AS91390 Demonstrate understanding of thermochemical principles and the properties of particles and substances

COLLATED QUESTIONS

Attractive forces between atoms, ions, and molecules. These will include ionic bonds, covalent bonds, and intermolecular attractions due to temporary dipoles and permanent dipoles (including hydrogen bonding).

2025:2

(b) (i) Identify all the types of attractive forces between particles of the following substances in their liquid state.

Substance	$\Delta_{vap}H^o$ / kJ mol^{-1}	Attractive forces
Hydrogen bromide, $HBr(\ell)$	17.3	
Hydrogen fluoride, $HF(\ell)$	25.2	
Bromine, $Br_2(\ell)$	29.6	

(ii) Explain why the $\Delta_{vap}H$ ° of HF is higher than that of HBr.

(iii) Justify why Br_2 has the highest $\Delta_{vap}H$ ° of the three substances.

2024:3

(a) (i) Identify all the types of attractive forces between particles of the following substances in their liquid state in the table below.

Structure	Boiling Point /°C	Attractive forces
Ammonia NH_3	-33	
Sulfur dioxide SO_2	-10	
Pentane $CH_3CH_2CH_2CH_2CH_3$	36	

(ii) Explain the difference in the boiling points of ammonia and sulfur dioxide.

(iii) Explain why the boiling point of pentane is higher than that of sulfur dioxide.

2023:1

(c) (i) Write the equation that represents the enthalpy of vaporisation, ΔvapH°, for hydrazine, N2H4.

(ii) Explain whether the process in part (i) is exothermic or endothermic.

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2023: 3

(b) (i) Identify all the types of attractive forces between particles of the following substances in their liquid state.

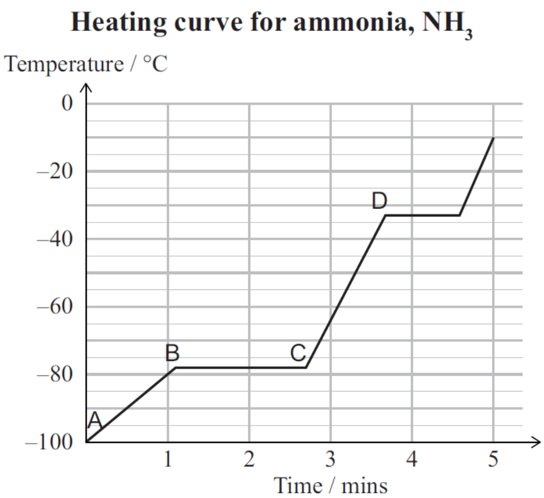
Substance	Boiling point / °C	Attractive forces
Propan-1-amine, $CH_3CH_2CH_2NH_2(\ell)$	48.5	
Chloroethane, $CH_3CH_2Cl(\ell)$	12.3	
Decane $CH_3(CH_2)_8CH_3(\ell)$	174	

(ii) Explain why the boiling point of propan-1-amine is higher than that of chloroethane.

(iii) Explain why the boiling point of decane is higher than that of chloroethane.

2022:2

(b) The heating curve below shows the change in temperature as a sample of ammonia, NH3, is supplied with a constant amount of heat over a time period of five minutes.



(i) Write the equation for the reaction that has an enthalpy change equal to the standard enthalpy of fusion, $\Delta_{fus}H°$, of NH_3.

(ii) With reference to the heating curve for ammonia above, explain the changes between points A and D. Your answer should refer to:

- energy and movement of particles
- intermolecular forces of attraction.

2022:3

(c) (i) Identify ALL the types of attractive forces between particles of the following substances in their liquid state.

Substance	Molar mass / g mol^{-1}	Boiling point / °C	Attractive forces
N_2H_4	32.0	114	
BF_3	67.8	–102	
NOCl	65.5	–6	

(ii) Explain why N_2H_4 has the highest boiling point of the three molecules.

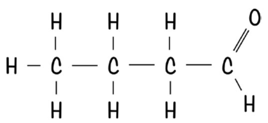
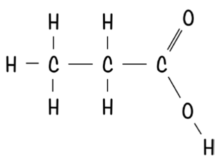
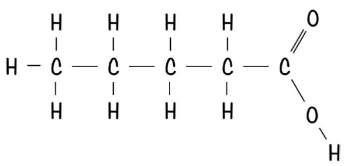
(iii) Justify why BF_3 has a much lower boiling point than NOCl.

2021:1

(b) (ii) Both $\Delta_{vap}H°(SeF_4)$ and $\Delta_{fus}H°(SeF_4)$ are positive. Explain why $\Delta_{vap}H°(SeF_4)$ is more positive.

2021:3

(a) (i) Identify all the types of attractive forces between the particles of the following substances in their liquid state.

