ASSESSMENT and QUALIFICATIONS ALLIANCE

General Certificate of Education

Chemistry 5421

CHM1 Atomic Structure, Bonding and Periodicity

Mark Scheme

2006 examination – January series

Mark schemes are prepared by the Principal Examiner and considered, together with the relevant questions, by a panel of subject teachers. This mark scheme includes any amendments made at the standardisation meeting attended by all examiners and is the scheme which was used by them in this examination. The standardisation meeting ensures that the mark scheme covers the candidates' responses to questions and that every examiner understands and applies it in the same correct way. As preparation for the standardisation meeting each examiner analyses a number of candidates' scripts: alternative answers not already covered by the mark scheme are discussed at the meeting and legislated for. If, after this meeting, examiners encounter unusual answers which have not been discussed at the meeting they are required to refer these to the Principal Examiner.

It must be stressed that a mark scheme is a working document, in many cases further developed and expanded on the basis of candidates' reactions to a particular paper. Assumptions about future mark schemes on the basis of one year's document should be avoided; whilst the guiding principles of assessment remain constant, details will change, depending on the content of a particular examination paper.

CHM1

Question 1

(penalty for sig fig error = 1 mark per question)

(a) neutron: relative mass = 1 relative charge = 0 1
(not 'neutral')

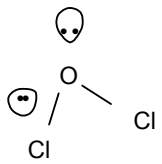
electron: relative mass = 1/1800 → 0/negligible *or*
$5.56 \times 10^{-4} \rightarrow 0$ relative charge = -1 1

(b) $^{17}_{(8)}O$ / O^{17} mass number (*Do not accept 17.0*) 1

oxygen symbol 'O' 1
(if 'O' + "mass number = 17" (1))
(if 'oxygen' + "mass number = 17" (0))
(if at N° given but ≠ 8, treat as 'con' for M2)
(if lp on Be, diagram = 0)
(ignore bond angles)
(not dot and cross diagrams)

(c)

Cl — Be — Cl (1)



(1) 2

QoL Linear (1) bent / V-shaped / angular (1) 2

(mark name and shape independently)
(accept (distorted) tetrahedral)
(if balls instead of symbols, lose M1 – can award M2)
(penalise missing 'Cl' once only)
(not 'non-linear')

(d) M_r ($Mg(NO_3)_2$) = 58(.3) *(if At N° used, lose M1 and M2)* 1

moles $Mg(OH)_2$ = 0.0172 *(conseq on wrong M_r) (answer to 3+ s.f.)* 1

moles HCl = 2×0.0172 = 0.0344 *or* 0.0343 (mol) *(process mark)* 1

vol HCl = $\frac{0.0343 \times 1000}{1}$ = 34.3 – 34.5 (cm^3) *(unless wrong unit)* 1

*(if candidate **used** 0.017 or 0.0171 lose M2)*
(just answer with no working, if in range = (4). if, say, 34 then =(2))
(if not 2:1 ratio, lose M3 and M4)
(if work on HCl, CE = 0/4)

Total 12

Question 2

(penalty for sig fig error = 1 mark per question)

(a) (i) moles KNO_3 = 1.00/101.1 = 9.89×10^{-3} (mol) 1

(ii) $pV = nRT$ *or* $n = pV/RT$ 1

moles O_2 = $n = \frac{pV}{RT} = \frac{100000 \times 1.22 \times 10^{-4}}{8.31 \times 298}$ (1) (1) 2

$= 4.93 \times 10^{-3}$ (mol) 1

(mark answer first – check back if wrong)
(transcription error lose M3, mark M4 conseq on error)
(if 'untraceable' figures used M3=M4=0)
(if wrong temp conversion – lose M3 – conseq M4)
(if n = RT/pV CE, lose M3 and M4)

(b) (i) simplest/lowest ratio of atoms of each / element/s in a compound / substance / species / entity / molecule 1

(ii)

K	*N*	*O*		
45.9 / 39.1	16.5 / 14	37.6 / 16 (1)		(1)
1.17	1.18	2.35		
1	1	2	KNO_2	(1)

3

(M3 tied to M2

(M3 can be transferred from equation if ratio correct but EF not given)

(if calc inverted, lose M2 and M3)

(if used At N^o / wrong N^o for A_r then CE, lose M2 and M3)

(if % of O missing, award M2 only)

(c) $2KNO_3 \rightarrow 2KNO_2 + O_2$ or fractions/multiples 1

(accept $2KNO_3 \rightarrow K_2N_2O_4 + O_2$)
(do NOT accept 'Y' in equation)

Total 10

Question 3

(a) tendency / strength / ability / power of an <u>atom</u> / <u>element</u> / <u>nucleus</u> to attract / pull / withdraw electron<u>s</u> / e^- density / bonding pair / shared pair 1

in a <u>covalent</u> bond 1

(b) (i) F_2 = van der Waals' / induced/temporary dipole-dipole / dispersion / London forces 1

CH_3F dipole-dipole *(not just 'dipole')* 1

HF = hydrogen bonding *(not just 'H' / 'hydrogen')* 1

(ii) large difference in electronegativity between H and F / F most/very/much more electronegative / values '4' & '2.1' quoted 1

(not just 'high<u>er</u>')

