



General Certificate of Education

Chemistry (5421)

**CHM1 Atomic Structure, Bonding and
Periodicity**

Mark Scheme

2008 examination - January series

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Question 1

(a)	M1	<u>Mean (average) mass of an atom / (all) the isotopes</u>	1
	M2	1/12 th mass of atom of ¹² C	1
		[allow mass of average atom]	
	Or	<u>Mass of 1 mole of atoms of an element</u>	(1)
		1/12 th mass of 1 mole of ¹² C	(1)
	Or	Average mass of an atom / all the isotopes	(1)
		Relative to the mass of a ¹² C atom taken as exactly 12 / 12.000	(1)
		(Penalise 'weight' once only) (Ignore 'average' mass of ¹² C)	
(b)	(i)	M1 Accelerate by electric field / -ve plate / -ve field / -ve electrode / electrostatic field	1
		[NOT charged plates / +ve plates / electrostatic plates / <u>electronic</u> field / electric current / +ve ion gate]	
	(ii)	M2 Deflected by magnet / magnetic field / electromagnet	1
	(iii)	M3 QWC Ions collide with detector and a current is generated / e ⁻ transferred / e ⁻ accepted (by ions)	1
		[NOT ion-current detector / detected electronically / ions release current / a circuit is created / charge created on -ve plate]	
(c)	(i)	M1 Horizontal label = m/z / mass : charge ratio / m/e [NOT M_r]	1
		M2 Vertical label = (relative/%) abundance / % ions detected [NOT frequency / intensity / number of ions detected / amount of substance]	1
	(ii)	M1 ³⁷ Cl peak shown at $m/z = 37$ and about 1/3 of ³⁵ Cl i.e. 2 lines up	1
		M2 Cl ²⁺ peaks at $m/z = 17.5$ and 18.5 [tick below axis]	1
		M3 Cl ²⁺ peak heights < Cl ⁺ peak height (max height = 3 lines) [tick above peaks] [M3 tied to M2 or 'near miss' (within range 15 – 20)] [if more than 3 peaks drawn but peaks at 17½ & 18½ are present, lose M2 but allow M3]	1

Total 10

Question 2

Sig fig penalty. 2 sf min [unless exact answer = 1 sf digit – e.g. 0.09 in (a)(ii)]

1 sig fig penalty only per question.

Ignore missing units but penalise wrong units once per question only

(a) (i) M1 Moles of HCl = $100 \times 10^{-3} \times 1.75 = 0.175$ (mol)
range 0.17 – 0.18 1
[Ignore units]

(ii) M2 Moles Na₂CO₃ = $0.175 \div 2 = 0.0875$ (mol)
range 0.085 – 0.09 1

M3 Mass Na₂CO₃ = $0.0875 \times 106.0 = 9.275$ g
range 9.01 – 9.54 1
[M2 & M3 conseq on previous answers]

3 marks

(b) (i) M1 $M_r(\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}) = 286.0$ 1

M2 $\frac{106 \times 100}{286.0}$ [if error in 106 above, conseq here] 1

$M2 = (106/\text{their } M_r \text{ value}) \times 100$ i.e. = process mark [$\times 100$ may be implied]

M3 = 37.1% range 37 – 37.1 [conseq on error in 286]

M3 is for correct arithmetic right answer = 3 ticks

[if 106 (or conseq equivalent) NOT used, then CE = 0 for M2 & M3]

[if 106 & 286 inverted = CE = 0 for M2 & M3]

[if not multiplied by 100, i.e. 0.371%, lose M2 but allow M3 conseq]

[equivalent marking for calculations using masses]

(ii) M4 Mass Na₂CO₃ · 10H₂O = $\frac{0.267}{2} \times 286 = 38.2$ g
range 38 – 38.4 1

[mark conseq on their M_r value in (b)(i)]

4 marks

(c) M1 $pV = nRT$ or rearranged 1

M2 $\frac{V = nRT}{p} = \frac{0.0775 \times 8.31 \times 298}{101000}$ pressure converted 1

[if 'V' expression incorrect = CE = 0 for M3 & M4]

[if no pressure conversion:

1. if answer quoted in dm³ no penalties

2. if units not dm³, penalise M2]