Substance	$\Delta_{vap}H°$/kJ mol^{-1}	Attractive forces
Butanal(l) 	34	
Propanoic acid(l) 	57	
Pentanoic acid(l) 	68	

(ii) With reference to the relative strength of all the attractive forces between the particles in each substance, justify the difference in standard enthalpy of vaporisation, $\Delta_{vap}H°$, for butanal, propanoic acid, and pentanoic acid.

2020:1

(a) (i) Identify all types of attractive forces between particles of the following substances in their liquid state.

Substance	Boiling point / °C	Attractive forces
Bromomethane $CH_3Br(l)$	3.6	
Bromine $Br_2(l)$	59	
Calcium bromide, $CaBr_2(l)$	1815	

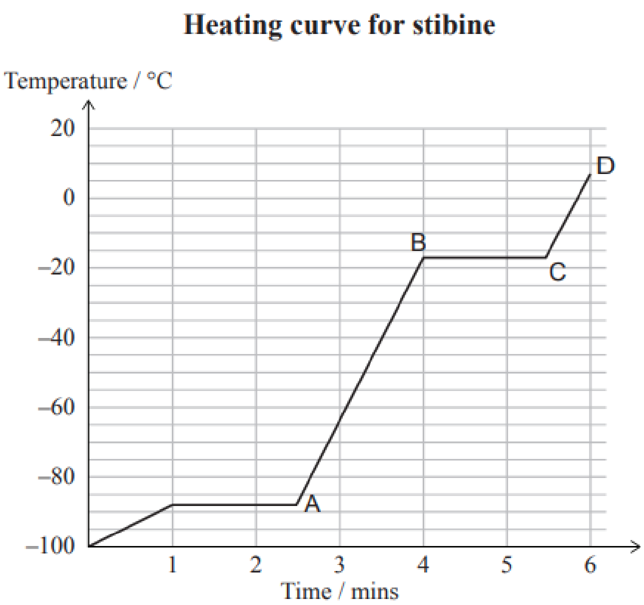
With reference to the relative strength of the attractive forces between the particles in each substance, justify the following:

(ii) Calcium bromide has a higher boiling point than both bromomethane and bromine.

(iii) Bromine has a higher boiling point than bromomethane.

2020:2

(a) The heating curve shows the change in temperature as a sample of stibine, SbH_3, is supplied with a constant amount of heat over a time period of six minutes.



(i) Write the equation for the reaction that has an enthalpy change equal to the standard enthalpy of vaporisation, $\Delta_{vap}H°$, of SbH_3

(ii) With reference to the heating curve for stibine, explain the physical changes between points A and D. Your answer should refer to:
- energy and movement of particles
- intermolecular forces of attraction.

2019:3

(a) List all the forces of attraction between the following molecules in their liquid state.

Molecule	Boiling point / °C	Attractive forces

Ammonia, $NH_3(l)$	-33.3	
Ethane, $C_2H_6(l)$	-88.6	
Methanamine, $CH_3NH_2(l)$	–6.3	

(b) (i) Using the data in the above table, identify the molecule that has the strongest forces of attraction between its molecules.

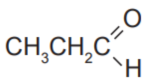
(ii) Justify why methanamine has a higher boiling point than ethane.

(iii) Justify why methanamine has a higher boiling point than ammonia.

2018:2

The standard enthalpy of vaporisation, $\Delta_{vap}H°$, of methanol, propan-1-ol, and propanal, are given in the table below.

(a) (i) List all the forces of attraction between the molecules in their liquid state.

Molecule	$\Delta_{vap}H°$ **/kJ mol^{-1}**	***M*** **/g mol^{-1}**	**Attractive forces**
Methanol CH_3-OH	38	32	
Propan-1-ol $CH_3CH_2CH_2-OH$	47	60	
Propanal 	30	58	

(ii) Compare and contrast the enthalpy of vaporisation of methanol, propan-1-ol, and propanal. Your answer should include an explanation of the relative strength of the attractive forces between the molecules.

2017:2

Molecule	Boiling Point / °C	M / g mol^{-1}
Hydrazine, N_2H_4	114	32
Iodomethane, CH_3I	42.4	142
Decane, $C_{10}H_{22}$	174	142

Use the information in the table above to compare and contrast the boiling points of the substances below. In your answers, you should:

- list the types of intermolecular forces present for each substance
- explain the relative strength between the particles involved.

(a) (i) Hydrazine and iodomethane.

(ii) Iodomethane and decane.

(b) Explain why the solubility of hydrazine in water is greater than that of decane in water.

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2017: 3

Chlorine, Cl_2, bromine, Br_2, and iodine, I_2, are all halogens. Bromine is a liquid at room temperature.

(a) (i) In the box below, tick the type(s) of intermolecular attractions in liquid bromine.

