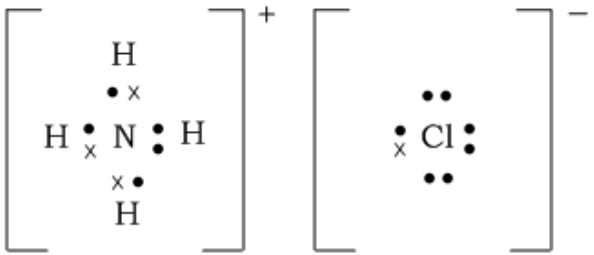
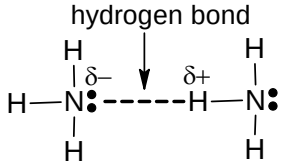
Question			Answer	Marks	Guidance
1	(a)	(i)	$Cl_2 + H_2O \rightarrow HClO + HCl$ ✓	1	
		(ii)	(Chlorine compounds are) carcinogenic **OR** (Chlorine compounds are) toxic **OR** poisonous ✓	1	**ALLOW** 'they' **OR** 'chlorinated hydrocarbons' **OR** 'it' for 'chlorine compounds' **IGNORE** harmful **OR** dangerous **IGNORE** references to HCl or HClO **IGNORE** chlorine is toxic **DO NOT ALLOW** chlorine is carcinogenic
	(b)	(i)	Precipitation ✓	1	
		(ii)	$Ag^+(aq) + Cl^-(aq) \rightarrow AgCl(s)$ ✓	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)		3	**DO NOT ALLOW** 24.3 and Mg without appropriate working Check to see if there is any ECF credit possible using working below
			If a Group 2 chloride is used amount of Group 2 chloride = ½ × 0.0600 **OR** = 0.0300 mol ✓		**ALLOW** calculator value or rounding to 2 significant figures or more but **IGNORE** 'trailing' zeroes, eg 0.200 allowed as 0.2 **ALLOW** ECF for correctly calculated ½ × answer to **(c)(i)**
			Mass of 1 mol of Group 2 chloride = $\frac{2.86}{0.0300}$ = 95.3(3) ✓		Must be at least 1 decimal place for second marking point **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 MCl_3 will give 0.0200 mol of metal chloride and this will likely give 2.86/0.0200 = 143.0*
			[Relative atomic mass of M = 95.3(3) – 71.0) = 24.3 (g mol^{-1})] **AND** metal = Mg ✓		**ALLOW** ECF for mass of Group 2 chloride – 71.0 provided it is not a negative value **ALLOW** ECF even if molar mass of chloride was given as a whole number above **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 ***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*

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** $NH_4Cl \rightarrow NH_4^+ + Cl^-$ **OR** $NH_4^+ + Cl^- \rightarrow NH_4Cl$
		(iii)	Ammonium ion with three covalent '*dot-and-cross*' bonds **AND** one dative covalent bond ✓ Chloride ion with $8e^-$ **AND** 1 of these electrons different ✓ 	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	

Question			Answer	Marks	Guidance
	(e)	(ii)	**FIRST CHECK THE ANSWER ON THE ANSWER LINE** **If answer = 242 (cm^3) award 3 marks**	3	**IGNORE** over rounding to two significant figures **once** **DO NOT ALLOW** over rounding to two significant figures twice eg **ALLOW** the following answer for 3 marks **241** (cm^3) (0.00672 was rounded to 0.0067 **OR** 0.0101 was rounded to 0.010) **ALLOW** the following answers for 2 marks **240** (cm^3) (0.00672 was rounded to 0.0067 **AND** 0.0101 was rounded to 0.010) **252** (cm^3) (0.00672 was rounded to 0.007) **161** cm^3 (no multiplying by 3/2) If there is an alternative answer, check to see if there is any ECF credit possible using working below
			(amount of $KClO_3$) = 0.824/122.6 **OR** = 0.00672 (mol) ✓		**ALLOW** up to correctly rounded calculator value of 0.006721044046
			(amount O_2) = (mol of $KClO_3$) 0.00672 × 3/2 **OR** = 0.0101 (mol)		**ALLOW** up to correctly rounded calculator value **ALLOW** ECF for mol of $KClO_3$ × 3/2 for 2nd mark
			(volume of O_2) = 0.0101 × 24 000 = 242 (cm^3) ✓		**ALLOW** ECF for (mol of $KClO_3$) × 3/2 × 24000
			Total	**16**	