M3 = $1.9(0) \times 10^{-3}$ or 1.9 if no pressure conversion (see above) 1
[if pressure conversion wrong, mark answer conseq on their value of

pressure – otherwise, no conseq on other errors such as transcription or arithmetic]

M4 units = m³ or dm³, if no pressure conversion (see above) 1

4 marks

Total 11

Question 3

- (a) M1 Electron arrangement = 1s²2s²2p⁶3s²3p⁴ 1
[accept upper case letters and subscripted numbers]
- M2 Element **E** = S / sulphur [Not conseq] [Not tied to M1] 1
- (b) (i) M1 Tendency / strength / ability / power of an atom / element / nucleus to attract / withdraw electrons / e- density / bonding pair / shared pair 1
- M2 In a covalent bond / shared/bonding pairs (tied to M1 – unless silly slip in M1 – e.g. e⁻ retained/e⁻ cloud/single e⁻/missing, e.g. 'atom') [CE if ions /into covalent bonds / lone pair / remove e⁻ = 0] 1
- (ii) M3 Trend in electronegativity = increasing [Decrease/stays same = CE = 0] [allow 'general increase' but mention of deviations = 'con' M3] 1
- M4 Increasing number of protons across period / inc nuclear charge [Not increased atomic number / effective nuclear charge] 1
- M5 Smaller size / bonding e- closer to nucleus /same shells / same shielding [Not molecules] 1
- (c) (i) M1 F more electronegative (than H) / F is very/highly electronegative / reference to electronegativity difference / bonding electrons more attracted towards F [Not δ+/δ-] 1
- (ii) M2 Trend = decreasing polarity [Increase/stays same = CE = 0] 1
- M3 Because electronegativity (difference) decreases 1
- (d) (i) M1 HF has hydrogen bonding / allow H-bonding [Not H and F have H-bonding] [Ions = CE = 0] [covalent bonds break = CE for M2 & M3] 1
- M2 Other HX have van der Waals'/dipole-dipole 1
- M3 Hydrogen bonding stronger than other imf's / is strongest /

		more energy to overcome / contra arguments	1
(ii)	M4	van der Waals' forces / London forces / temporary / induced dipole-dipole / dispersion forces <i>[if "imf's" here but clarified by vdW mention in (d)(i), allow] [ignore dipole-dipole unless its trend said to be increasing, then 'con' M4] [Not 'fluctuating']</i>	1
	M5	increase with size / M_r / number of e ⁻ s / surface area <i>[M5 tied to van der Waals']</i>	1
	M6	size / M_r / number of e-s / surface area increase (HCl to HI) / atomic size	1
(e)	(i)	M1 e ⁻ cloud distorted / e ⁻ s or e ⁻ density unequally distributed / more -ve one side than other <i>[Atoms = CE = 0]</i>	1
	(ii)	M2 High charge density / high charge / small size <i>[Not small atomic radius]</i>	1
			Total 18

Question 4

(a)	M1	Observation with HCl bubbles/fizz/effervescence <i>[accept gas evolved but NOT CO₂ evolved] [ignore references to specific gases even if wrong] [apply 'list' rule if multiple observations] [allow valid observation in 'Product' unless it contradicts what's already there]</i>	1
	M2	Product with HCl CO ₂ <i>[If wrong gas quoted above, treat as 'con' of CO₂] [treat 'list' as 'con' of CO₂ unless its clear from observation that gas = CO₂]</i>	1
	M3	Equation with HCl $\text{Na}_2\text{CO}_3 + 2\text{HCl} \rightarrow 2\text{NaCl} + \text{H}_2\text{O} + \text{CO}_2$ <i>[ignore sulphate equ] $\text{CO}_3^{2-} + 2\text{H}^+ \rightarrow \text{H}_2\text{O} + \text{CO}_2$ [Not H₂CO₃]</i>	1
(b)	M1	Observation with BaCl ₂ <u>white</u> ppt/solid/suspension/powder <i>[Not cloudy/milky/emulsion/residue/opaque] [apply 'list' rule if multiple observations] [allow valid observation in 'Product' unless it contradicts what's already here]</i>	1
	M2	Product with BaCl ₂ Barium sulphate / BaSO ₄ <i>[Must be stated – not from equation] [treat 'list' as 'con' of BaSO₄ unless its clear from observation that ppt = BaSO₄]</i>	1
	M3	Equation with BaCl ₂ $\text{Na}_2\text{SO}_4 + \text{BaCl}_2 \rightarrow 2\text{NaCl} + \text{BaSO}_4$ <i>[ignore carbonate equ] $\text{Ba}^{2+} + \text{SO}_4^{2-} \rightarrow \text{BaSO}_4$ [BaSO₄(aq) = 0 for M3]</i>	1
			Total 6

