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ASSESSMENT and QUALIFICATIONS ALLIANCE

General Certificate of Education

Chemistry 5421

CHM1 Atomic Structure, Bonding, and Periodicity

Mark Scheme

2007 Examination – January series

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Question 1

(a)

	relative mass	**and**	relative charge	
Proton	1		+1	1
Electron	1/1800		-1	1

Accept < 5.6×10^{-4} / negligible / 0

(b) ^{38}Ar mass number *[allow separate 38]* 1
element 1
[Not AR] [M1: Not 38.0 / M2 Not symbol with a charge]
[Wrong proton number = 'con' for M2] [$_{38}A_r$ scores 1 mark]

(c) (i) $1s^2 2s^2 2p^6$ 1
[Allow upper case letters and subscripted numbers] [Not [*He*]$2s^2 2p^6$*]*

(ii) More protons / atomic number / proton number /higher or stronger nuclear charge
Al^{3+} smaller (size) than Na^+ / e^- closer to nucleus
More attraction for e^- from / e^- held/pulled more strongly by Al^{3+}
any 2 points 2

[M3 Al^{3+} may be inferred] [M2 Not 'atomic radius' / 'atom'/
'molecule' = 'con']
Greater charge density/charge-size ratio = alternative for either M1 or M2 but not for both]

(d) (i) High energy/speed electrons / electrons from an electron gun / electron gun fires e^- 1
Knock off/displaces/removes an electron/electrons (from the gaseous atom) 1
[Accept correct equation for M2]

(ii) Electric field / -ve plate / electrostatic field/oppositely charged plates 1
[Not electronic field; magnetic field / electric current/high pd/high voltage]

(e) $\frac{(194 \times 32.8) + (195 \times 30.6) + (196 \times 25.4) + (198 \times 11.2)}{100}$ 1
= 195.3 (1 d.p. only)
[Mark M2 conseq. on transcription error]

Question 2

(a) (i) $21.7 \times 10^{-3} \times 0.150 = 3.255 \times 10^{-3}$ (mol) 1
[Accept 3.25 – 3.26 $\times 10^{-3}$]

(ii) In 25 cm^3 = $(3.255 \times 10^{-3})/2$ = 1.63×10^{-3} (mol) *[Conseq on (i)]* 1
In sample = 1.63×10^{-2} *[Conseq on (ii)]* 1

(iii) = 1.92 / 1.63×10^{-2} *[Process mark]* 1
= 117.9 = 118 *[Conseq on (ii)]* ***[M5 Tied to M4]*** 1
[Accept 117.7 – 118.2]
[If '÷ 2' not done in M2, CE = 0 for M2 and M5]
[If 1.63×10^{-3} used in (a)(iii), lose M3 only]

(b) (i) Simplest/lowest ratio of atoms of each element (in a compound) 1
QoL *[Allow 'elements' for 'each element] ['atoms' needed in molar definitions]*
*[Not atoms of **an** element]*

(ii)

C	**H**	**O**
49.31	6.85	43.84
12	1	16
4.11	6.85	2.74
1.5	2.5	1

Ratio 3 5 2 or $C_3H_5O_2$ 1

[If any A_r value used is wrong / calculation inverted = CE = 0]
= $C_3H_5O_2 \times 146/73$ = $C_6H_{10}O_4$ 1
[If transcription error in % data, allow M1 only]
[Not $(C_3H_5O_2)_2$]

(c) (i) pV = nRT 1

= $\frac{pV}{RT}$ = $\frac{100000 \times 352 \times 10^{-6}}{8.31 \times 298}$ *[volume conversion]* 1
[numbers correct] 1

Moles CO_2 = 0.0142 (mol) 1
[If transcription error, lose M3 – so, '325' loses M2 (no conversion) and M3 (transcription error)]
[If expression inverted (i.e. RT/pV calculated) = CE = 0 for M3 and M4]

Moles $NaHCO_3$ = 0.0142×2 (= 0.0284 (mol)) *[Process]* 1

Mass $NaHCO_3$ = 84×0.0284 *[mark for the M_r] [accept correct 'string']* 1

= 2.38 - 2.39 g *[Conseq on M_r error]* 1
[If '× 2' not used – i.e. M5 = 0, then CE and M7 is also lost. Can get M6 for M_r]
Answers using 0.0230 mol:
Moles $NaHCO_3$ = 0.0460 Mass = 3.86-3.87
[Sig figs for whole question. For <3 sf (unless 2sf dead) award 1 mark penalty ONLY for sf errors]

Question 3

(a) (i) (A covalent bond in which) the electron density is/electrons are unequally shared. 1
[Allow idea of δ+ and δ- across bond / charge separation / bonding pair / e^-s closer to one atom] [accept clear diagram]
[Not electron cloud unless clearly describing a covalent bond]