Intermolecular attraction	Tick (✓)
Temporary dipole-dipole attractions	
Permanent dipole-dipole attractions	
Hydrogen bonding	

(ii) Explain why bromine is a liquid at room temperature, whereas chlorine is a gas.

(b) (i) Write an equation for the sublimation of iodine in the box below.

(ii) Define the enthalpy of sublimation for iodine.

2016:2

The standard enthalpy of vaporisation, $\Delta_{vap}H°$, of sodium chloride, NaCl, hydrogen chloride, HCl, and chloromethane, CH_3Cl, are given in the table below.

(a) Identify all the attractive forces between particles of the following compounds in their liquid state.

Compound	$\Delta_{vap}H°$ / kJ mol^{-1}	Attractive forces
NaCl	194	
HCl	16.0	
CH_3Cl	22.0	

(b) (i) Explain why Δ_{vap} H°(NaCl) is significantly higher than both Δ_{vap} H°(HCl) and Δ_{vap} H°(CH_3Cl).

(ii) Explain why Δ_{vap} H°(CH_3Cl) is greater than Δ_{vap} H°(HCl).

(c) (i) Define Δ_{fus}H°(NaCl).

(ii) Why is Δ_{vap} H°(NaCl) greater than Δ_{fus}H°(NaCl)?

(iii) Why does NaCl readily dissolve in water, even though the process is slightly endothermic? NaCl(s) → Na^+(aq) + Cl^-(aq) $\Delta_r H°$ = +3.90 kJ mol^{-1}

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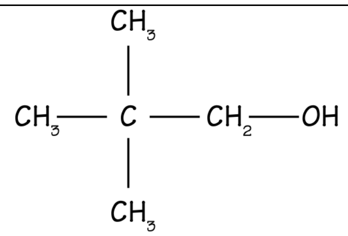
2015: 3

(c) The two molecules below have the same molecular formula ($C_5H_{12}O$) but have different boiling points.

Name	Pentan-1-ol	Dimethylpropan-1-ol
Structure	$CH_3-CH_2-CH_2-CH_2-CH_2-OH$	
Boiling point	138°C	113°C

(i) List all the forces of attraction between these molecules in each of their liquid states.

(ii) Use the information above to explain the difference in the boiling points of pentan-1-ol and dimethylpropan-1-ol by comparing and contrasting the relative strengths of the attractive forces between the molecules involved.

2014: 2

(a) The boiling points of ammonia, NH_3, fluorine, F_2, and hydrogen chloride, HCl, are given in the table below. Complete the table to identify (all) the attractive forces between the molecules in their liquid state.

Molecule	Boiling point / °C	Attractive forces
Ammonia, NH_3	-33	
Fluorine, F_2	-188	
Hydrogen chloride, HCl	-85	

(b) Discuss the differences between the boiling points of NH_3 and HCl, in terms of the strength of the attractive forces between the particles involved. Then describe why F_2 has the lowest boiling point.

2013: 3

Molecule	Boiling point / °C
Hydrazine, N_2H_4	114
Fluoromethane, CH_3F	78.4
Decane, $C_{10}H_{22}$	174

Use the information in the table above to compare and contrast the boiling points of hydrazine, fluoromethane, and decane in terms of the relative strengths of the attractive forces between the particles involved.

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2012: 4 (From expired AS 90780)

(a) (ii) Explain why $\Delta_{vap}H°(H_2O)$ = 40.7 kJ mol^{-1} is greater than $\Delta_{fus}H°(H_2O)$ = 6.01 kJ mol^{-1}. In your answer you should include:

- a description of the attractive forces between the molecules in the different phases (states) of water
- a discussion of how these forces relate to the given enthalpy values.

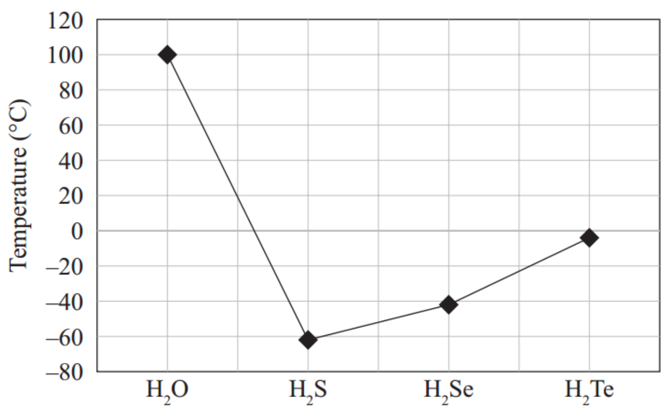
(b) Chloroethanol ($HOCH_2CH_2Cl$) and chloropropane ($CH_3CH_2CH_2Cl$) have similar molar masses, but significantly different boiling points. Identify the substance with the higher boiling point, and justify your choice.

