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ASSESSMENT and QUALIFICATIONS ALLIANCE

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) <u>protons</u> and different (number of) <u>neutrons</u>** *[Not same atomic number/mass number/molecules/ element/ions/diff electrons]* *[allow 'different versions of the same element with…']*	(1)
(b)		$A_r = \dfrac{(204 \times 1.5) + (206 \times 23.6) + (207 \times 21.4) + (208 \times 53.5)}{\mathbf{100}}$	(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)	$PbO_2 + Pb + \mathbf{2}H_2SO_4 \rightarrow \mathbf{2}PbSO_4 + \mathbf{2}H_2O$ *[fractions/multiples]*	(1)
	(ii)	<u>No</u> difference in reaction/chemistry/ chemical properties <u>identical</u>/<u>same</u> *[Not 'similar' etc.]*	(1)
	Tied to **M2**	They have same electron arrangement / number of electrons **or** chemistry determined by electrons / electron arrangement *[Not just same protons]* *[allow if near-miss for **M2**]* *[accept 'same protons and electrons]* *[If **M2** = blank or wrong, CE = 0 for **M3**]*	(1)
(d)		^{24}Mg mass number anywhere element name/symbol	(1)
		[If wrong atomic number given, 'con' Mg mark] *[Not 24.3 or24.0]*	(1)
(e)	(i)	High energy/speed electron / electron from electron gun *[Not just 'bombarded with electrons']*	(1)
	Ind	Knock off/made to lose (one) e^- (from the atom) /electron displaced from atom *[Not equations here]*	(1)
	(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 H_2O_2 = $150 \times 10^{-3} \times 2.72$
*[if $\times 10^{-3}$ missing, lose **M1** and **M2**]* (1)

= 0.408 / 0.41 (1)

Moles O_2 = $0.408 \div 2$ = 0.20 - 0.21 (mol)
[mark conseq on error in moles H_2O_2] (1)

(b) (i) Moles PH_3 = $1.43 \div 34.0$ = 0.0421/0.042 (mol) (1)

(ii) Moles of oxygen reacted = 0.0421×2 = 0.084 - 0.0842 (mol)
[mark conseq on error in moles PH_3] (1)

(iii) M_r of H_3PO_4 = 98(.0) (1)
Mass of H_3PO_4 = $0.0421 \times 98(.0)$ = 4.1 - 4.13 g
[mark conseq on error in moles PH_3] (1)

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

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

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

= 239906<u>Pa</u> / 2.40×10^5 <u>Pa</u> / <u>240 kPa</u>

*[If 1725×10^{-3} / 1.725 used **AND** units = <u>kPa</u> allow all marks]*

[If units = Pa, treat 1725×10^{-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.* 1725×10^{-6}*]*

Total = 11

Question 3

(a) **<u>Energy</u> / <u>enthalpy</u> required/change to remove one electron** (1)

From a gaseous atom (1)
[Accept 'enthalpy change for the process $M(g) \rightarrow M^+(g) + e^-$' for** *2 marks]***
[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 ΔH for atom $\rightarrow$ ion$^+$ earns** *M1* **and 'gaseous' gets** *M2]***

(b) **Increase in number of protons / <u>nuclear</u> charge** (1)

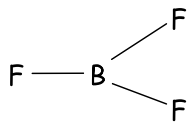
Decrease in size / same shielding / same shells / similar shielding / increased attraction between nucleus and <u>outer</u> <u>electrons</u> (1)

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

e^- pair in 3p (sub-level) (1)

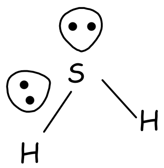
(Easier to remove e^- due to) repulsion between these <u>paired</u> e^- (wtte) (1)
QoL *[allow following error in 3p orbital – e.g. 2p]*
[not just diagram/electron arrangement]

(d) (i) **BF_3 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 —:— for bond (it's the shape we want)

