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ASSESSMENT and QUALIFICATIONS ALLIANCE

General Certificate of Education

Chemistry (5421)

CHM1 Atomic Structure, Bonding and Periodicity

Mark Scheme

2008 examination - January series

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Registered address: AQA, Devas Street, Manchester M15 6EX *Dr Michael Cresswell Director General*

Question 1

(a)		M1	Mean (average) mass of an atom / (all) the isotopes	1
		M2	$1/12^{th}$ mass of atom of ^{12}C	1
			[allow mass of average atom]	
		Or	Mass of 1 mole of atoms of an element	(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 / electronic 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 ⅓ 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 Na_2CO_3 = $0.175 \div 2$ = 0.0875 (mol)
range 0.085 – 0.09 1

M3 Mass Na_2CO_3 = 0.0875×106.0 = 9.275 g
range 9.01 – 9.54 1
[M2 & M3 conseq on previous answers]

3 marks

(b) (i) M1 $M_r(Na_2CO_3.10H_2O)$ = 286.0 1

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

M2 = (106/their M_r value) × 100 i.e. = process mark [×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 $Na_2CO_3.10H_2O$ = $\frac{0.267}{2} \times 286$ = 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^3 no penalties
2. if units not dm^3, 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^3 or dm^3, if no pressure conversion (see above) 1

4 marks

Total 11

Question 3

(a) M1 Electron arrangement = $1s^2 2s^2 2p^6 3s^2 3p^4$ 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 1
[Decrease/stays same = CE = 0]
[allow 'general increase' but mention of deviations = 'con' M3]

M4 Increasing number of protons across period / inc nuclear charge 1
[Not increased atomic number / effective nuclear charge]

M5 Smaller size / bonding e- closer to nucleus /same shells / same shielding 1
[Not molecules]

(c) (i) M1 F more electronegative (than H) / F is very/highly electronegative / reference to electronegativity difference / bonding electrons more attracted towards F [Not $\delta+/\delta-$] 1

(ii) M2 Trend = decreasing polarity 1
[Increase/stays same = CE = 0]

M3 Because electronegativity (difference) decreases 1

(d) (i) M1 HF has hydrogen bonding / allow H-bonding 1
[Not H and F have H-bonding]
[Ions = CE = 0]
[covalent bonds break = CE for M2 & M3]

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 1
[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']

M5 increase with size /M_r / number of e^-s / surface area 1
[M5 tied to van der Waals']

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 1
[Atoms = CE = 0]

(ii) M2 High charge density / high charge / small size
[Not small atomic radius] 1

Total 18

Question 4

(a) M1 Observation with HCl bubbles/fizz/effervescence 1
[accept gas evolved but NOT CO_2 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]

M2 Product with HCl CO_2 1
[If wrong gas quoted above, treat as 'con' of CO_2]
[treat 'list' as 'con' of CO_2 unless its clear from observation that gas = CO_2]

M3 Equation with HCl $Na_2CO_3 + 2HCl \rightarrow 2NaCl + H_2O + CO_2$ 1
[ignore sulphate equ] $CO_3^{2-} + 2H^+ \rightarrow H_2O + CO_2$
[Not H_2CO_3]

(b) M1 Observation with $BaCl_2$ <u>white</u> ppt/solid/suspension/powder 1
[Not cloudy/milky/emulsion/residue/opaque]
[apply 'list' rule if multiple observations]
[allow valid observation in 'Product' unless it contradicts what's already here]

M2 Product with $BaCl_2$ Barium sulphate / $BaSO_4$ 1
[Must be stated – not from equation]
[treat 'list' as 'con' of $BaSO_4$ unless its clear from observation that ppt = $BaSO_4$]

M3 Equation with $BaCl_2$ $Na_2SO_4 + BaCl_2 \rightarrow 2NaCl + BaSO_4$ 1
[ignore carbonate equ] $Ba^{2+} + SO_4^{2-} \rightarrow BaSO_4$
[$BaSO_4$(aq) = 0 for M3]

Total 6

Question 5

(a) M1 NH_4^+ 4 bonds / bonding/shared pairs / 3 b.p. + 1 dative bond / diagram / dot-and-cross 1
[diagram: ignore error in shape but penalise error in bonds, e.g. line/arrow = ÷— or ÷⟶]

M2 shape equal repulsion between bonding pairs / e^- pairs 1
[Not repulsion between atoms / bonds]

M3 NH_3 3 bonds / bonding/shared pairs + 1 lone/non-bonding pair / diagram / dot-and-cross 1
[ignore error in shape but penalise error in bonds, e.g. line/arrow = ÷— or ÷⟶]

M4 shape repulsion from lone pair > repulsion from bonding pair 1
QWC *[comparison essential]*
[allow even if number of lp wrong – not tied to M3]
[Not electron pairs] *[not lp repels bp]*

(b) M1 NH_2^- tetrahedral layout with 2 lone pairs 1
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]

M2 Name of shape V-shaped / bent / bent planar / angular 1
[mark independently of M1]
[ignore bent-linear / distorted linear / non-linear]
[Not triangular / arrow head / distorted tetrahedral]

Total 6

Question 6

(a) M1 macromolecular/giant atomic/giant covalent / giant molecular / giant lattice of atoms 1
[not giant lattice of molecules, i.e. atoms ↔ molecules
'slip', M1 = 0, but allow M2/3/4]

M2 mp covalent bonds must be broken/overcome *[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 1
[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 Max 2]

(b)	M1	**P_4 / S_8 / Cl_2 comparison**	**Red phosphorus + S_8 / Cl_2 comparison**	
	Mp	S > P / S > Cl / P > Cl *[ignore references to b.p.]*	red phosphorus > S/Cl *[ignore references to b.p.]*	1
	M2	Expl^{n} both molecular structures / formulae given *[incorrect formula OK as 'molecular' here]*	P = macromolecular **and** S/Cl = molecular	1
	M3	(only) vdW forces (between molecules)	vdW forces (between S / Cl molecules) *[incorrect formula OK as 'molecules' here]*	1
	M4	vdW inc with size /M_r / number of e^-s / SA *[M4 tied to van der Waals']* *[Not mass]*	Covalent bonds stronger than vdW	1
	M5	S_8 > P_4 / S_8 > Cl_2 / P_4 > Cl_2 *[for M5: size/etc. comparison is be between molecules, i.e. S has more e^- than Cl = 0]*	heat/energy to break covalent bond > heat/energy to overcome vdW	1

Comments below refer to **S_8 / P_4 / Cl_2 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