



EXAM PAPERS PRACTICE

Boost your performance and confidence with these topic-based exam questions

Practice questions created by actual examiners and assessment experts

Detailed mark scheme

Suitable for all boards

Designed to test your ability and thoroughly prepare you

2002

XVIII

1583

Time allowed
81 Minutes

Score

/68

Percentage

%

CHEMISTRY

OCR
AS & A LEVEL

Mark Scheme

Module 3: Periodic table and energy

Question			Answer	Marks	Guidance
1	(a)	(i)	$\text{Cl}_2 + \text{H}_2\text{O} \rightarrow \text{HClO} + \text{HCl}$ ✓	1	
		(ii)	(Chlorine compounds are) carcinogenic OR (Chlorine compounds are) toxic OR poisonous ✓	1	ALLOW 'they' OR 'chlorinated hydrocarbons' OR 'it' for 'chlorine compounds' IGNORE harmful OR dangerous IGNORE references to HCl or HClO IGNORE chlorine is toxic DO NOT ALLOW chlorine is carcinogenic
	(b)	(i)	Precipitation ✓	1	
		(ii)	$\text{Ag}^+(\text{aq}) + \text{Cl}^-(\text{aq}) \rightarrow \text{AgCl}(\text{s})$ ✓	1	Equation AND state symbols required for mark DO NOT ALLOW spectator ions
	(c)	(i)	$8.604/143.4 = 0.06(00)$ (mol) ✓	1	

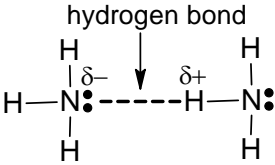
Question		Answer	Marks	Guidance
	(c) (ii)	<p>If a Group 2 chloride is used amount of Group 2 chloride = $\frac{1}{2} \times 0.0600$ OR = 0.0300 mol ✓</p> <p>Mass of 1 mol of Group 2 chloride = <u>2.86</u> = 95.3(3) ✓ 0.0300</p> <p>[Relative atomic mass of M = 95.3(3) – 71.0) = 24.3 (g mol⁻¹)] AND metal = Mg ✓</p>	3	<p>DO NOT ALLOW 24.3 and Mg without appropriate working</p> <p>Check to see if there is any ECF credit possible using working below</p> <p>ALLOW calculator value or rounding to 2 significant figures or more but IGNORE 'trailing' zeroes, eg 0.200 allowed as 0.2</p> <p>ALLOW ECF for correctly calculated $\frac{1}{2} \times$ answer to (c)(i)</p> <p>Must be at least 1 decimal place for second marking point</p> <p>ALLOW ECF for 2.86/mol of metal chloride seen above eg MCl will give 0.0600 mol of metal chloride and this will likely give 2.86/0.0600 = 47.7 eg MCl₃ will give 0.0200 mol of metal chloride and this will likely give 2.86/0.0200 = 143.0</p> <p>ALLOW ECF for mass of Group 2 chloride – 71.0 provided it is not a negative value</p> <p>ALLOW ECF even if molar mass of chloride was given as a whole number above</p> <p>ALLOW ECF for mass of metal chloride – 35.5 if amount of metal chloride = 0.0600 mol eg 47.7 – 35.5 = 12.2 AND Be</p> <p>ALLOW ECF for mass of metal chloride – 106.5 if amount of metal chloride = 0.0200 mol eg 143.0 – 106.5 = 36.5 AND Ca</p>

