



## **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 <sup>th</sup> mass of atom of <sup>12</sup> C	1
		[allow mass of average atom]	
	<b>Or</b>	<u>Mass of 1 mole of atoms of an element</u>	(1)
		1/12 <sup>th</sup> mass of 1 mole of <sup>12</sup> C	(1)
	<b>Or</b>	Average mass of an atom / all the isotopes	(1)
		Relative to the mass of a <sup>12</sup> C atom taken as exactly 12 / 12.000	(1)
		(Penalise 'weight' once only) (Ignore 'average' mass of <sup>12</sup> 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 <b>QWC</b> Ions collide with detector and a current is generated / e <sup>-</sup> transferred / e <sup>-</sup> 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 <sup>37</sup> Cl peak shown at $m/z = 37$ <b>and</b> about $\frac{1}{3}$ of <sup>35</sup> Cl i.e. 2 lines up	1
		M2 Cl <sup>2+</sup> peaks at $m/z = 17.5$ <b>and</b> 18.5 [tick below axis]	1
		M3 Cl <sup>2+</sup> peak heights < Cl <sup>+</sup> 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 Na<sub>2</sub>CO<sub>3</sub> =  $0.175 \div 2 = 0.0875$  (mol)  
range 0.085 – 0.09 1
- M3 Mass Na<sub>2</sub>CO<sub>3</sub> =  $0.0875 \times 106.0 = 9.275$  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 Na<sub>2</sub>CO<sub>3</sub> · 10H<sub>2</sub>O =  $\frac{0.267}{2} \times 286 = 38.2$  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 dm<sup>3</sup> no penalties
2. if units not dm<sup>3</sup>, 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 = m<sup>3</sup> or dm<sup>3</sup>, if no pressure conversion (see above) 1

4 marks

**Total 11**

### Question 3

- (a) M1 Electron arrangement = 1s<sup>2</sup>2s<sup>2</sup>2p<sup>6</sup>3s<sup>2</sup>3p<sup>4</sup> 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<sup>-</sup> 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<sup>-</sup> retained/e<sup>-</sup> cloud/single e<sup>-</sup>/missing, e.g. 'atom') [CE if ions /into covalent bonds / lone pair / remove e<sup>-</sup> = 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<sup>-</sup> 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<sup>+</sup>/δ<sup>-</sup>] 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 <u>but clarified</u> 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 <sup>-</sup> 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 <sup>-</sup> cloud distorted / e <sup>-</sup> s or e <sup>-</sup> 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
			<b>Total 18</b>

**Question 4**

(a)	M1	Observation with HCl bubbles/fizz/effervescence <i>[accept gas evolved but NOT CO<sub>2</sub> 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 <sub>2</sub> <i>[If wrong gas quoted above, treat as 'con' of CO<sub>2</sub>] [treat 'list' as 'con' of CO<sub>2</sub> unless its clear from observation that gas = CO<sub>2</sub>]</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] <math>\text{CO}_3^{2-} + 2\text{H}^+ \rightarrow \text{H}_2\text{O} + \text{CO}_2</math> [Not H<sub>2</sub>CO<sub>3</sub>]</i>	1
(b)	M1	Observation with BaCl <sub>2</sub> <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 <sub>2</sub> Barium sulphate / BaSO <sub>4</sub> <i>[Must be stated – not from equation] [treat 'list' as 'con' of BaSO<sub>4</sub> unless its clear from observation that ppt = BaSO<sub>4</sub>]</i>	1
	M3	Equation with BaCl <sub>2</sub> $\text{Na}_2\text{SO}_4 + \text{BaCl}_2 \rightarrow 2\text{NaCl} + \text{BaSO}_4$ <i>[ignore carbonate equ] <math>\text{Ba}^{2+} + \text{SO}_4^{2-} \rightarrow \text{BaSO}_4</math> [BaSO<sub>4</sub>(aq) = 0 for M3]</i>	1
			<b>Total 6</b>

**Question 5**

(a)	M1	NH <sub>4</sub> <sup>+</sup>	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 <sup>-</sup> pairs [Not repulsion between atoms / bonds]	1
	M3	NH <sub>3</sub>	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 <b>QWC</b>	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 <sub>2</sub> <sup>-</sup>	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 <sub>2</sub> 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	<b>P<sub>4</sub> / S<sub>8</sub> / Cl<sub>2</sub> comparison</b>	<b>Red phosphorus + S<sub>8</sub> / Cl<sub>2</sub> comparison</b>
	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 <sup>l</sup> both molecular structures / formulae given <i>[incorrect formula OK as 'molecular' here]</i>	P = macromolecular <b>and</b> 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 <sub>r</sub> / number of e <sup>-</sup> s / SA <i>[M4 tied to van der Waals'] [Not mass]</i>	Covalent bonds stronger than vdW 1
	M5	S <sub>8</sub> > P <sub>4</sub> / S <sub>8</sub> > Cl <sub>2</sub> / P <sub>4</sub> > Cl <sub>2</sub> <i>[for M5: size/etc. comparison is be between <u>molecules</u>, i.e. S has more e<sup>-</sup> than Cl = 0]</i>	heat/energy to break covalent bond > heat/energy to overcome vdW 1

Comments below refer to **S<sub>8</sub> / P<sub>4</sub> / Cl<sub>2</sub> 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**