

2.2.1 Intermolecular forces: drawings and evidence transfer

Name: _____ Class: _____ Date: _____

Total: 30 marks

KEY WORDS hydrogen bond

Objective

Draw and explain intermolecular attractions, then transfer the model to unfamiliar liquids and solvents. All questions and marking guidance are original.

1 Key knowledge and worked examples

A hydrogen bond joins a suitable donor H (covalently bonded to N, O or F) to a lone pair on N, O or F of another molecule. London forces act in all these liquids too. Polar molecules also have permanent dipole–dipole attractions; finding a dipole does not prove hydrogen bonding.

■ Worked comparison

Propanal and propan-1-ol both have three carbons. Propanal has a polar C=O bond and accepts hydrogen bonds from water, but has no N–H/O–H/F–H donor. Pure propan-1-ol has O–H donors and oxygen lone pairs, so its molecules form hydrogen bonds to one another. Compare particles and attractions; do not say boiling breaks the C=O or O–H bonds.

For solubility, compare attractions broken and formed. Water's $\text{O}\delta^-$ faces a cation; its $\text{H}\delta^+$ faces an anion. Small alcohols form hydrogen bonds with water. A non-polar solvent can suit iodine because London attractions replace London attractions; polarity alone is not a complete solubility test.

2 Practice

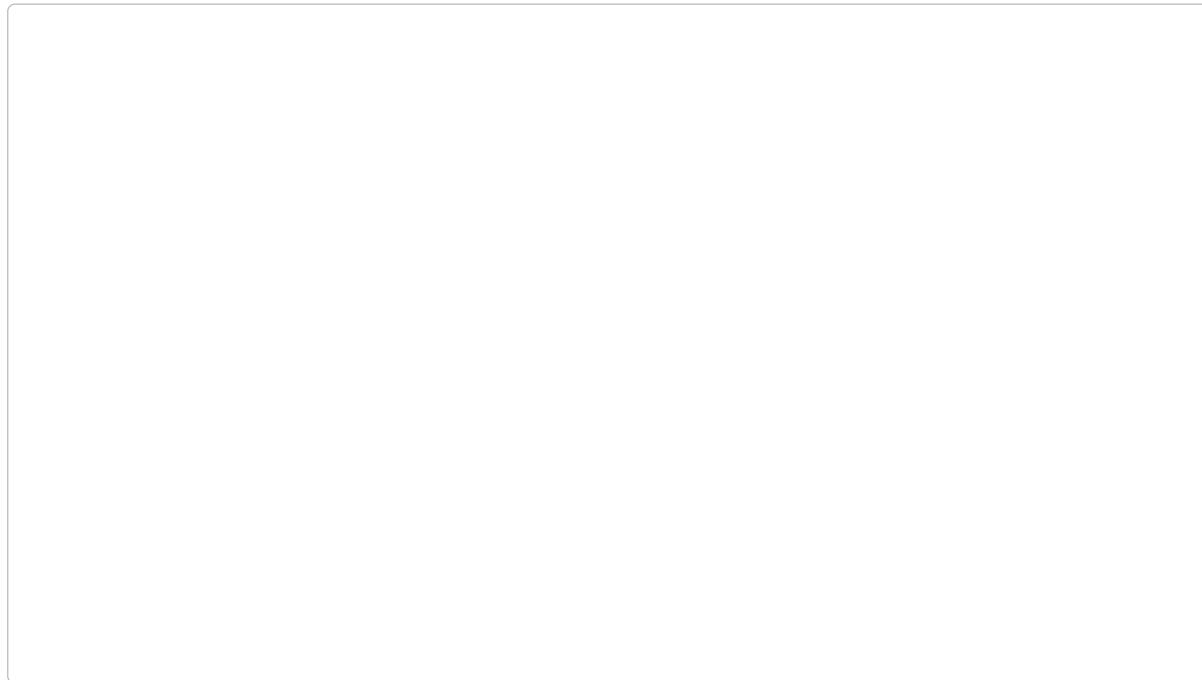
2.1 Compare pure propanal, $\text{CH}_3\text{CH}_2\text{CHO}$, and propane, $\text{CH}_3\text{CH}_2\text{CH}_3$. State the attractions each has, identify which has permanent dipole–dipole attractions, and explain why neither forms a hydrogen-bond network with its own molecules. [4]

2.2 Predict whether pure methanamide, HCONH_2 , can hydrogen-bond to itself. Identify a donor and an acceptor. Compare pure propanone, CH_3COCH_3 , and its ability to accept a hydrogen bond from water. [4]

