

- 3 The table below shows the boiling points of some hydrogen compounds formed by Group 6 elements.

	H <sub>2</sub> O	H <sub>2</sub> S	H <sub>2</sub> Se	H <sub>2</sub> Te
Boiling point / K	373	212	232	271

- 3 (a) State the strongest type of intermolecular force in water and in hydrogen sulfide (H<sub>2</sub>S).

Water .....

Hydrogen sulfide .....

(2 marks)

- 3 (b) Draw a diagram to show how two molecules of water are attracted to each other by the type of intermolecular force you stated in part (a). Include partial charges and all lone pairs of electrons in your diagram.

(3 marks)

- 3 (c) Explain why the boiling point of water is much higher than the boiling point of hydrogen sulfide.

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(1 mark)

- 3 (d) Explain why the boiling points increase from H<sub>2</sub>S to H<sub>2</sub>Te

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(2 marks)



- 3 (e) When  $\text{H}^+$  ions react with  $\text{H}_2\text{O}$  molecules,  $\text{H}_3\text{O}^+$  ions are formed.

Name the type of bond formed when  $\text{H}^+$  ions react with  $\text{H}_2\text{O}$  molecules.  
Explain how this type of bond is formed in the  $\text{H}_3\text{O}^+$  ion.

Type of bond .....

Explanation .....

.....

(2 marks)

- 3 (f) Sodium sulfide ( $\text{Na}_2\text{S}$ ) has a melting point of 1223 K.  
Predict the type of bonding in sodium sulfide and explain why its melting point is high.

Type of bonding .....

Explanation .....

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(3 marks)

(Extra space) .....

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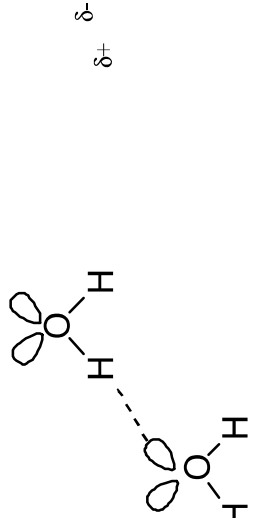
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**Turn over for the next question**

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Question	Part	Sub Part	Marking Guidance	Mark	Comments
3	(a)		Hydrogen/H bonds van der Waals/vdw/ dipole-dipole/London/temporarily induced dipole/dispersion forces	1 1	Not just hydrogen Not just dipole
3	(b)			3	M1 for partial charges as indicated in diagram (correct minimum) M2 for all four lone pairs M3 for H bond from the lp to the H ( $\delta^+$ ) on the other molecule Lone pair on hydrogen CE = 0 OHO CE = 0 If only one molecule of water shown CE = 0
3	(c)		Hydrogen bonds/IMF (in water) stronger <b>OR</b> IMF / VDW / dipole-dipole forces (in H <sub>2</sub> S) are weaker <b>OR</b> H bonding is the strongest IMF	1	Ignore energy references Comparison must be stated or implied
3	(d)		Atoms/molecules get larger/more shells/more electrons/ more surface area therefore increased <u>Van der Waals/IMF</u> forces	1 1	Not heavier/greater Mr Ignore references to dipole-dipole forces

3	(e)		<p>Dative (covalent)/ coordinate</p> <p>(Lone) pair/both electrons/two electrons on O(H<sub>2</sub>) donated (to H<sup>+</sup>) OR pair/both electrons come from O(H<sub>2</sub>)</p>	1  1	<p>If not dative/coordinate CE = 0/2 If covalent or blank read on</p> <p>Explanation of a coordinate bond specific to oxygen or water required Not just H<sup>+</sup> attracted to lone pair since that is nearer to a H bond</p>
3	(f)		<p>ionic</p> <p>oppositely charged <u>ions</u> /+ and – <u>ions or particles</u></p> <p>ions attract <u>strongly</u> OR strong/many (ionic) bonds must be broken</p>	1  1  1	<p>if not ionic CE = 0</p> <p>atoms or molecules loses M2 and M3 S<sup>-</sup> loses M2 Reference to IMF loses M2 and M3</p>