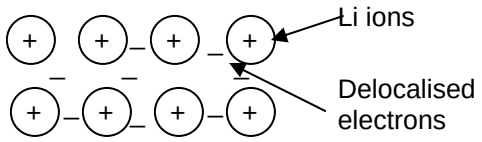
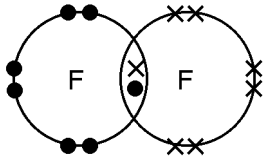
Question			er	Mark	Guidance
2	(a)	(i)	The hydrogen **ions OR** H^+ **OR** protons (of hydrochloric acid) are replaced by zinc **ions OR** Zn^{2+} ✓	1	**ALLOW** Zn ions **OR** positive ions replace H **ions OR** a metal ion has replaced a hydrogen ion **OR** protons **DO NOT ALLOW** Zn replaces H. Ions 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)				***USE annotations with ticks, crosses, con, ECF, etc for this part.***
			reactivity increases (down the group) ✓	1	'down the group' not required **ALLOW** alternative phrases for 'reactivity increases'
			Increasing size mark atomic radii increases **OR** there are more shells ✓	1	**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'
			Increased shielding mark there is **more** shielding ✓	1	**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*
			Nuclear attraction mark The nuclear attraction decreases **OR** (outermost) electrons experience less attraction (to nucleus) **OR** Increased shielding / distance outweighs the increased nuclear charge ✓	1	**ALLOW** 'there is less nuclear pull' **OR** 'electrons less tightly held' **IGNORE** 'there is less effective nuclear charge' **IGNORE** 'nuclear charge' for 'nuclear attraction'
			easier to remove (outer) electrons **OR** ionisation energy decreases ✓ **ORA** throughout	1	**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*
			Total	7	

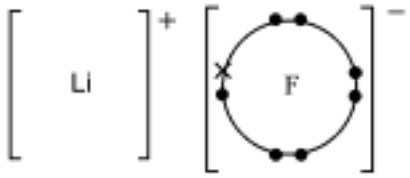
Question			er	Mark	Guidance
3	(a)		Metallic lattice has delocalised **OR** mobile electrons **OR** metallic bonding has delocalised **OR** mobile electrons ✓	1	**IGNORE** 'free electrons' for 'mobile electrons' **DO NOT ALLOW** references to incorrect bonding
			Ionic lattice has no mobile ions **OR** 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 Hδ+ and at least one Nδ- (can be on the same or different molecules) ✓	1	There must be 3H atoms bonded to one N atom **DO NOT ALLOW** any Hδ- **OR** Nδ+ **ALLOW** 2-D NH_3 molecules **IGNORE** lone pair(s) for first marking point
			H-bond between H in one ammonia and lone pair of N in another ammonia molecule ✓ 	1	All H-bonds drawn must hit the lone pair H-bond does not need to be labelled but must be different from covalent bond **DO NOT ALLOW** more than one lone pair on N for second marking point **ALLOW** a pair of molecules with two 'correct' hydrogen bonds forming a 'dimer'
		(ii)	Ice has stronger hydrogen bonds ✓	1	**ALLOW** 'more' for 'stronger' **OR** Ice has twice as many hydrogen bonds as ammonia **ALLOW** ice has strong**er** intermolecular forces than ammonia **OR** big**ger** 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'
			O has two lone pairs (**AND** N has one) **OR** O more electronegative (than N) ✓	1	**ALLOW** O has more lone pairs