Question			Answer	Marks	Guidance
	(d)	(i)	A shared pair of electrons AND both electrons are donated by one atom ✓	1	
		(ii)	NH_4^+ AND Cl^- ✓	1	ALLOW $\text{NH}_4\text{Cl} \rightarrow \text{NH}_4^+ + \text{Cl}^-$ OR $\text{NH}_4^+ + \text{Cl}^- \rightarrow \text{NH}_4\text{Cl}$
		(iii)	Ammonium ion with three covalent ' <i>dot-and-cross</i> ' bonds AND one dative covalent bond ✓ Chloride ion with $8e^-$ AND 1 of these electrons different ✓ <div style="display: flex; align-items: center; justify-content: center;"> <div style="text-align: center;"> $\left[\begin{array}{c} \text{H} \\ \bullet \times \\ \text{H} \times \text{N} \bullet \text{H} \\ \times \bullet \\ \text{H} \end{array} \right]^+$ </div> <div style="margin: 0 10px;">+</div> <div style="text-align: center;"> $\left[\begin{array}{c} \bullet \bullet \\ \times \text{Cl} \bullet \bullet \\ \bullet \bullet \end{array} \right]^-$ </div> </div>	2	ALLOW other symbols for dots and crosses eg triangles IGNORE charges IGNORE 'dative' arrow within the lone pair of the N atom
	(e)	(i)	(Thermal) decomposition ✓	1	



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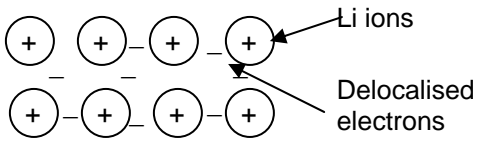
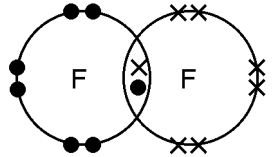
Question			er	Mark	Guidance
2	(a)	(i)	The hydrogen ions OR H^+ OR protons (of hydrochloric acid) are replaced by zinc ions OR Zn^{2+} ✓	1	ALLOW Zn ions OR positive ions replace H ions OR a metal ion has replaced a hydrogen ion OR protons DO NOT ALLOW Zn replaces H. Ions are key either in word form or symbol form DO NOT ALLOW Zn^+ i.e. if charge is shown it must be correct
		(ii)	$Zn_3(PO_4)_2$ ✓	1	ALLOW $ZnHPO_4$ OR $Zn(H_2PO_4)_2$ ALLOW $Zn_3P_2O_8$
	(b)		<p>reactivity increases (down the group) ✓</p> <p><i>Increasing size mark</i> atomic radii increases OR there are more shells ✓</p> <p><i>Increased shielding mark</i> there is more shielding ✓</p> <p><i>Nuclear attraction mark</i> The nuclear attraction decreases OR (outermost) electrons experience less attraction (to nucleus) OR Increased shielding / distance outweighs the increased nuclear charge ✓</p> <p>easier to remove (outer) electrons OR ionisation energy decreases ✓</p> <p>ORA throughout</p>	<p>1</p> <p>1</p> <p>1</p> <p>1</p>	<p><i>USE annotations with ticks, crosses, con, ECF, etc for this part.</i> 'down the group' not required ALLOW alternative phrases for 'reactivity increases'</p> <p>ALLOW 'there are more energy levels' ALLOW 'electrons are in a higher energy level' ALLOW 'the electrons are further from nucleus' IGNORE there are more orbitals OR more sub-shells IGNORE 'different shell' or 'new shell'</p> <p>ALLOW 'more screening' There must be a clear comparison i.e. 'more shielding' OR 'increased shielding'. i.e. DO NOT ALLOW 'there is shielding' ALLOW 'there is more electron repulsion from inner shells' 'more' is essential</p> <p>ALLOW 'there is less nuclear pull' OR 'electrons less tightly held' IGNORE 'there is less effective nuclear charge' IGNORE 'nuclear charge' for 'nuclear attraction'</p> <p>ALLOW 'easier to oxidise' Quality of Written Communication – 'electron(s)' OR 'ionisation' OR 'ionization' OR 'oxidise' OR oxidize' spelled correctly at least once for 5th marking point</p>
Total				7	

