



General Certificate of Education

Chemistry 5421

**CHM1 Atomic Structure, Bonding and
Periodicity**

Mark Scheme

2007 examination - June series

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CHM1**Question 1**

- (a) Decreasing (1)
[If wrong trend = 0] [If trend missing mark on]
- Increase in protons / nuclear charge / nucleus more +ve (1)
[Not increased atomic number]
- Similar/same shielding / shells (1)
 Or increased attraction between nucleus and (outer) e⁻ [tied to increase in number of protons]
[Not similar orbitals/sub-shells]
- (b) (i) $\text{Mg(g)} \rightarrow \text{Mg}^{\text{+}}(\text{g}) + \text{e}^{-}$ *[state symbols required]* (1)
 $\text{Mg(g)} + \text{e}^{-} \rightarrow \text{Mg}^{\text{+}}(\text{g}) + 2\text{e}^{-}$
 $\text{Mg(g)} - \text{e}^{-} \rightarrow \text{Mg}^{\text{+}}(\text{g})$
- (ii) e⁻ removed from a shell of lower energy/smaller size (1)
 or e⁻ closer to nucleus
 or harder to remove an e⁻ from +2 ion than from +1 ion / more highly charged ion
- Less shielding / clear description of difference in shielding (1)
[Accept converse arguments]
[Not just unexplained identification of orbitals involved]
[Not just 'increased attraction']
[Not increased nuclear charge]
- (iii) Decreasing (1)
[If wrong trend = 0] [If trend missing mark on]
- e⁻ further from nucleus / increased atomic radius / bigger atoms (1)
[Not references to ionic radius / bonding e⁻]
[Not higher energy levels / electronic energy levels further from nucleus]
- More shells / shielding / energy levels *[Not more sub-shells]* (1)
 or decreased attraction between nucleus and outer e⁻ (tied to e⁻ further from nucleus)
- Accept 'e⁻ to be removed / valance e⁻ as alternative to 'outer e⁻'*
[Accept converse arguments]
[NOT references to charge/size ratio / charge density / delocalised e⁻/bonding e⁻]
- (c) Mg Steam/high temperature/gaseous water (1)
[Not heat / hot water]
- $\text{Mg} + \text{H}_2\text{O} \rightarrow \text{MgO} + \text{H}_2$ (1)
- Ca Cold/water / RT (1)
[Not hot/warm water/'none'/standard conditions/just 'liquid']
- $\text{Ca} + 2\text{H}_2\text{O} \rightarrow \text{Ca(OH)}_2 + \text{H}_2$ (1)

*[Don't transfer condition mark to M1/M3, from state symbol in equation]
 [Ignore state symbols – even if wrong – for equation marks]
 [Treat incorrect state symbols as contradictions of correct conditions]*

Question 2

(a)

<u>C</u>	<u>O</u>	<u>N</u>	<u>H</u>	
<u>15.38</u>	<u>41.03</u>	<u>35.90</u>	<u>7.69</u>	
12	16	14	1	(1)

[Incorrect A_r used = 0]

1.28	2.56	2.56	7.69	
and 1	2	2	6	(1)
So, CH ₆ N ₂ O ₂				

(b) (i) M_r of ammonium carbamate = 78.0 (1)

Moles ammonium carbamate = $\frac{7.50}{78.0} = 9.62 \times 10^{-2}$ (1)
[range = 9.6 – 9.62 × 10⁻²]

[Mark consequentially on their M_r]

Moles gas = $3 \times 9.62 \times 10^{-2} = 0.288$ (1)
[range = 0.288 – 0.29]

[Mark consequentially on their moles of ammonium carbamate]

(ii) $pV = nRT$ (1)
[In lieu of this, accept correctly rearranged version of expression]

$V = \frac{nRT}{P} = \frac{0.288 \times 8.31 \times 473}{98.7 \times 10^3}$ (populating expression) (1)
 (pressure conversion) (1)

[If expression wrongly rearranged or if n/R etc. missing, lose M2/M4]

= $1.15 \times 10^{-2} \text{ m}^3$ *[range = 1.1 – 1.2 × 10⁻² m³]* (1)

[Using 0.253 gives 1.0 – 1.01 × 10⁻² m³]

[If 'n' ≠ 0.253 or their moles of gas lose M2 but mark consequentially for M4]

[If no pressure conversion and correct answer in dm³, allow M3/M4]

[If no pressure conversion and consequentially answer in m³, allow M4]

[Check that moles shown in equation = moles used in calculation]

Question 3

(b) (i) Moles HNO₃ = $150 \times 10^{-3} \times 1.65$ (1)

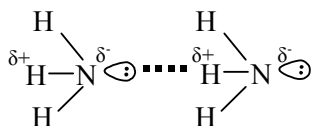
= 0.2475/0.248 *[range = 0.247 – 0.25]* (1)