H_2S 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 <u>pairs</u>/electron <u>pairs</u> (1)
*'T' shape/pyramidal – allow this mark (**M3**) but not **M4** below]*
with equal repulsion between them (1)
*[allow 'equal repulsion between three bonds for **M4** but don't award **M3**]*
*[**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]*** ***[allow correct trend across the Period]***	(1)
	Ind	**Na as fewer protons/lower <u>nuclear</u> charge than Cl** ***[allow contra argument]***	(1)
	Ind	**Both Na and Cl have the same shielding/shells / similar shielding**	(1)
	Tied to **M1**	**Weaker attraction between nucleus and electrons of Na** ***[allow contra arguments]***	(1)
(b)	(i)	**$\underline{1s^22s^22p^63s^1}$** ***[accept caps and subscripted numbers]*** ***(Not [Ne] $3s^1$)***	(1)
	(ii)	**Na/sodium (atom) (larger than Na^+/sodium ion)**	(1)
	Tied	**Ion has one less shell/energy level than atom** ***[accept correct references to 2p and 3s sub-levels]*** ***[Not 'less electrons, so more attraction']***	(1)
	(iii)	**$1s^22s^22p^63s^23p^5 \rightarrow 1s^22s^22p^63s^23p^6$ / ion has more electrons/fills its outer shell**	(1)
		Ion has more e^-- e^- repulsion	(1)
		[Accept argument that this is not a fair comparison as: Cl value is ½ covalent radius. (1) Cl^- value is determined from lattice measurements. (1)]	
(c)		Least soluble sulphate = $BaSO_4$ not name only	(1)
		Most soluble hydroxide = $Ba(OH)_2$ not name only	(1)
		[Allow, for 1 mark, correct identification of Ba/barium in <u>both</u>] *[if formulae of Radium compounds given, penalise $RaSO_4$ but allow $Ra(OH)_2$ as 'repeated error' – mark as RE]*	

Total = 11

Question 5

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

	M1	Diamond = 3D / C bonds to 4 C atoms / co-ord number = 4 / shows tetrahedral structure *[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']*	(1)
	M2	Graphite = 2D/planar/layers / sheets / plates / trigonal planar/ planes of atoms/C bonds to 3 C atoms / co-ord number = 3 *[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]*	(1)
	M3	Diamond (hard) as (covalent) bonds must be broken/overcome *[not loosened]* *[allow chemical bonds]* *[if answer <u>clearly focussed</u> on melting point = 0]*	(1)
	M4	Graphite lubricates as layers slide/move over each other	(1)
	M5	only weak forces/attractions between <u>layers</u> **or** van der Waals' forces / attractions between <u>layers</u> *[Not 'bonds']*	(1)
	M6	Graphite conducts because it has <u>delocalised</u>/<u>free</u> electrons *[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 *Looking for a clear idea of electrons moving in a specific direct, rather than randomly* *[Not 'carry current' / 'charge carriers]*	(1)

Total = 7

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 *[not 'metal bonds']*	metallic	(1)
Ind	**M2**	Held together by <u>attraction</u> between <u>+ve</u> ions/nucleus/lattice/atoms/<u>+ve</u> centres and delocalised/free electrons *[not just an unexplained diagram]* *Wrong bonding = CE = 0 for* ***M1*** *and* ***M2***		(1)
	M3	Bonding in iodine	covalent	(1)
Ind	**M4**	Molecules / I_2 / it / solid held together by <u>van der Waals</u>' <u>attractions</u>/<u>forces</u> *[Not Atoms]*	*Wrong bonding = CE = 0 for* ***M3*** *and* ***M4***	(1)
	M5	Bonding in sodium iodide	ionic	(1)
Ind	**M6**	Held together by <u>attraction</u> between +ve ion and –ve ion / electrostatic <u>attractions</u>/<u>forces</u> *Wrong bonding = CE = 0 for* ***M5*** *and* ***M6*** *[not 'poles']*	*[not just attraction between opposite charges]*	(1)
Ind	**M7**	Van der Waals' forces (in I_2) are <u>much</u> weaker than the ionic bonding (in NaI) *['<u>much</u> 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]*		(1)
	M8	Each sodium atom loses <u>one</u> electron to an iodine atom. *[Clear idea of the transfer of* ***<u>1e⁻</u>*** *from Na to I]* *[award this mark if <u>both</u> 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_2 molecule / to iodine]* *[Not electron transferred from Na to I_2/iodine molecule]*		(1)

Total = 8