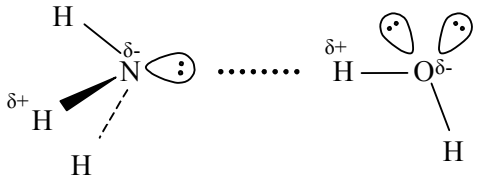
(ii) Bonds in hydrogen non-polar
Bonds in water polar *[need both]* 1
[If bond types reversed, lose M1, not CE]

Atoms in a non-polar bond / in H_2 have <u>the same electronegativity</u> 1

Atoms in a polar bond have <u>different electronegativities</u> **Or** 1
O more/very electronegative / has different electronegativity than H

[Allow M1 in 'Explanation' section if gaps in bond type section]
[If 'gaps' and bond types not identified in explanation, allow 1 mark for H_2 has no electronegativity diff. but H and O have electronegativity diff.]
[If M1 = wrong, e.g. van der Waals' etc, then CE = 0]

(b) (i) At least one dipole on each molecule 1



Lone pair on N **and** H-Bond correctly indicated *[Not arrows or solid lines]* 1
Two lone pairs on oxygen 1
[An extra, incorrect, hydrogen bond contradicts a correct one]

(ii) Bond angle in ammonia = 106.5°-107.5° 1
Idea that lone pair repulsion > bonding pair repulsion 1
Oxygen/water has more lone pairs than nitrogen/ammonia 1
Mark points independently

(c) Type of bond = Dative bond / coordinate bond 1
Lone pair donated from/by N (to Al) / N provides both electrons 1
[Accept NH_3 in place of N]

Question 4

(a) Least soluble hydroxide = $Mg(OH)_2$ 1

(b) (i) $BaCl_2$ / any soluble barium cpd **Or** $AgNO_3$ / any soluble silver cpd 1
[If formula used, must be correct] [Not Ba^{2+} ions / Ba element]
[If 'impossible' reagent, e.g. $BaSO_4$ or NaOH, = CE = 0]

(ii) Obs with NaCl = no change/ppt/reaction **Or** white ppt etc*. 1

Obs with Na_2SO_4 = white ppt* /solid **Or** no change etc. 1

Equation = $Ba^{2+} + SO_4^{2-} \rightarrow BaSO_4$ **Or** $Ag^+ + Cl^- \rightarrow AgCl$ 1

[If Ba / Ba^{2+}/ wrong formula – i.e. M1 lost but not 'impossible' reagent, allow M2/3/4]

[Allow full credit for a valid test for Cl^- ions – the points below apply]

[If no reagent given but Ba^{2+} / $BaCl_2$ in equation, allow credit for M2/3/4]

[Ignore state symbols in the equation – even if wrong]

*[*ppt or solid or powder or suspension]*

[Not cloudy, milky, emulsion, residue, opaque]

[Not nothing / no observations / none]

Question 5

Diagram: Na^+ and Cl^- ions correctly placed in 2D (Min 4 ions) 1
Cubic – min 8 ions (or 7 with hidden ion) 1

[Looking for shape, so ignore missing charges]
[Accept circles with '+' and '-' / different size circles / different coloured circles]

Opposite-ion/electrostatic attractions / forces *[Not electrostatic bonds]* 1
are strong / difficult to break / overcome / loosen 1

[Accept 'strong ionic bonding' for 1 mark]
[Accept high energy needed to overcome attractions in place of 'strong']
[Not just high energy needed to melt NaCl]
[atoms / molecules / IMFs / covalent / delocalised e^- = CE= 0]

Conducts only when molten or in aqueous solution 1
As ions can move. 1
[Mark M5 / M6 separately

Question 6

(a) Atomic radius decreases 1
[If trend wrong = CE = 0] [If trend blank award M2 /M3 / M4 on merit]

Increase in number of protons / atomic number / nuclear charge 1

Same shells / energy level / shielding / screening
[Accept similar shielding] 1

QoL Increase in attraction/pull between nucleus and outer electrons 1

(b) Energy/enthalpy change when one electron is removed 1
from a gaseous atom 1
[Molar definitions must have reference to 'atoms']

General trend = increasing 1
[Do NOT treat wrong trend as CE but comparisons with Mg / P must be emphatic – i.e. IE of Al is much lower than that of Mg]

Deviation:

first IE of Al is low / < Mg	**M4**	first IE of S is low / < P	1
(Outer) e^- *(singular)* in 3p/p orbital / p sublevel	**M5**	(e^- removed from) e^- pair in 3p / p orbital / p sublevel	1
In higher energy orbital/sub-level Or e^- further from nucleus Or shielding/screened by 3s	**M6**	repulsion between these paired e^- *['e^- pair' may be inferred]*	1

Mark part (b) to 5 max

[If both Al and S described, mark both and award higher mark – cross out rejected answer]
[If not Al / S then CE for M4/5/6]