Question			er	Mark	Guidance
	(c)				***USE annotations with ticks, crosses, con, ECF, etc for this part.***
			SiO_2 is **giant covalent** (lattice)✓	**1**	**ALLOW** macromolecular **OR** giant atomic **ALLOW** SiO_2 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
			$SiCl_4$ is **simple molecular** (lattice) ✓	**1**	**ALLOW** simple covalent **DO NOT ALLOW** any reference to 'giant' **OR** 'ionic' **OR** 'metallic' **If neither of the 1st 2 marks have been awarded,** **ALLOW** 1 mark for SiO_2 is giant **AND** $SiCl_4$ is simple **OR** molecular
			van der Waals' forces in $SiCl_4$ ✓	**1**	**ALLOW** induced dipoles **DO NOT ALLOW** permanent dipoles
			Covalent bonds broken in SiO_2 ✓	**1**	**ALLOW** alternative words to broken e.g. overcome
			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**	**ALLOW** incorrect forces in $SiCl_4$ **OR** SiO_2 for this mark
			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	$Cl_2 + 2Br^- \longrightarrow 2Cl^- + Br_2$ ✓	1	**IGNORE** state symbols **ALLOW** correct multiples, including fractions
		iii	Addition of $Br_2(aq)$ to $I^-(aq)$ 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** $Br_2 + I^-$ 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** chlor**IDE** 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	$\frac{1.47}{84.3}$ = 0.0174 mol of $MgCO_3$ ✓ $0.0174 \times 24.0 = 0.418\ dm^3$ **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 $MgCO_3$** $\times$ 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		 Diagram showing a regular arrangement of **labelled** '**Li^+**' or **'+ ions'** with some attempt to show electrons ✓ Scattering of **labelled** electrons **between** other species **OR** a statement anywhere of **delocalised** electrons (can be in text or in diagram) ✓ The attraction between + ions and e^- is strong **OR** metallic bonding is strong ✓	3	Lattice diagram must have at least two rows of correctly charged ions and a minimum of 2 ions per row **ALLOW** as label: + ions, positive ions, cations If '+' is unlabelled in diagram, award label from a correct statement within the text below **DO NOT ALLOW** 2+, 3+ etc ions **DO NOT ALLOW** for label or in text: nuclei **OR** positive atom **OR** protons **ALLOW** e^- **OR** e as label for electron **ALLOW** a lot of energy is needed to break the (metallic) bond **DO NOT ALLOW** incorrect particles or incorrect attraction e.g. 'intermolecular attraction' or 'nuclear attraction'
	b	i	 Dot and cross bond + 6 matching electrons on each F atom ✓	1	**ALLOW** diagram consisting of all dots **OR** all crosses Circles not essential **ALLOW** 'Fl' for fluorine
		ii	F_2 has induced dipoles **OR** temporary dipoles **OR** van der Waals' forces (between the molecules) ✓ which are **weak** ✓	2	**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

Question			Expected Answers	Marks	Additional Guidance
5	c	i	 Li shown with either 2 or 0 electrons **and** F shown with 8 electrons with 7 crosses and one dot (or *vice versa*) ✓ correct charges on both ions ✓	2	**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** 'Fl' for fluorine Circles not essential **DO NOT ALLOW** Li^+ with 8 electrons Second mark is independent
		ii	Ions cannot move in a solid ✓ **Ions** can move **OR** are mobile when molten ✓	2	**ALLOW** ions are fixed in place **IGNORE** electrons **IGNORE** 'charge carriers' or 'charged particles' **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**
	d	i	$2B + 3F_2 \longrightarrow 2BF_3$ ✓	1	**ALLOW** B_2 **ALLOW** multiples including fractions
		ii	*Shape*: trigonal planar ✓ *Bond angle:* 120° ✓ *Explanation*: **Pairs** of electrons repel (one another equally) ✓ **Boron** has 3 bonded pairs (and 0 lone pairs) ✓	4	**'Trigonal planar' must be seen and spelt correctly at least ONCE** **DO NOT ALLOW** 'atoms repel' or 'electrons repel' **ALLOW** 'bonds repel' **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'

Question			Expected Answers	Marks	Additional Guidance
5	e		F is more electronegative than N **OR** $^{\delta-}$F–N$^{\delta+}$ ✓ Dipoles do not cancel **OR** NF_3 is pyramidal (in words) / asymmetrical ✓	2	**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 **ALLOW** unsymmetrical, non-symmetrical etc
	f		(As you go across the period) The atomic radii decreases ✓ The nuclear charge increases **OR** protons increase ✓ electrons are added to the same shell **OR** shielding remains the same ✓ great**er** (nuclear) attraction on (outer) electrons / (outer) shell(s) ✓	4	**Use annotations with ticks, crosses ECF etc. for this part** Assume 'across the period from Li to F' **ALLOW** (outer shell) electrons get closer (to nucleus) **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' **Nuclear OR proton(s) OR nucleus spelt correctly ONCE and used in context of 2nd marking point** **ALLOW** shielding is similar **ALLOW** screening for shielding **DO NOT ALLOW** 'subshells' **DO NOT ALLOW** 'distance is similar' This will CON first marking point **ALLOW** 'greater (nuclear) pull for greater nuclear attraction' **DO NOT ALLOW** 'pulled in more' as this is a restatement of the first marking point
			Total	**21**	