



## **General Certificate of Education**

# **Chemistry 5421**

**CHM1      Atomic Structure, Bonding and  
Periodicity**

## **Mark Scheme**

*2008 examination - June series*

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**CHM1****Question 1**

- (a) **(Atoms/isotopes/particles/species with the) same (number of) protons and different (number of) neutrons** (1)  
*[Not same atomic number/mass number/molecules/ element/ions/diff electrons]*  
*[allow 'different versions of the same element with...']*

- (b)  $A_r = \frac{(204 \times 1.5) + (206 \times 23.6) + (207 \times 21.4) + (208 \times 53.5)}{100}$  (1)  
**[Wrong approach or not dividing by 100 = CE = 0]**  
 207.3 *[Answer to 1 d.p.] [Mark conseq on transcription error]* (1)

- (c) (i)  $\text{PbO}_2 + \text{Pb} + 2\text{H}_2\text{SO}_4 \rightarrow 2\text{PbSO}_4 + 2\text{H}_2\text{O}$  *[fractions/multiples]* (1)  
 (ii) No difference in reaction/chemistry/ chemical properties identical/same (1)  
*[Not 'similar' etc.]*

They have same electron arrangement / number of electrons  
 Tied **or** chemistry determined by electrons / electron arrangement  
 to *[Not just same protons] [allow if near-miss for M2]* (1)  
**M2** *[accept 'same protons and electrons]*  
*[If M2 = blank or wrong, CE = 0 for M3]*

- (d)  $^{24}\text{Mg}$  mass number anywhere (1)  
 element name/symbol (1)  
*[If wrong atomic number given, 'con' Mg mark]*  
*[Not 24.3 or 24.0]*

- (e) (i) High energy/speed electron / electron from electron gun (1)  
*[Not just 'bombarded with electrons']*  
**Ind** Knock off/made to lose (one)  $e^-$  (from the atom) /electron displaced from atom (1)  
*[Not equations here]*  
 (ii) Acceleration (1)

**Total = 11**

## Question 2

Significant figures – accept a minimum of 2 sig. figs. (no maximum); penalise sig. fig. errors once in the question. Mark repeated sig. fig. errors as ‘RE’

(a) Moles  $\text{H}_2\text{O}_2$  =  $150 \times 10^{-3} \times 2.72$  (1)  
*[if  $\times 10^{-3}$  missing, lose M1 and M2]*

=  $0.408 / 0.41$  (1)

Moles  $\text{O}_2$  =  $0.408 \div 2 = 0.20 - 0.21$  (mol) (1)  
*[mark conseq on error in moles  $\text{H}_2\text{O}_2$ ]*

(b) (i) Moles  $\text{PH}_3$  =  $1.43 \div 34.0 = 0.0421/0.042$  (mol) (1)

(ii) Moles of oxygen reacted =  $0.0421 \times 2 = 0.084 - 0.0842$  (mol) (1)  
*[mark conseq on error in moles  $\text{PH}_3$ ]*

(iii)  $M_r$  of  $\text{H}_3\text{PO}_4$  = 98(.0) (1)

Mass of  $\text{H}_3\text{PO}_4$  =  $0.0421 \times 98(.0) = 4.1 - 4.13$  g (1)  
*[mark conseq on error in moles  $\text{PH}_3$ ]*

(c) (ii)  $pV = nRT$  *[accept correctly rearranged formula]* (1)  
*[accept letters in wrong case]*

$p = \frac{nRT}{V} = \frac{0.166 \times 8.31 \times 300}{1725 \times 10^{-6}}$  volume conversion (1)  
 all other numbers correct (1)

*[if number missing, e.g. omitted 300, lose M3 and M4]*

= 239906Pa /  $2.40 \times 10^5$  Pa / 240 kPa

*[If  $1725 \times 10^{-3} / 1.725$  used AND units = kPa allow all marks]*

*[If units = Pa, treat  $1725 \times 10^{-3} / 1.725$  as an error in volume conversion]* (1)

*[If equation incorrectly rearranged, CE = 0 for M3 and M4 but can still earn M2 for correct volume conversion, i.e.  $1725 \times 10^{-6}$ ]*