Question 5

(a)	M1	NH ₄ ⁺	4 bonds / bonding/shared pairs / 3 b.p. + 1 dative bond / diagram / dot-and-cross [diagram: ignore error in shape but penalise error in bonds, e.g. line/arrow = \div or \rightarrow]	1
	M2	shape	<u>equal</u> repulsion between bonding pairs / e ⁻ pairs [Not repulsion between atoms / bonds]	1
	M3	NH ₃	3 bonds / bonding/shared pairs + 1 lone/non-bonding pair / diagram / dot-and-cross [ignore error in shape but penalise error in bonds, e.g. line/arrow = \div or \rightarrow]	1
	M4 QWC	shape	repulsion from lone pair > repulsion from bonding pair [comparison essential] [allow even if number of lp wrong – not tied to M3] [Not electron pairs] [not lp repels bp]	1
(b)	M1	NH ₂ ⁻	tetrahedral layout with 2 lone pairs shape [brackets and charges not needed – ignore error in charges] [Not dot-and-cross diagram. Atoms must be shown. Ignore bond angles] [Not empty orbital ‘bubble’, i.e. electron pair dots required]	1
	M2	Name of shape	V-shaped / bent / bent planar / angular [mark independently of M1] [ignore bent-linear / distorted linear / non-linear] [Not triangular / arrow head / distorted tetrahedral]	1

Total 6**Question 6**

(a)	M1	macromolecular/giant atomic/giant covalent / giant molecular / giant lattice of atoms [not giant lattice of molecules, i.e. atoms \leftrightarrow molecules ‘slip’, M1 = 0, but allow M2/3/4]	1
	M2	mp <u>covalent</u> bonds must be <u>broken/overcome</u> [if ‘covalent’ omitted, lose M2, allow M3/4]	1
	M3	these bonds are strong / many / = 4 / hard to break/overcome	1
	M4	requiring much heat / energy to break [M3 & M4 tied to M2] [IF SiO ₂ or diamond instead of Si, ‘con’ M1] [CE if ionic / metallic / hydrogen bonding] [if vdW or dipole-dipole, but still describes cov bonds breaking, ‘con’ M1 and <u>Max 2</u>]	1

(b)	M1	P₄ / S₈ / Cl₂ comparison	Red phosphorus + S₈ / Cl₂ comparison
	Mp	S > P / S > Cl / P > Cl <i>[ignore references to b.p.]</i>	red phosphorus > S/Cl <i>[ignore references to b.p.]</i> 1
	M2	Exp ^l both molecular structures / formulae given <i>[incorrect formula OK as 'molecular' here]</i>	P = macromolecular and S/Cl = molecular 1
	M3	(only) vdW forces (between molecules)	vdW forces (between S / Cl molecules) <i>[incorrect formula OK as 'molecules' here]</i> 1
	M4	vdW inc with size /M _r / number of e ⁻ s / SA <i>[M4 tied to van der Waals'] [Not mass]</i>	Covalent bonds stronger than vdW 1
	M5	S ₈ > P ₄ / S ₈ > Cl ₂ / P ₄ > Cl ₂ <i>[for M5: size/etc. comparison is be between <u>molecules</u>, i.e. S has more e⁻ than Cl = 0]</i>	heat/energy to break covalent bond > heat/energy to overcome vdW 1

Comments below refer to **S₈ / P₄ / Cl₂ comparison**

[if imf, not vdW, M3 = M4 = 0, but allow M5]

[if vdW + dipole-dipole, but vdW based explanation, 'con' M3 but allow rest]

[if H-bond = CE M3/4/5]

[if just dipole-dipole = CE M3/4 but allow M5]

If only 1 element, allow M3/4 only = Max 2]

[if wrong order, allow M2/3/4 only]

[if breaking cov bonds here, M1/2 only]

[if ionic/metallic allow M1 only]

Total 9