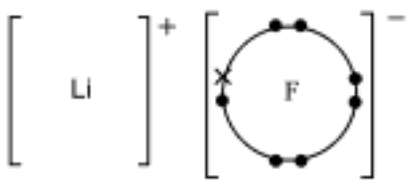
Question			er	Mark	Guidance
3	(a)		Metallic lattice has delocalised OR mobile electrons OR metallic bonding has delocalised OR mobile electrons ✓	1	IGNORE 'free electrons' for 'mobile electrons' DO NOT ALLOW references to incorrect bonding
			Ionic lattice has no mobile ions OR ionic solid has no mobile ions ✓	1	ALLOW 'ions are fixed in place' IGNORE 'no mobile electrons' for solid ionic IGNORE 'no mobile charge carriers' for solid ionic
			molten ionic (compounds) have mobile ions ✓	1	IGNORE 'delocalised ions' OR 'free ions' for 'mobile ions' DO NOT ALLOW any mention of electrons moving IGNORE 'aqueous ionic compounds have mobile ions'
	(b)	(i)	Two (or more) ammonia molecules with at least one H δ^+ and at least one N δ^- (can be on the same or different molecules) ✓ H-bond between H in one ammonia and lone pair of N in another ammonia molecule ✓ <div style="text-align: center;"> hydrogen bond  </div>	1	There must be 3H atoms bonded to one N atom DO NOT ALLOW any H δ^- OR N δ^+ ALLOW 2-D NH ₃ molecules IGNORE lone pair(s) for first marking point
		(ii)	Ice has stronger hydrogen bonds ✓ O has two lone pairs (AND N has one) OR O more electronegative (than N) ✓	1	ALLOW 'more' for 'stronger' OR Ice has twice as many hydrogen bonds as ammonia ALLOW ice has stronger intermolecular forces than ammonia OR bigger permanent dipole than ammonia DO NOT ALLOW comparisons between different types of force DO NOT ALLOW reference to van der Waals' IGNORE 'more energy needed'
				1	ALLOW O has more lone pairs

Question		er	Mark	Guidance
(c)		SiO ₂ is giant covalent (lattice) ✓	1	<p><i>USE annotations with ticks, crosses, con, ECF, etc for this part.</i></p> <p>ALLOW macromolecular OR giant atomic ALLOW SiO₂ is a 'giant structure with covalent bonds' ALLOW even if reference to 'covalent' only appears later in answer. DO NOT ALLOW any reference to 'ionic' OR 'intermolecular' OR 'metallic' Quality of Written Communication - Covalent OR macromolecular OR atomic spelt correctly ONCE and used in context of the first marking point</p> <p>ALLOW simple covalent DO NOT ALLOW any reference to 'giant' OR 'ionic' OR 'metallic'</p> <p>If neither of the 1st 2 marks have been awarded, ALLOW 1 mark for SiO₂ is giant AND SiCl₄ is simple OR molecular</p> <p>ALLOW induced dipoles DO NOT ALLOW permanent dipoles</p> <p>ALLOW alternative words to broken e.g. overcome</p> <p>ALLOW incorrect forces in SiCl₄ OR SiO₂ for this mark</p>
		SiCl ₄ is simple molecular (lattice) ✓	1	
		van der Waals' forces in SiCl ₄ ✓	1	
		Covalent bonds broken in SiO ₂ ✓	1	
		Forces OR bonds are stronger in SiO ₂ (than in SiCl ₄) OR more energy is needed to break forces OR bonds in SiO ₂ (than in SiCl ₄) ✓ ORA	1	
Total			12	

