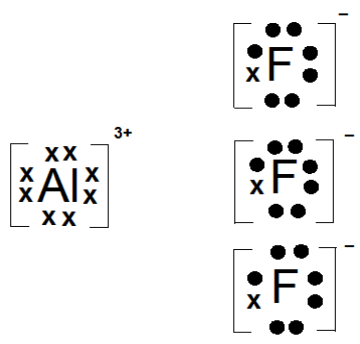
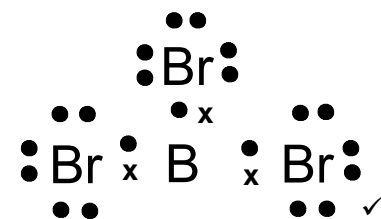


Question		Answer	Mark	Guidance
1	(a)	$2\text{Al} + 3\text{F}_2 \rightarrow 2\text{AlF}_3$ ✓	1	<b>ALLOW</b> multiples <b>IGNORE</b> state symbols
	(b) (i)	Repeating pattern ✓ of oppositely charged ions ✓	2	<b>ALLOW</b> 'regular' <b>OR</b> 'alternating' <b>OR</b> 'uniform (arrangement)' for 'repeating pattern' <b>ALLOW</b> positive and negative ions <b>OR</b> aluminium ions and fluoride ions <b>ALLOW</b> oppositely charged ions from a labelled diagram
	(ii)	 <p>Al with 8 (or no) outermost electrons <b>AND</b> 3 x fluoride (ions) with 'dot-and-cross' outermost octet ✓ Correct charges ✓</p>	2	For first mark: If 8 electrons are shown in the cation then the 'extra' electron in the anion must match the symbol chosen for the electrons in the cation <b>IGNORE</b> inner shells <b>IGNORE</b> circles  <b>ALLOW</b> one mark if both electron arrangements and charges are correct but only one F is drawn.  <b>ALLOW</b> one mark if incorrect symbol is the only error, unless ECF from 2(a) in which both marks are available  <b>DO NOT ALLOW</b> any marks for $\text{BF}_3$  <b>ALLOW</b> $3[\text{F}^-]$ $3[\text{F}]^-$ $[\text{F}^-]_3$ (brackets not required)  <b>DO NOT ALLOW</b> $[\text{F}_3]^-$ $[\text{F}_3]^{3-}$ $[3\text{F}]^{3-}$ $[\text{F}]_3^-$
	(c) (i)	A shared pair of electrons.	1	
	(c) (ii)		1	

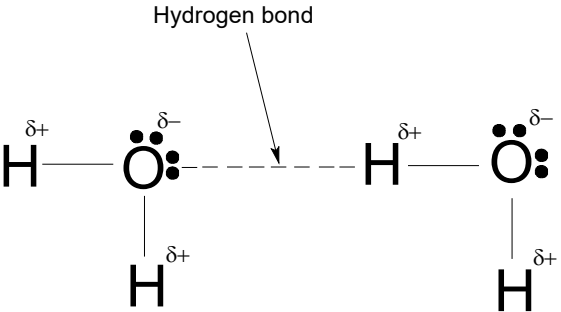
Question	Answer	Mark	Guidance
(d)	<p><i>Conductivity of Al mark</i> M1: Aluminium conducts in solid and molten states ✓</p> <p><i>Reason for conductivity of Al mark</i> M2: Aluminium has delocalised electrons ✓</p> <p><i>Conductivity and reason for molten AlF<sub>3</sub> mark</i> M3: Aluminium fluoride conducts when molten <b>AND</b> because it has mobile <b>ions</b> ✓</p> <p><i>Conductivity and reason for solid AlF<sub>3</sub> mark</i> M4: Aluminium fluoride does not conduct when solid <b>AND</b> Solid aluminium fluoride has <b>ions</b> which are fixed (in position) <b>OR ions</b> are held (in position) <b>OR ions</b> are not mobile <b>AND</b> In an (ionic) lattice <b>OR</b> (ionic) structure <b>OR</b> by (ionic) bonds ✓</p>	5	<p><b>ALLOW</b> 'carries charge' for conducts <b>IGNORE</b> 'charge carriers' for 'electrons' or 'ions' for M2, M3 and M4.</p> <p><i>Quality of written communication:</i> 'delocalis(z)ed' spelled correctly and used in context for the second marking point.</p> <p><b>DO NOT ALLOW</b> M2 if incorrect bonding is seen for Al <b>DO NOT ALLOW</b> 'ions move' for solid Al. <b>IGNORE</b> 'ions move' for molten Al.</p> <p><b>IGNORE</b> references to 'aqueous' AlF<sub>3</sub> for M3 <b>IGNORE</b> 'delocalised ions' <b>OR</b> 'free ions' for mobile ions in M3 <b>DO NOT ALLOW</b> M3 if incorrect bonding is seen in AlF<sub>3</sub> <b>DO NOT ALLOW</b> any mention of electrons moving for M3 <b>DO NOT ALLOW</b> suggestion that it is only positive or only negative ions moving for M3 For conductivity parts of M3 + M4 <b>ALLOW</b> 'AlF<sub>3</sub> only conducts when molten'</p> <p><b>ALLOW</b> Solid AlF<sub>3</sub> is a poor conductor for M4 <b>ALLOW</b> second and third statements to be unlinked in separate sentences for M4 <b>IGNORE</b> 'there are no delocalised electrons' for M4 <b>DO NOT ALLOW</b> M4 if incorrect bonding is seen in AlF<sub>3</sub> Lattice <b>OR</b> structure <b>OR</b> ionic bonds can be seen anywhere in relation to AlF<sub>3</sub>.</p> <p><b>ALLOW</b> Solid BBr<sub>3</sub> is a poor conductor for M5 <b>ALLOW</b> electrons are fixed in position <b>OR</b> used in bonds</p>