$^{\delta+}$H-F $^{\delta-}$ dipole created or dipole clearly implied 1

(accept arguments such as 'uneven charge in bond'/'polar bond' ∴ F slightly negative/H slightly positive)

attraction/bond formed between $^{\delta+}$H and lone pair on F 1

(M2/M3 may be scored from a diagram)
(CE if full charges shown - lose M2 and M3)

(c) (i) van der Waals' / induced/temporary dipole-dipole / dispersion / London forces / attractions *(ignore references to dipole-dipole)* 1

increase with the increasing M_r / size / mass / N^o of e^- / size of e^- cloud (in the hydrogen halides) 1

(if ionic, or if 'covalent bonds broken' = CE = 0)
(mark M1 and M2 separately)

(ii) hydrogen bonding stronger than van der Waals' attraction/forces 1

(accept hydrogen bonding is very strong / strongest)
(accept arguments such as 'HF has H-bonds, others <u>only</u> have van der Waals')
(not just 'HF has H-bonding')

Total 11

Question 4

(a) enthalpy/energy change/required when an electron is removed/knocked out / displaced/ to form a uni-positive ion *(ignore 'minimum' energy)* 1

from a gaseous atom 1
(could get M2 from a correct equation here)
(accept 'Enthalpy/energy change for the process...' followed by an appropriate equation, for both marks)
(accept molar definitions)

(b) $1s^2$ $2s^2 2p^6$ *(accept capitals and subscripts)* 1

(c) 's' block *(not a specific 's' orbital – e.g. 2s)* 1

(d) $Mg^+(g) \rightarrow Mg^{2+}(g) + e^-$ or 1

$Mg^+(g) + e^- \rightarrow Mg^{2+}(g) + 2e^-$ or

$Mg^+(g) - e^- \rightarrow Mg^{2+}(g)$

(e) Mg^{2+} ion smaller than Ne atom / Mg^{2+} e^- closer to nucleus 1
(not 'atomic radius' for Mg^{2+})

Mg^{2+} has more protons than Ne / higher nuclear charge or 1
e^- is removed from a charged Mg^{2+} ion / neutral neon atom
(accept converse arguments)
(if used 'It' or Mg/magnesium/Mg^{3+} etc. & 2 correct reasons, allow (1))

(f) (i) trend: increases *(if 'decreases', CE = 0/3)* 1

Expl^n: more protons / increased proton number / increased nuclear charge 1
(*NOT increased atomic number)*

same shell / same shielding / smaller size 1

(ii) **QoL** reference to the e^- pair in the 3p sub-level 1
(*penalise if wrong shell, e.g. '2p', quoted)*

repulsion between the e^- in this e^- pair 1
(if not stated, 'e^- pair' must be clearly implied)
(mark M4 and M5 separately)

Total 12

Question 5

(a) **Mean (average) mass of an atom / all the isotopes or** 1

1/12th mass of atom of ^{12}C 1

Mass of 1 mole of atoms of an element or
1/12th mass of 1 mole of ^{12}C

average mass of an atom / all the isotopes
relative to the mass of a ^{12}C atom taken as exactly 12 / 12.000

(penalise 'weight' once only)
(ignore 'average' mass of ^{12}C)
(not 'mass of average atom')

(b) $A_r = (64 \times 0.389) + (66 \times 0.278) + (67 \times 0..147) + (68 \times 0.186)$ 1
$= 65.7$

(*mark M2 conseq on transcription error or incorrect addition of %*) 1

identity: zinc / Zn 1
(*Conseq on A_r but only if their A_r is within range of Periodic Table*)

(c) electron gun (fires) electrons or high speed/energy electrons 1
(*not just 'bombarded by electrons' or 'bombarded by electron gun'*)

knocks off e^- from **Q** 1
(*may be earned from a real or generic equation*)

Reasons: to allow ions to be: 1
accelerated (by an electric field)

deflected (by a magnet/magnetic field) 1

detected / description of current formed at the detector/sensor 1

(*accept in any order*)
(*allow clear descriptions of 'accelerated', 'deflected', 'detected'*)

Total 10

Question 6

M1 macromolecule = a giant/massive/huge molecule/lattice/structure with covalent bonding 1

(in words, not diagram)
(not just 'very large')
(not 'molecules bonded together'/reference to ions)

M2 **White**: IMF = van der Waals' 1

M3 which are weak 1

(tied to 'IMF' or van der Waals' in M2)
(if H-bonding or dipole-dipole, treat as CE, M2 = M3 = 0)

M4 **Red**: (covalent) bonds must be broken/overcome 1
(not weakened / loosened)

M5 (covalent) bonds are strong [tied to M4]
Or there are many (covalent) bonds
Or much energy is required to … 1

Total 5

- If wrong bonding quoted, e.g. ionic bonding in white phosphorus or an IMF in red phosphorus, award no marks for that allotrope.
- In order for marks to be awarded for red phosphorus, the bonding must be stated to be covalent. One reference to covalent bonding is sufficient; the rest may be inferred as shown above. Thus, failure to refer to covalent bonding anywhere would result in the loss of M1, M4 and M5,
- Mark M1 independently. Allow the criteria for this mark to be earned elsewhere, but do not treat errors in the red allotrope description as contradictions of M1.