**Total = 11**

## Question 3

- (a) **Energy / enthalpy required/change to remove one electron** (1)

From a gaseous atom

[Accept 'enthalpy change for the process  $M(g) \rightarrow M^+(g) + e^-$ ' for 2 marks] (1)

[allow 'gaseous' from equation]

"Enthalpy change when one mole of gaseous atoms forms one mole of (gaseous) unipositive ions." scores 2 marks

[i.e. idea of  $\Delta H$  for atom  $\rightarrow$  ion<sup>+</sup> earns M1 and 'gaseous' gets M2]

- (b) **Increase in number of protons / nuclear charge** (1)

Decrease in size / same shielding / same shells / similar shielding / increased attraction between nucleus and outer electrons (1)

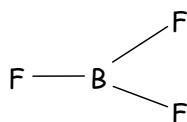
- (c) **S has a lower than expected 1<sup>st</sup> IE value / is low / < P / decreases** (1)  
[if IE said to be higher, CE = 0 for M3 but allow M2]

e<sup>-</sup> pair in 3p (sub-level) (1)

(Easier to remove e<sup>-</sup> due to) repulsion between these paired e<sup>-</sup> (wtte)

**QoL** [allow following error in 3p orbital – e.g. 2p] (1)  
[not just diagram/electron arrangement]

- (d) (i) **BF<sub>3</sub> shown as trigonal planar with no lone pairs** (1)



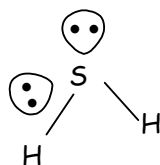
Ignore errors in dots-and-wedges as long as shape is right

Not 'T' shape / pyramidal

Not dot-and-cross diagram

Allow  $\text{---}$  for bond (it's the shape we want)

H<sub>2</sub>S shown as bent/ V shaped with 2 lone pairs (1)



Not S=H

Not empty orbital envelopes

Allow two dots without envelope

- (ii) (Because there are 3) bonding pairs/electron pairs (1)  
'T' shape/pyramidal – allow this mark (M3) but not M4 below]

with equal repulsion between them

[allow 'equal repulsion between three bonds for M4 but don't award M3] (1)  
[M4 only available if correct diagram given]

[not 'equal repulsion between atoms']

[If NOT just 3 bonding pairs (e.g. shows a lone pair), CE = 0 for M3 and M4]

- (e) H-S-H bond angle = **107.5** down to 95° (1)

**Total = 12**

## Question 4

- (a) **Na larger than Cl** *[allow contra argument]* (1)  
*[allow correct trend across the Period]*
- Ind Na as fewer protons/lower nuclear charge than Cl** (1)  
*[allow contra argument]*
- Ind Both Na and Cl have the same shielding/shells / similar shielding** (1)
- Tied to M1 Weaker attraction between nucleus and electrons of Na** (1)  
*[allow contra arguments]*
- (b) (i)  $1s^2 2s^2 2p^6 3s^1$  *[accept caps and subscripted numbers]* (1)  
*(Not [Ne] 3s<sup>1</sup>)*
- (ii) **Na/sodium (atom) (larger than Na<sup>+</sup>/sodium ion)** (1)  
**Ion has one less shell/energy level than atom**  
**Tied** *[accept correct references to 2p and 3s sub-levels]* (1)  
*[Not 'less electrons, so more attraction']*
- (iii)  $1s^2 2s^2 2p^6 3s^2 3p^5 \rightarrow 1s^2 2s^2 2p^6 3s^2 3p^6$  / **ion has more electrons/fills its outer shell** (1)  
**Ion has more e<sup>-</sup> - e<sup>-</sup> repulsion** (1)  
*[ Accept argument that this is not a fair comparison as:*  
*Cl value is ½ covalent radius. (1)*  
*Cl<sup>-</sup> value is determined from lattice measurements. (1) ]*
- (c) **Least soluble sulphate = BaSO<sub>4</sub> not name only** (1)  
**Most soluble hydroxide = Ba(OH)<sub>2</sub> not name only** (1)  
*[Allow, for 1 mark, correct identification of Ba/barium in both]*  
*[if formulae of Radium compounds given, penalise RaSO<sub>4</sub> but allow Ra(OH)<sub>2</sub> as 'repeated error' – mark as RE]*