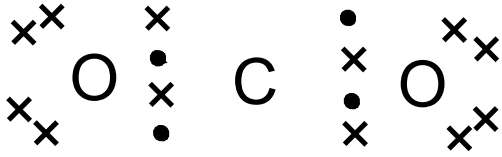
Question			Answer	Mark	Guidance
			<p><i>Conductivity and reason for BBr<sub>3</sub> mark</i></p> <p>M5 Boron tribromide does not conduct in solid and molten states</p> <p><b>AND</b></p> <p>Boron tribromide has no mobile electrons <b>OR</b> no (mobile) ions <b>OR</b> no mobile charge carriers <b>OR</b> no mobile charged particles ✓</p>		<p><b>IGNORE</b> 'there are no delocalised electrons' <b>OR</b> 'there are no free electrons' for M5</p> <p><b>DO NOT ALLOW</b> M5 if incorrect bonding is seen in BBr<sub>3</sub> eg 'ions are fixed in position'</p> <p><b>ALLOW</b> 'no (free) ions'</p>
1	(e)	(i)	$\text{Al}^{2+}(\text{g}) \rightarrow \text{Al}^{3+}(\text{g}) + \text{e}^{-} \checkmark$	1	<p>State symbols required (ignore states on electrons)</p> <p><b>ALLOW</b> <math>\text{Al}^{2+}(\text{g}) - \text{e}^{-} \rightarrow \text{Al}^{3+}(\text{g})</math></p> <p><b>ALLOW</b> e for e<sup>-</sup></p>
		(ii)	<p>All (thirteen) ionisation energies show an increase ✓</p> <p>The two largest increases are between the third and fourth</p> <p><b>AND</b></p> <p>the eleventh and twelfth ionisation energies ✓</p>	2	<p><b>IGNORE</b> line if drawn</p> <p><b>IGNORE</b> 0 if included</p> <p><b>ALLOW</b> one mark for three lines (no crosses) showing an increase between: first and third; fourth and eleventh; twelfth and thirteenth</p> <p><b>AND</b></p> <p>Largest increases between each line</p> <p><b>ALLOW</b> crosses outside grid</p>
			<b>Total</b>	<b>15</b>	

Question		Answer	Mark	Guidance
2	(a)	<p>The attraction (between nuclei and outermost electrons) increases (across the period)</p> <p><b>AND</b></p> <p>The nuclear charge increases</p> <p><b>OR</b></p> <p>The number of protons increase ✓</p> <p>(Outer) electrons are in the same shell</p> <p><b>OR</b></p> <p>(Outer) electrons experience similar shielding</p> <p><b>OR</b></p> <p>Same number of shells</p> <p><b>OR</b></p> <p>Atomic radius decreases ✓</p>	2	<p><b>ALLOW</b> There is no change in shielding But <b>DO NOT ALLOW</b> 'there is no shielding'</p> <p><b>DO NOT ALLOW</b> electrons are at the same distance</p>