- (ii) Moles Cu = $\frac{3}{8} \times 0.2475$ [if mole ratio wrong, lose M3/4] (1)
 = 0.0928 [range = 0.0926 – 0.094] (1)
 [consequentially on their moles]
 Mass Cu = 0.0928×63.5
 = 5.89 – 5.91 g [range = 5.88 – 6.0] (1)
 [consequentially on their moles]
 [Using 0.172 gives: Moles Cu = 0.0645 – 0.065
 Mass Cu = 4.09 – 4.13 g]

Question 4

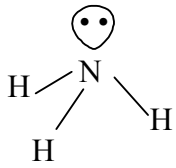
- (a) **QoL** Covalent bond Two atoms share a pair of/2 e⁻ / shared pair/2 of e⁻ (1)
 [Allow multiple pairs of e⁻s]
 [NOT ions / molecules / elements/metal] [Not donated]
 [Not just one e⁻ from each atom; must have idea of shared pair(s)]
 Polar bond; a covalent bond in which the e⁻ distribution is not (1)
 symmetrical / a bond with unequal/unfair sharing of e⁻ /
 bond with δ^+ and δ^- on the ends /
 bonding e⁻s spend more time near one end of bond
 [Allow e⁻ pair closer to one atom]
 [Not just a diagram] [Not distorted e⁻/cloud]
- (b) (i) Difference in electronegativity / (1)
 F more electronegative than H / F is very electronegative /
 clear description of electronegativity difference in terms of bonding e⁻
 [Not diagram]
 Bonding e⁻s drawn towards F (1)
 [Not bonding e⁻s spend more time near one end of bond]
- (ii) NH₃ [if wrong compound score 0 for (b)(iii)] (1)
- (iii) N has smallest electronegativity of N, O and F/ (1)
 NH₃ has smallest electronegativity difference
 [Not 'more bonds']
- (c) (i) Hydrogen bonding / H bonding (1)

[If only 1 NH₃ molecule shown = 0]

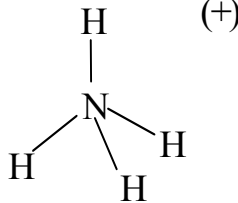


- 1 pair of charges shown on both molecules (1)
 lone pair on both molecules (1)
 hydrogen bond between lone pair and H atom (1)

[Allow dimeric structure]
 [H-bonded N-H-N does NOT need to be linear]
 [if full structure of NH₃ molecules not shown, treat as a contradiction;
 lose 1st mark earned]

- (d) (i) Dative/coordinate [ignore 'covalent' but ionic/hydrogen etc, = 0] (1)
 Both bonding e⁻ come from the same atom (1)
 Correct direction of electron pair donation (i.e. from N/NH₃) (1)
 [So, 'both e⁻ come from NH₃ to form bond' scores 2]
- (ii)
- 

[Not H-N-H linear]



[penalise missing 'H' once]
- (iii) Pyramidal / (distorted)tetrahedral / (trigonal) pyramid (1)
- (iv) 109°/109.5° (1)

Question 5

- (a) Both have 7 protons (1)
¹⁴N has 7n **and** ¹⁵N has 8n (1)
 [allow 1 mark for traditional 'same protons; different neutrons' /¹⁵N has an extra neutron style of answer]
- Chemical properties identical [Not similar] (1)
 as chemistry determined by electrons / electron arrangement / (1)
 they have same electron arrangement / number of electrons / same e⁻
 [Not just 'same p and e⁻' – there needs to be a focus on the number of e⁻]
- (b) 'p' block (1)
- QoL** Highest energy/outermost electron(s)/last e⁻ in p sub-shell/orbital/ (1)
 level/sub-level
 [Answer must be in words] [Not 'p shell']
- 1s²2s²2p⁶ [accept upper case letters & subscripted numbers] (1)
 [Not [He] 2p⁶]

Question 6

(a) Ionisation (1)

By an electron gun/clear description of electron gun – tied to ‘ionisation’ (1)
[Ignore descriptions of the ionisation process]
[Not ionisation chamber]

Deflection (1)

By a magnetic field / electromagnet/magnetic plate - tied to ‘deflection’ (1)
[Not negative plate etc.]

Ignore ‘vaporisation’ explanations]

(b)
$$\frac{(188 \times 1.5) + (189 \times 2.5) + (190 \times 3.0) + (192 \times 4.5)}{11.5}$$
 (1)
 (1)

*[If not divided by 11.5 (or thereabouts) then:
 if an arithmetic error; allow consequentially on M3
 if ‘silly value’ e.g. 100 or 759 = 0 for M3]*

= 190.3 *[Allow consequentially to an arithmetic error or
 ‘almost’ 11.5 totals]* (1)

Z = Os [accept whenever seen] (1)
[Consequentially on M_r but must be a metal]