3. Chemical bonding

3.6 Intermolecular forces

Paper 3

Marking Scheme

Q1.

(d)(i)	**M1** molecules CH_4 to PbH_4 have greater number of electrons / number of electrons increase	**1**
	M2 greater / stronger instantaneous dipole–induced forces / London forces / dispersion forces **OR** more energy required to overcome the instantaneous dipole–induced forces / London forces / dispersion forces	**1**
(d)(ii)	tetrahedral	**1**

Q2.

(c)(i)	(molecules) H_2S to H_2Te / they have greater number of electrons	**1**
	stronger instantaneous dipole–induced dipole / London dispersion forces OR more energy required to overcome the instantaneous dipole–induced dipole / London dispersion forces	**1**
(c)(ii)	(only) H_2O has hydrogen bonding **AND** hydrogen bonding (much) stronger than the other intermolecular forces **OR** H_2O has hydrogen bonding **AND** because of higher electronegativity of O compared to S **OR** stronger van der waals' forces because (only) H_2O has hydrogen bonding **OR** hydrogen bond **AND** increased strength of permanent dipoles in H_2O outweighs the increase in strength of id-id in the others	**1**

Q3.

(b)(iii)	hydrogen bond	**1**
(b)(iv)	**M1** link shown as a dashed line between the lone pair of electrons from N of one NH_3 to one H on other NH_3 **M2** minimum 3 correct partial charges (on adjacent atoms) over two NH_3 molecules **EITHER** $^{\delta-}N—^{\delta+}H$ - - - $^{\delta-}N$ **OR** $^{\delta+}H$ - - - $^{\delta-}N—^{\delta+}H$	**2**
(b)(v)	**M1** O is more electronegative than N **M2** two H-bonds per water molecule : 1 per ammonia molecule.	**2**

Q4.

(a)(iii)	dashed (or distinctly labelled) bond between O and H in different molecules of H-O-H and propanoic acid	**1**
	correct sequence of three partial charges over the H-bond $H^{\delta+}$ $O^{\delta-}—H^{\delta+}$ OR $O^{\delta-}$ $H^{\delta+}—O^{\delta-}$	**1**
	lone pair on O in line with H-bond	**1**

Q5.

<table>
<tr><td>(a)(II)</td><td><table><tr><td></td><td>N_2</td><td>CO</td></tr><tr><td>number of electrons per molecule</td><td>14</td><td>14</td></tr><tr><td>type of van der Waals'</td><td>temporary / instantaneous dipole–induced dipole</td><td>permanent dipoles–(permanent) dipoles
(and temporary / induced / instantaneous dipoles)</td></tr></table></td><td>2</td></tr>
<tr><td>(b)</td><td>CO / it is a polar molecule / it has a (permanent) dipole (but N_2 is non-polar)</td><td>1</td></tr>
</table>

Q6.

<table>
<tr><td>(c)(iii)</td><td><table><tr><td>$N_2(g)$</td><td>$CO(g)$</td></tr><tr><td>instantaneous dipole–induced dipole ✓</td><td>instantaneous dipole–induced dipole
(and)
permanent dipole–permanent dipole ✓</td></tr></table></td><td>2</td></tr>
<tr><td>(c)(iv)</td><td>O is more electronegative than C</td><td>1</td></tr>
</table>

Q7.

(a)(i)	**M1** (HI / I / iodine / hydrogen iodide has a) greater number of electrons **M2** greater induced dipoles (between molecules)	2
(a)(ii)	**M1** bar at HF shows any boiling point above HI on graph **M2** *explanation of difference in boiling point of a sample of HF in terms of strength* (sum of) hydrogen bonds (and induced dipoles in HF) are **stronger** than (sum of) induced dipoles (and permanent dipoles in HC*l* / HBr / HI)	2

Q8.

(d)(i)	$C^{\delta-}$–$H^{\delta+}$	1
	$Si^{\delta+}$–$H^{\delta-}$	1
(d)(ii)	**M1** tetrahedral (molecule)	1
	M2 (so individual bond) dipoles / partial charges cancel	1

Q9.

(a)	Different (hydrocarbon) molecules have different numbers of electrons	**1**
	so different strengths / numbers / amount of VdW / IMFs / id-id	**1**