Question	Answer	Mark	Guidance
(b)	<p><i>M1 NH<sub>3</sub> forces mark</i> NH<sub>3</sub> has hydrogen bonding ✓</p> <p><i>M2 F<sub>2</sub> AND Br<sub>2</sub> forces mark</i> F<sub>2</sub> AND Br<sub>2</sub> have van der Waals' (forces) ✓</p> <p><i>M3 Type of particle mark</i> Forces OR attractions are between molecules OR are intermolecular for ammonia <b>AND</b> Forces OR attractions are between molecules OR are intermolecular for fluorine OR for bromine ✓</p>	5	<p><i>Quality of written communication:</i> 'molecule(s)' or 'intermolecular' spelled correctly once and used in context for the third marking point.</p> <p><b>ALLOW</b> H-bonding for hydrogen bonding <b>IGNORE</b> van der Waals' forces <b>AND</b> permanent dipoles in M1 <b>IGNORE</b> covalent bonds for M1 <b>AND</b> M2</p> <p><b>ALLOW</b>, for van der Waal's: vdWs <b>OR</b> induced dipole temporary <b>OR</b> instantaneous dipole (-dipole) forces <b>ALLOW</b> for forces: attractions <b>OR</b> interactions;</p> <p><b>DO NOT ALLOW</b> M3, M4 or M5 if covalent <b>OR</b> ionic bonds are the forces between the particles in that mark</p> <p>M3 can be seen anywhere eg in M1 NH<sub>3</sub> has hydrogen bonding between molecules <b>AND</b> the intermolecular force in Br<sub>2</sub> is stronger than that of F<sub>2</sub> eg a generic statement such as 'boiling point of these substances is determined by strength of <i>intermolecular bonding</i>' eg 'All these <i>molecules</i> are <i>held</i> together by weak forces'</p>

Question	Answer	Mark	Guidance
	<p><i>M4 Br<sub>2</sub> / F<sub>2</sub> comparison mark</i>            The van der Waals' forces in Br<sub>2</sub> are greater than in F<sub>2</sub>  <b>AND</b>            Because bromine has more electrons than fluorine ✓</p> <p><i>M5 Br<sub>2</sub> / NH<sub>3</sub> / F<sub>2</sub> comparison mark</i>            The van der Waals' forces in Br<sub>2</sub> are greater than hydrogen bonding in NH<sub>3</sub>  <b>AND</b>            hydrogen bonding in NH<sub>3</sub> is stronger than van der Waals' forces in F<sub>2</sub> ✓</p>		<p>If correct force is given in M2 <b>ALLOW</b>, for M4, 'intermolecular force in Br<sub>2</sub> is stronger than that in F<sub>2</sub>'</p> <p><b>ALLOW</b> more van der Waals' for greater van der Waals'  <b>ALLOW</b> more shells of electrons</p> <p><b>IGNORE</b> 'permanent dipoles' in NH<sub>3</sub> for M5 if quoted in addition to hydrogen bonding</p> <p>If correct force is given in M1 <b>AND</b> M2 <b>ALLOW</b>, for M5, 'intermolecular force in Br<sub>2</sub> is stronger than that in NH<sub>3</sub>'  <b>AND</b> 'intermolecular force in NH<sub>3</sub> is stronger than that in F<sub>2</sub>'</p> <p>If incorrect intermolecular force is given in M1 <b>OR</b> M2 <b>ALLOW</b> this as ECF for M5 but <b>DO NOT ALLOW</b> if the comparison is based only on van der Waals' forces            Eg <b>DO NOT ALLOW</b> the van der Waals' forces in bromine are stronger than those in ammonia which in turn are stronger than those in fluorine</p>
	<b>Total</b>	<b>7</b>	

Question	Answer	Mark	Guidance
3 (a) (i)	<p><i>The Dipole Mark</i> At least one H<sup>δ+</sup> <b>AND</b> one O<sup>δ-</sup> shown correctly on each water molecule (see diagram) ✓</p> <div style="text-align: center;">  </div> <p><i>The Hydrogen bonding Mark</i> <b>One</b> Hydrogen bond between H in one water molecule and a lone pair of O in an adjacent water molecule ✓</p>	2	<p><b>DO NOT ALLOW</b> H<sup>δ-</sup> <b>OR</b> O<sup>δ+</sup> <b>IGNORE</b> lone pairs for first marking point</p> <p>All Hydrogen bonds must hit a lone pair Hydrogen bond does <b>NOT</b> need to be labelled but it must be different from the covalent bond if it is not labelled</p> <p><b>ALLOW</b> H-bond as label <b>ALLOW</b> only one lone pair on O atom <b>ALLOW</b> additional, correctly drawn Hydrogen bonded water molecules with correct dipoles <b>DO NOT ALLOW</b> more than two lone pairs on O atom</p>

