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Question	Expected answers		Marks	Additional guidance
1 (a)	Correct electronic structures magnesium either 8 electrons in outer shell or none and <b>both</b> chloride ions with 8 electrons in the outer shell (1); Correct charge on the ions, $Mg^{2+}$ and $Cl^{-}$ (1); Correct 'dot-and-cross' diagram for $SiCl_4$ with four covalent Si—Cl bonds and all lone pairs for chlorine (1)		3	
(b)	$MgCl_2$ dissolves / dissociates / ionises / forms a colourless solution / equation showing dissociation (1); With a pH of (almost) 7 (1);  $SiCl_4$ is hydrolysed / reacts with water (1); to give a white precipitate / steamy fumes / white fumes / misty fumes (1); and a pH of 3 or below (1); $SiCl_4 + 2H_2O \rightarrow SiO_2 + 4HCl$ (1)		6	Not $MgCl_2$ fizzes or forms a white ppt <b>Allow</b> for $MgCl_2$ any pH between and 7  Ignore state symbols in the equation <b>Allow</b> $Si(OH)_2Cl_2$ or $Si(OH)_4$ in the equation
(c)	$MgCl_2$ is giant ionic and $SiCl_4$ is a simple molecule (1) $MgCl_2$ – (Electrostatic) attraction between <b>ions</b> / attraction between (positive and negative) <b>ions</b> / aw (1); $SiCl_4$ - intermolecular attraction / van der Waals forces of attraction (1); Force of attraction in $MgCl_2$ is <b>stronger</b> than in $SiCl_4$ / ora (1)		3	The comparison of the strengths forces/bonding must refer to the correct type of bonding e.g. strong ionic bonding and weak van der Waals (1) <b>Not</b> ionic bonds are stronger than covalent bonds

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1 (d) (i)	Al <sub>2</sub> Cl <sub>6</sub> (1)		1	
(ii)	2Al + 3Cl <sub>2</sub> → Al <sub>2</sub> Cl <sub>6</sub> (1)		1	Allow any correct multiple of equation Allow ecf from wrong formula in (i)
(iii)	(Solid aluminium chloride is covalent but) in solution has <b>ions that can move</b> / (solid aluminium chloride has no ions but) in solution <b>ions can move</b> (1)		1	<b>Not</b> ions cannot move in solid <b>Not</b> reference to ionic solid
(e)	PCl <sub>6</sub> <sup>-</sup> (1)		1	
			<b>Total = 16</b>	

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2 (a) (i)	<b>CaCO<sub>3</sub> → CaO + CO<sub>2</sub> (1)</b>		1	<b>Ignore</b> state symbols
(ii)	Calcium ion has a larger charge density than barium ion / Ca <sup>2+</sup> has a smaller ionic radius than Ba <sup>2+</sup> / ora (1); So calcium ion polarises the carbonate (ion) <b>more</b> than the barium ion / so Ca <sup>2+</sup> distorts the CO <sub>3</sub> <sup>2-</sup> <b>more</b> than Ba <sup>2+</sup> / ora (1)		2	Particles referred to must be correct <b>Not</b> Ca has a higher charge density <b>Not</b> calcium has a higher charge density <b>Allow</b> calcium has a smaller ionic radius <b>Allow</b> correct description of <b>more</b> polarisation <b>Allow</b> CO <sub>3</sub> <sup>-</sup> <b>Not</b> Ca <sup>2+</sup> polarises CO <sub>3</sub>
(b) (i)	Oxidation state of nitrogen goes from +5 to +4 (1); Oxidation state of oxygen goes from -2 to 0 (1);  Correct linking of changes of oxidation state with reduction <b>and</b> with oxidation (1)		3	If oxidation state of barium given is incorrect <b>max 1</b> for the oxidation numbers.  <b>Allow</b> ecf from wrong oxidation states for the correct linking mark <b>Both</b> oxidation <b>and</b> reduction needed
(ii)	Correct use of molar ratios (1); Correct cycle (1); (+)1000 (kJ mol <sup>-1</sup> ) (1)		3	<b>Award</b> full marks for (+) 1000 (kJ mol <sup>-1</sup> ) <b>Only allow</b> ecf for final lattice energy answer from a correct cycle <b>Allow</b> -1000 (1), +467 (2), +901 (2), +1558 (2),