2.3 Explain why boiling temperatures generally rise from methane to pentane. Then explain why a three-carbon alcohol usually boils above a similar-size alkane. State the type of bond or attraction chiefly overcome in each case. [4]

3 Exam-style questions

3.1 Draw a pair of molecules joined by one hydrogen bond for each liquid: H_2O , NH_3 and HF . Include every atom and covalent bond, all acceptor-atom lone pairs, the donor/acceptor partial charges and a distinct hydrogen-bond line. [6]



3.2 Rounded boiling temperatures in $^{\circ}\text{C}$ are HCl -85 , HBr -67 , HI -35 and HF $+20$. Explain the trend $\text{HCl} \rightarrow \text{HI}$ and the HF exception. Separately, compare water with the similar simple molecule H_2S (boiling -60°C): Water melts at 0°C , while H_2S melts at -85°C . Explain water's high melting and boiling temperatures, then why ice is less dense than liquid water near 0°C . [6]

3.3 Choose water or hexane as the more suitable solvent in each case: sodium chloride, ethanol, iodine. Explain the particle attractions. State how a water molecule orients toward Na^+ and Cl^- , and explain why a polar halogenoalkane may dissolve poorly in water. [6]

Solutions

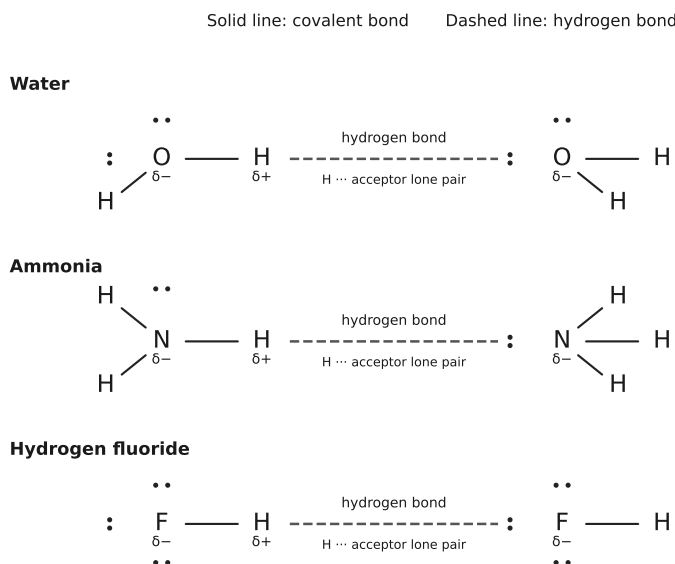
Original marking guidance: B1 for each stated earning point.

2.1 Both have London forces; propanal also has permanent dipole–dipole attractions from its polar carbonyl. Propane lacks a suitable donor/acceptor pair; propanal has an oxygen acceptor but no H bonded to N/O/F to donate.

2.2 Methanamide can form intermolecular hydrogen bonds: N–H is a donor and the carbonyl oxygen lone pair is an acceptor. Propanone lacks an N/O/F–H donor for its own network but its oxygen can accept from water.

2.3 More electrons/more polarisable clouds in longer chains strengthen London attractions. The alcohol also hydrogen-bonds. Boiling mainly overcomes intermolecular attractions, preserving the molecules and their covalent bonds.

3.1



Original marking guidance: for each pair, B1 for complete molecules/acceptor lone pairs and B1 for donor $\text{H}\delta+ \cdots \text{acceptor } \delta-$ attraction distinguished from covalent bonds (six marks total).

3.2 From HCl to HI, more electrons/more polarisable clouds give stronger London attractions and higher boiling temperatures. HF has H bonded to F and F lone pairs, enabling hydrogen bonds. Water also hydrogen-bonds whereas H_2S does not form the same strong network. More energy is needed to disrupt water's hydrogen-bonded intermolecular network during melting or boiling. Ice has an open hydrogen-bonded structure with molecules further apart, so lower density.

3.3 NaCl: water, which hydrates its ions. $\text{O}\delta-$ faces Na^+ and $\text{H}\delta+$ faces Cl^- . Ethanol: water, with new $\text{O}-\text{H} \cdots \text{O}$ hydrogen bonds. Iodine: hexane, with compatible London attractions. A halogenoalkane cannot replace disrupted water hydrogen bonding effectively; favourable new attractions must compensate for attractions broken, so a polar bond alone does not guarantee high solubility.