Beryllium is amphoteric (1)