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2 (c) (i)	Moles of $\text{Ba}(\text{NO}_3)_2 = 0.005$ or $0.00502$ (1); Moles of gas made = $0.0125$ / $0.0126$ (1); Volume of gas = $300 \text{ cm}^3$ to $302 \text{ cm}^3$ (1)		3	<b>Allow</b> ecf within question <b>Ignore</b> significant figures
(ii)	Decomposition temperature may be too high / too much gas will be produced / to fill a gas syringe need a smaller amount of solid / gas syringe too small (1)		1	<b>Allow</b> $\text{NO}_2$ is toxic / barium compounds are toxic Answer is <b>consequential</b> on answer to (i)
(d) (i)	Enthalpy change when one mole of a solid / energy released when one mole of solid (1); Is made from its gaseous ions (1)		2	<b>Not</b> energy required <b>Allow</b> marks via an equation <b>Allow</b> ionic compound / crystals instead of solid
(ii)	Calcium (ion) has a higher charge density / smaller (ionic) radius / ora (1); So it is <b>more</b> strongly attracted to the oxide (ion) / ora (1)		2	<b>Allow</b> calcium oxide has stronger ionic bond / ora
			<b>Total = 17</b>	

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3	<p><b>Transition element</b>  <math>\text{Cu}^{2+} 1s^2 2s^2 2p^6 3s^2 3p^6 3d^9</math> (1);            Transition elements have one oxidation state that has an incomplete set of 3d electrons / have one ion with a half-filled 3d orbital (1)</p> <p><b>Complex ion</b>            Example of a <b>copper</b> complex ion e.g. <math>[\text{Cu}(\text{H}_2\text{O})_6]^{2+}</math> or <math>\text{CuCl}_4^{2-}</math> (1);            Diagram of the copper complex showing three dimensions e.g. use of wedges or dotted lines (1);            Correct bond angle to match the complex / correct name of the shape of the complex (1);</p> <p>Ligand is an electron <b>pair</b> donor (1);            Copper(II) ion is an electron <b>pair</b> acceptor (1);            Dative bond exists between ligand and the copper(II) ion (1)</p> <p><b>Properties</b>            Several oxidation states e.g. copper has +1 and +2 or iron has +2 and +3 (1);</p> <p>Forms coloured compounds e.g. copper(II) chloride is green or iron(II) sulphate is pale green (1);            Element or compound has catalytic properties e.g. Iron is a catalyst in the Haber process (1)</p>		11	<p><b>Allow</b> has at least one half-filled d orbital / partially filled 3d sub-shell</p> <p>If a copper complex that does not exist is used then first three marks not available            If a correct iron complex is given then example mark cannot be awarded  <b>Allow</b> square planar where appropriate</p> <p>Electron pair donor, electron pair acceptor and dative bond marks can awarded from an appropriate diagram</p> <p>Ignore copper has a +3            Ignore iron has a +6 oxidation state</p>

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3	<b>Quality of written communication</b>  Use of technical terms – at least three terms from the following list are used in the correct context <ul style="list-style-type: none"> <li>• ligand</li> <li>• dative bond</li> <li>• coordinate bond</li> <li>• tetrahedral</li> <li>• square planar</li> <li>• octahedral</li> <li>• oxidation (state)</li> <li>• catalyst</li> <li>• electron pair</li> <li>• lone pair</li> <li>• orbital</li> <li>• sub-shell (1)</li> </ul>		1	Put a ring around the technical terms
			<b>Total = 12</b>	