Question			Expected Answers	Marks	Additional Guidance
4	a	i	1 = purple / lilac / violet / pink / mauve ✓ 3 = orange ✓	2	ALLOW any combination of these but no others for 1 ALLOW yellow as an alternative for 3 DO NOT ALLOW 'precipitate' in either
		ii	$\text{Cl}_2 + 2\text{Br}^- \longrightarrow 2\text{Cl}^- + \text{Br}_2$ ✓	1	IGNORE state symbols ALLOW correct multiples, including fractions
		iii	Addition of $\text{Br}_2(\text{aq})$ to $\text{I}^-(\text{aq})$ ions ✓	1	ALLOW Addition of bromine to iodide (i.e. aqueous not needed) DO NOT ALLOW Addition of bromine to iodine ALLOW Addition of I_2 to Br^- , but NOT if accompanied by description of displacement of bromine ALLOW $\text{Br}_2 + \text{I}^-$ even if seen in an unbalanced equation
	b	i	Cl_2 is 0 AND HCl is -1 AND HClO is $(+1)$ ✓ Chlorine has been both oxidised and reduced OR Chlorine's oxidation state has increased and decreased ✓ Chlorine has been oxidised (from 0) to $+1$ AND chlorine has been reduced (from 0) to -1 ✓ (These two points together subsume the second marking point)	3	ALLOW 1– ALLOW 1+ Oxidation states may be seen above the equation DO NOT ALLOW Cl^- in HCl DO NOT ALLOW Cl^+ in HClO in text of answer DO NOT ALLOW chlorIDE in place of 'chlorine' IF CORRECT OXIDATION STATES ARE SEEN, ALLOW second and third marking points for: Chlorine is oxidised to form HClO Chlorine is reduced to form HCl ALLOW Cl or Cl_2 for 'chlorine' IGNORE reference to electron loss / gain if correct DO NOT ALLOW 3rd mark for reference to electron loss / gain if incorrect ALLOW one mark for 'disproportionation is when a species is both oxidised and reduced' if chlorine / chloride is not mentioned
		ii	Kills bacteria OR 'kills germs' kills micro-organisms OR makes water safe to drink OR sterilises water ✓ OR 'disinfects'	1	ALLOW to make water potable ALLOW 'removes' for 'kills' IGNORE 'virus' IGNORE 'purifies water'
	c	i	Thermal decomposition ✓	1	DO NOT ALLOW just 'decomposition' or 'thermodecomposition'
		ii	$1.47 = 0.0174 \text{ mol of MgCO}_3$ ✓ 84.3 $0.0174 \times 24.0 = 0.418 \text{ dm}^3$ OR (Calculator value $\times 24.0$) = 0.419 dm^3 ✓	2	ALLOW mol of MgCO_3 as calculator value of 0.017437722 or correct rounding to 2 sig figs or more DO NOT ALLOW 0.0175 (this has taken M_r of MgCO_3 as 84) ALLOW , for 2nd mark calculated moles of $\text{MgCO}_3 \times 24(.0)$ as calculator value or correct rounding to 2 sig figs or more [e.g. $0.017 \times 24(.0) = 0.408$] DO NOT ALLOW 84.3 or $1.47 \times 24(.0)$ as no mole calculation has been done ALLOW two marks for correct answer with no working shown

Question			Expected Answers	Marks	Additional Guidance
4	c	iii	The ease of (thermal) decomposition decreases (down the group) ora ✓	1	ALLOW (thermal) stability increases IGNORE more heat would be needed IGNORE 'takes longer' or 'is slower' IGNORE reference to trend in reactivity IGNORE answers which include 'more / less mol of CO ₂ '
			Total	15	

Question	Expected Answers	Marks	Additional Guidance
5 a	 <p>Diagram showing a regular arrangement of labelled 'Li⁺' or '+ ions' with some attempt to show electrons ✓</p> <p>Scattering of labelled electrons between other species OR a statement anywhere of delocalised electrons (can be in text or in diagram) ✓</p> <p>The attraction between + ions and e⁻ is strong OR metallic bonding is strong ✓</p>	3	<p>Lattice diagram must have at least two rows of correctly charged ions and a minimum of 2 ions per row</p> <p>ALLOW as label: + ions, positive ions, cations If '+' is unlabelled in diagram, award label from a correct statement within the text below</p> <p>DO NOT ALLOW 2+, 3+ etc ions DO NOT ALLOW for label or in text: nuclei OR positive atom OR protons</p> <p>ALLOW e⁻ OR e as label for electron</p> <p>ALLOW a lot of energy is needed to break the (metallic) bond</p> <p>DO NOT ALLOW incorrect particles or incorrect attraction e.g. 'intermolecular attraction' or 'nuclear attraction'</p>
b i	 <p>Dot and cross bond + 6 matching electrons on each F atom ✓</p>	1	<p>ALLOW diagram consisting of all dots OR all crosses Circles not essential ALLOW 'F' for fluorine</p>
ii	<p>F₂ has induced dipoles OR temporary dipoles OR van der Waals' forces (between the molecules) ✓ which are weak ✓</p>	2	<p>ALLOW little energy needed to overcome intermolecular bonding for second mark ALLOW 'weak' intermolecular bonding for second mark ALLOW max 1 mark if structure is referred to as giant with first and second marking points correct Award no marks if 'weak' is applied to incorrect bonding. E.g. ionic, covalent, metallic or unspecified bonding</p>