**Total = 11**

## Question 5

van der Waals' / London forces / dispersion forces / induced dipole-dipole /temporary dipole-dipole

Diamond = 3D / C bonds to 4 C atoms / co-ord number = 4 / shows tetrahedral  
**M1** structure (1)  
*[not 'bonds to 4 molecules'] [not 'has tetrahedral bonds']*  
*[if diamond NOT covalent, CE = 0 = M1 and M3 e.g. hydrogen bonding/van der Waals']*

Graphite = 2D/planar/layers / sheets / plates / trigonal planar/ planes of atoms/C  
**M2** bonds to 3 C atoms / co-ord number = 3 (1)  
*[if graphite NOT covalent, CE M2 and M5]*  
*[Allow M1/M2 from clear diagrams – diamond minimum = 5C; graphite minimum = 3 'non-linear' rings]*  
*[ignore diagram, unless it helps]*

Diamond (hard) as (covalent) bonds must be broken/overcome  
**M3** *[not loosened] [allow chemical bonds]* (1)  
*[if answer clearly focussed on melting point = 0]*

**M4** Graphite lubricates as layers slide/move over each other (1)

**M5** only weak forces/attractions between layers  
**or** van der Waals' forces / attractions between layers (1)  
*[Not 'bonds']*

Graphite conducts because it has delocalised/free electrons  
**M6** *[not just 'a sea of electrons / non-bonding electrons / electrons not involved in bonding']* (1)

**QoL M7** electrons can flow **or** electrons can move through/between the layers/through the structure (1)  
*Looking for a clear idea of electrons moving in a specific direct, rather than randomly*  
*[Not 'carry current' / 'charge carriers']*

**Total = 7**

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**Question 6**

**M1 to 6** if a type of bonding is correctly identified, but later contradicted by an incorrect type of bonding, the CE penalty is triggered for that pair of marks. E.g. the bonding in sodium is stated to be 'metallic' but reference is later made to, e.g., sodium molecules / van der Waals' attractions / ionic bonding /etc. then CE = 0 for **M1** and **M2**

- M1** Bonding in sodium metallic (1)  
[not 'metal bonds']
- Ind M2** Held together by attraction between +ve ions/nucleus/lattice/atoms/+ve centres and delocalised/free electrons (1)  
[not just an unexplained diagram]  
Wrong bonding = CE = 0 for **M1** and **M2**
- M3** Bonding in iodine covalent (1)
- Ind M4** Molecules / I<sub>2</sub> / it / solid held together by van der Waals' attractions/forces (1)  
[Not Atoms] Wrong bonding = CE = 0 for **M3** and **M4**
- M5** Bonding in sodium iodide ionic (1)
- Ind M6** Held together by attraction between +ve ion and -ve ion / electrostatic attractions/forces (1)  
Wrong bonding = CE = 0 for **M5** and **M6**  
[not 'poles'] [not just attraction between opposite charges]
- Ind M7** Van der Waals' forces (in I<sub>2</sub>) are much weaker than the ionic bonding (in NaI) (1)  
['much weaker' may be inferred from a clear comparison of, e.g.:  
weak versus strong attractions,  
or of low versus high energy required to overcome attractions]  
Type of attraction may be inferred from earlier answers]  
  
[if van der Waals' or ionic bonding wrong, don't allow **M7** – **BUT** you may find you can award **M4** or **M6** here, if not clear earlier]
- M8** Each sodium atom loses one electron to an iodine atom. (1)  
[Clear idea of the transfer of 1e from Na to I]  
[award this mark if both half-equations are given]  
[allow a dot-and-cross diagram showing the transfer of an electron from Na to I atoms – but NOT a diagram which just shows the resulting ions]  
[accept '2 Na transfer 2 electrons to an iodine/I<sub>2</sub> molecule / to iodine']  
[Not electron transferred from Na to I<sub>2</sub>/iodine molecule]

**Total = 8**