Question			Answer	Mark	Guidance
3	(a)	(ii)	<p><i>Property 1</i> Ice is less dense than water ✓</p> <p><i>Explanation 1</i> The molecules in ice are held apart by hydrogen bonds ✓ <b>OR</b> ice has an open lattice <b>OR</b> structure</p> <p><i>Property 2</i> Ice has a relatively high melting point ✓</p> <p><i>Explanation 2</i> Hydrogen bonds are relatively strong <b>OR</b> Hydrogen bonds are stronger (than other intermolecular attractions or forces) <b>OR</b> More energy is needed to overcome hydrogen bonding</p>	4	<p><b>ALLOW</b> ice floats (on water) <b>ALLOW</b> ice contracts when it melts</p> <p><b>ALLOW</b> ice (water) has a higher melting point than expected <b>OR</b> predicted <b>ALLOW</b> other expressions which convey that the melting point is anomalously high eg 'Ice has an unusually high melting point' <b>IGNORE</b> boiling point <b>IGNORE</b> the following unqualified statements 'Ice has a higher melting point' or 'Ice has a high melting point' <b>IGNORE</b> references to surface tension as a property <b>IGNORE</b> explanations of surface tension</p> <p><b>ALLOW</b> hydrogen bonds are the strongest intermolecular attraction or force <b>DO NOT ALLOW</b> 'hydrogen bonds are strong' but <b>ALLOW</b> this as part of a qualified statement (eg 'hydrogen bonds are strong compared with weak van der Waals forces')</p>
3	(b)		 <p>'dot-and-cross' of CO<sub>2</sub> ✓</p>	1	<p>Lone pairs on O must be seen Lone pairs may be seen as 4 individual electrons <b>ALLOW</b> correct use of three different symbols</p>

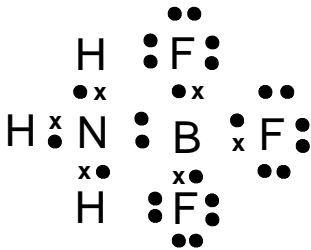


Question	Answer	Mark	Guidance
(c)	Giant covalent (lattice) ✓	1	<b>ALLOW</b> 'Giant lattice with covalent bonds' <b>ALLOW</b> 'Giant covalent bonds' <b>IGNORE</b> ' Giant molecular' or 'macromolecular' <b>DO NOT ALLOW</b> 'Covalent bonds between molecules'
(d)	<p><i>Conductivity of Na mark</i>  M1: Sodium conducts in the solid and molten states ✓</p> <p><i>Reason for conductivity of Na mark</i>  M2: Sodium has delocalised electrons (in both solid and liquid state) ✓</p> <p><i>Conductivity of Na<sub>2</sub>O mark</i>  M3: Na<sub>2</sub>O conducts when molten and not when solid ✓</p> <p><i>Reason for conductivity of Na<sub>2</sub>O marks</i>  M4: Molten Na<sub>2</sub>O has <b>ions</b> which are mobile ✓</p> <p>M5: Solid Na<sub>2</sub>O has <b>ions</b> which are fixed (in position) <b>OR ions</b> are held (in position) <b>OR ions</b> are not mobile <b>AND</b> in an (ionic) lattice <b>OR</b> structure ✓</p>	5	<p><b>Quality of written communication</b>  'delocalis(z)ed spelled correctly once and used in context for second marking point</p> <p><b>ALLOW</b> 'carries charge' for conducts for M1 and M3  <b>IGNORE</b> 'charge carriers' for electrons <b>OR</b> ions for M2, M4 and M5</p> <p><b>DO NOT ALLOW</b> M2 if incorrect bonding is seen for Na  <b>DO NOT ALLOW</b> ions move for solid Na for M2  <b>IGNORE</b> ions move for molten Na for M2</p> <p><b>ALLOW</b> solid Na<sub>2</sub>O is a poor conductor for M3  <b>IGNORE</b> references to aqueous Na<sub>2</sub>O for M3</p> <p><b>IGNORE</b> references to aqueous Na<sub>2</sub>O for M4  <b>IGNORE</b> 'delocalised ions' <b>OR</b> 'free ions' for 'mobile ions' for M4  <b>DO NOT ALLOW</b> M4 <b>AND</b> M5 if incorrect bonding is seen in Na<sub>2</sub>O  <b>DO NOT ALLOW</b> any mention of electrons moving for M4  <b>DO NOT ALLOW</b> suggestion that it is only positive or only negative ions move for M4  <b>IGNORE</b> 'there are no delocalised electrons' for M5  <b>ALLOW</b> first and second statements of M5 to be unlinked in separate sentences  <b>ALLOW</b> 'ions fixed in position by ionic bonds' for M5</p>
<b>Total</b>		<b>13</b>	