Question			Expected Answers	Marks	Additional Guidance
5	c	i	 <p>Li shown with either 2 or 0 electrons and F shown with 8 electrons with 7 crosses and one dot (or <i>vice versa</i>) ✓ correct charges on both ions ✓</p>	2	<p>For first mark, if 2 electrons are shown in the cation then the 'extra' electron in the anion must match symbol chosen for electrons in the cation IGNORE inner shell electrons ALLOW 'F⁻' for fluorine Circles not essential DO NOT ALLOW Li⁺ with 8 electrons</p> <p>Second mark is independent</p>
		ii	<p>Ions cannot move in a solid ✓</p> <p>Ions can move OR are mobile when molten ✓</p>	2	<p>ALLOW ions are fixed in place IGNORE electrons IGNORE 'charge carriers' or 'charged particles'</p> <p>DO NOT ALLOW ions can move when in solution IGNORE charge carriers IGNORE 'delocalised ions' or 'free ions' ALLOW 'ions can only move when molten' for one mark Any mention of electrons moving when molten is a CON</p>
	d	i	$2\text{B} + 3\text{F}_2 \longrightarrow 2\text{BF}_3$ ✓	1	<p>ALLOW B₂ ALLOW multiples including fractions</p>
		ii	<p>Shape: trigonal planar ✓ Bond angle: 120° ✓</p> <p>Explanation: Pairs of electrons repel (one another equally) ✓</p> <p>Boron has 3 bonded pairs (and 0 lone pairs) ✓</p>	4	<p>'Trigonal planar' must be seen and spelt correctly at least ONCE</p> <p>DO NOT ALLOW 'atoms repel' or 'electrons repel' ALLOW 'bonds repel'</p> <p>ALLOW diagram showing B atom with three dot-and-cross pairs of electrons, but no lone pairs for 4th mark Must refer to boron / central atom ALLOW 'bonds' for 'bonded pairs'</p>

Question		Expected Answers	Marks	Additional Guidance
5	e	<p>F is more electronegative than N OR $\delta^- \text{F} - \text{N}^{\delta+}$ ✓</p> <p>Dipoles do not cancel OR NF_3 is pyramidal (in words) / asymmetrical ✓</p>	2	<p>ALLOW F attracts electrons more than N ALLOW N has a partial positive charge and F has a partial negative charge (partial must be seen) DO NOT ALLOW diagrams that contradict statements about polarity</p> <p>ALLOW unsymmetrical, non-symmetrical etc</p>
	f	<p>(As you go across the period) The atomic radii decreases ✓</p> <p>The nuclear charge increases OR protons increase ✓</p> <p>electrons are added to the same shell OR shielding remains the same ✓</p> <p>greater (nuclear) attraction on (outer) electrons / (outer) shell(s) ✓</p>	4	<p>Use annotations with ticks, crosses ECF etc. for this part</p> <p>Assume 'across the period from Li to F' ALLOW (outer shell) electrons get closer (to nucleus)</p> <p>IGNORE 'atomic number increases', but ALLOW 'proton number' increases IGNORE 'nucleus gets bigger' 'Charge increases' is insufficient ALLOW 'effective nuclear charge increases' OR 'shielded nuclear charge increases'</p> <p>Nuclear OR proton(s) OR nucleus spelt correctly ONCE and used in context of 2nd marking point</p> <p>ALLOW shielding is similar ALLOW screening for shielding DO NOT ALLOW 'subshells' DO NOT ALLOW 'distance is similar' This will CON first marking point</p> <p>ALLOW 'greater (nuclear) pull for greater nuclear attraction' DO NOT ALLOW 'pulled in more' as this is a restatement of the first marking point</p>
		Total	21	