Question			Answer	Marks	Guidance
4	(a)	(i)	<p>P in <math>P_4</math> is 0 <b>AND</b> in <math>PH_3</math> is <math>-3</math> <b>AND</b> in <math>NaH_2PO_2</math> is <math>(+1)</math> ✓</p> <p>Phosphorus has been oxidised (from 0) to <math>+1</math> ✓</p> <p>Phosphorus has been reduced (from 0) to <math>-3</math> ✓</p>	3	<p><b>FULL ANNOTATIONS WITH TICKS, CROSSES, CON, etc MUST BE USED</b></p> <p><b>ALLOW</b> oxidation states written above the equation if not seen in the text <b>BUT IGNORE</b> oxidation states written above the equation if seen in the text</p> <p><b>ALLOW</b> <math>3-</math> <b>AND</b> <math>1+</math>  <b>DO NOT ALLOW</b> ions  <b>DO NOT ALLOW</b> <math>P^{3-}</math> in <math>PH_3</math> <b>OR</b> <math>P^+</math> in <math>NaH_2PO_2</math>  <b>DO NOT ALLOW</b> phosphide or phosphine or phosphate in place of phosphorus  <b>ALLOW</b> P or <math>P_4</math> for phosphorus  <b>ALLOW</b> ECF for the second and third marks if <b>ONE</b> incorrect oxidation number is assigned but directional changes are correct eg P = 0 and <math>-3</math> and <math>+2</math> instead of 0 and <math>-3</math> and <math>+1</math>.  <b>IGNORE</b> references to electron loss / gain</p> <p>If correct oxidation numbers are seen <b>ALLOW</b> second <b>AND</b> third marking points for:  'Phosphorus is oxidised to form <math>NaH_2PO_2</math>'  <b>AND</b>  'Phosphorus is reduced to form <math>PH_3</math>'</p> <p><b>IF</b> neither second and third marks have been awarded <b>ALLOW</b> for <b>ONE</b> mark:  Phosphorus has been both oxidised and reduced  <b>OR</b>  Phosphorus's oxidation number has increased and decreased</p>

Question		Answer	Marks	Guidance
(a)	(ii)	<p><b>First check the answer on the answer line.</b>  <b>If answer = 360 (cm<sup>3</sup>) award 2 marks</b></p> <p>Correctly calculates amount of P<sub>4</sub> = 1.86/124.0 = 0.015(0) mol ✓</p> <p>Correctly calculates volume of PH<sub>3</sub> = 0.015(0) x 24000 = 360 (cm<sup>3</sup>) ✓</p>	2	<p>If there is an alternative answer, check to see if there is any ECF credit possible using working below</p> <p><b>ALLOW</b> ECF for wrong amount of P<sub>4</sub> x 24000 for second mark  <b>ALLOW</b> one mark for (1.86/31.0) x 24000 = 1440</p> <p><b>DO NOT ALLOW</b> 2<sup>nd</sup> mark for 1.86 x 24000 = 44640  <b>ALLOW</b> calculator value or rounding to 2 significant figures or more <b>BUT IGNORE</b> 'trailing' zeroes, eg 0.200 allowed as 0.2.</p>
(b)		4PH <sub>3</sub> + 8O <sub>2</sub> → P <sub>4</sub> O <sub>10</sub> + 6H <sub>2</sub> O ✓	1	<p><b>ALLOW</b> correct multiples  <b>IGNORE</b> state symbols</p>
(c)	(i)	The hydrogen <b>ions OR H<sup>+</sup> OR</b> protons (of phosphoric acid) are replaced by sodium <b>ions OR Na<sup>+</sup></b> ✓	1	<p><b>ALLOW</b> Na ions <b>OR</b> positive ions replace H ions <b>OR</b> metal ions have replaced hydrogen ions <b>OR</b> protons</p> <p><b>DO NOT ALLOW</b> Na replaces H. Ions are key in either word or symbol form.  <b>DO NOT ALLOW</b> incorrect charge on Na ions (eg Na<sup>2+</sup>)</p>
	(ii)	Correctly calculates 0.100 x 15 / 1000 = 1.5(0) x 10 <sup>-3</sup> <b>OR</b> 0.0015(0) ✓	1	
	(iii)	22.5 ✓	1	<p><b>ALLOW</b> ECF from (ii)  Answer from (ii) x (3/0.2) x 1000</p>
(d)	(i)	hydrogen bonding ✓ Permanent dipole(-dipole interactions) ✓	2	

Question		Answer	Marks	Guidance
(d)	(ii)	the intermolecular forces are weaker in PH <sub>3</sub> ✓	1	<p><b>ALLOW</b> the energy needed to overcome the intermolecular forces in NH<sub>3</sub> is greater</p> <p>Check table in part (i)</p> <p><b>IF</b> NH<sub>3</sub> = hydrogen bonds <b>AND</b> PH<sub>3</sub> = permanent dipoles <b>OR</b> van der Waal's forces;  <b>ALLOW</b> 'Hydrogen Bonds are stronger' <b>ORA</b></p> <p><b>IF</b> NH<sub>3</sub> = permanent dipoles <b>AND</b> PH<sub>3</sub> = van der Waal's forces;  <b>ALLOW</b> 'permanent dipoles are stronger' <b>ORA</b></p> <p><b>IF</b> NH<sub>3</sub> = permanent dipoles <b>AND</b> PH<sub>3</sub> = permanent dipoles;  <b>ALLOW</b> 'permanent dipoles are stronger in NH<sub>3</sub>' <b>ORA</b></p> <p><b>DO NOT ALLOW</b> PH<sub>3</sub> has weaker vdW's than NH<sub>3</sub>  <b>DO NOT ALLOW</b> NH<sub>3</sub> has stronger hydrogen bonds than PH<sub>3</sub>  <b>DO NOT ALLOW</b> implication that covalent bonds are broken</p>
(e)	(i)	Both electrons have been donated by one atom ✓	1	<p><b>ALLOW</b> 'they' for electrons  <b>IGNORE</b> elements for atom  <b>DO NOT ALLOW</b> 'transfer' in place of 'donated'  <b>DO NOT ALLOW</b> more than one electron pair is donated</p>

Question		Answer	Marks	Guidance
(e)	(ii)	 <p>Correct 'dot-and-cross' arrangement of B covalently 'dot-and-cross' bonded to three F atoms, including full octet on F atoms  <b>AND</b>  Correct 'dot-and-cross' arrangement of N covalently 'dot-and-cross' bonded to three H atoms ✓  Dative covalent shown between N and B atoms ✓</p>	2	<p>Must be 'dot-and-cross', but <b>ALLOW</b> other symbols for electrons of third and fourth atoms eg Δ, +, o, etc</p> <p>Circles for outer shells are not needed  <b>IGNORE</b> inner shells  <b>IGNORE</b> use of charges</p> <p>Non-bonding electrons of F do not need to be seen as pairs</p> <p><b>IGNORE</b> dative-covalent arrows from N to B, but  <b>DO NOT ALLOW</b> arrow from B to N</p> <p><b>DO NOT ALLOW</b> two separate molecules for first mark</p> <p><b>DO NOT ALLOW</b> dative covalent bond mark if electron pair matches the B electrons ie to be correct the dative pair must be the same symbol as non-bonding electrons on F atoms if only two symbols are used</p> <p><b>DO NOT ALLOW</b> dative covalent bond mark if F atoms have no non-bonding electrons <b>UNLESS</b> B has different electron symbol to N or H atoms</p>
	(iii)	<p><math>\text{BF}_3 = 120(\circ)</math> ✓  <math>\text{H}_3\text{NBF}_3 = 109.5(\circ)</math> ✓</p>	2	<p><b>ALLOW</b> 109–110(°) for <math>\text{H}_3\text{NBF}_3</math></p>

Question		Answer	Marks	Guidance
	(e) (iv)	<p>(N in) <math>\text{NH}_3</math> has three bonding pairs and one lone pair of electrons ✓</p> <p>(N in) <math>\text{H}_3\text{NBF}_3</math> has <b>four</b> bonding pairs (and no lone pairs) of electrons  <b>OR</b>  Lone pair on N now becomes bonding pair ✓</p> <p>Lone pair of electrons repels <b>more</b> than bonding pairs ✓</p>	3	<p><b>ALLOW</b> 'bonds' for 'bonding pairs'</p> <p><b>IGNORE</b> 'electrons repel'  <b>DO NOT ALLOW</b> 'atoms repel'</p>
		<b>Total</b>	<b>20</b>	