2011:3 (From expired AS 90780)

(b) Discuss the trend in boiling points shown in the graph below for the Group 16 hydrides. In your discussion:

- explain why H_2O has a much higher boiling point than the other hydrides
- account for the rise in boiling points from H_2S to H_2Te
- compare the boiling points of H_2S, H_2Se and H_2Te, and explain the observed trend in terms of bonding AND mass

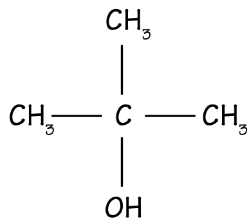
Group 16 hydrides – boiling points



2010:4 (From expired AS 90780)

(b) Ethanol (CH_3CH_2OH) and propane ($CH_3CH_2CH_3$) have similar molar masses but ethanol is a liquid at room temperature, while propane is a gas. Identify the types of intermolecular forces for each of these substances and explain why ethanol has a higher boiling point than propane.

(c) Account for the difference in the boiling points of the two substances in the table below by comparing all the intermolecular forces.

Name	Structure	Boiling Point / °C
butan-1-ol	$CH_3—CH_2—CH_2—CH_2—OH$	117.7 2
methylpropan-2-ol		82.6

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Answers

2025:2

(b) (i) HBr(ℓ): TD-TD attractions, PD-PD attractions
HF(ℓ): TD-TD attractions, PD-PD attractions, hydrogen bonding
Br_2(ℓ): TD-TD attractions

(ii) HF and HBr have permanent dipole attractions between their molecules, but HF also has strong hydrogen bonding due to large electronegativity difference between H and F, explaining its higher $\Delta_{vap}H$ than HBr (despite HBr having a larger electron cloud).

(iii) The temporary dipole attractions between the molecules are of different strengths because all three molecules have different sized electron clouds. The much larger electron cloud of Br2 means there are much stronger temporary dipole attractions between Br2 molecules, outweighing permanent dipole attractions and hydrogen bonding between the smaller HBr and HF molecules.

2024:3

(a) (i) NH_3: Hydrogen bonding, (permanent dipole), temporary dipole
SO_2: Permanent dipole, temporary dipole
C_5H_{12}: Temporary dipole

(ii) Due to the large electronegativity difference between H and N, there is strong hydrogen bonding between NH_3 molecules. This is stronger than the permanent dipole attractions between the polar SO_2 molecules. However, SO_2 is a larger molecule than NH_3, with a larger electron cloud. This means $_{SO2}$ has stronger / more temporary dipole attractions between the SO_2 molecules, and therefore a higher boiling point.

(iii) Despite the molecules having quite similar-sized e– clouds (molar mass), pentane has stronger intermolecular attractions. Pentane is a longer molecule when compared to the more spherical shape of polar SO2, so it has a greater surface area for interaction, meaning stronger temporary dipole attractions. Even though there are strong permanent dipole attractions between the polar SO2 molecules, more energy is needed to break the attractions between the pentane molecules, so pentane has a higher boiling point.

2023:1

(c) (i) $N_2H_4(l) \rightarrow N_2H_4(g)$

(ii) The enthalpy of vaporisation of hydrazine is an endothermic process since heat energy is required / absorbed to break / overcome the intermolecular forces between the hydrazine molecules to change from a liquid to a gas.

2023:3

(b) (i) Propan-1-amine: temporary dipole, permanent dipole, hydrogen bonding
Chloroethane: temporary dipole, permanent dipole
Decane: temporary dipole

(ii) Propan-1-amine and chloroethane both have electron clouds of a similar size and therefore the temporary dipole attractions between the molecules are of similar strength. Both chloroethane and propan-1-amine have permanent dipole attractions between their molecules, (due to the C–Cl dipole and the N–H dipole, respectively). However, propan-1-amine also has hydrogen bonding between its molecules, due to the strong N–H dipole / the large difference in electronegativity between N and H. As a result, more heat energy is required to overcome the intermolecular forces between propan-1-amine, so it has a higher boiling point than chloroethane.

(iii) Chloroethane has permanent dipole attractions between its molecules (due to the C–Cl dipole), as well as temporary dipole attractions. However, since decane has a much larger electron cloud due to its larger molar mass, the sum of its temporary dipole interactions is greater, so more heat energy is required to separate decane molecules compared to chloroethane molecules. As a result, decane has a higher boiling point than chloroethane.

2022:2

(b) (i) $NH_3(s) \rightarrow NH_3(l)$

(ii) Between A and B, ammonia molecules (in solid state) gain kinetic energy, so the temperature increases. Due to the increase in kinetic energy, the molecules are vibrating / moving to a greater extent (and the intermolecular forces between them become weaker).
Between B and C, the added heat energy is used to break some of the intermolecular attractions between the ammonia molecules when changing state from a solid to a liquid / melting. Since the kinetic energy of the ammonia molecules remains constant, the temperature also remains constant.
Between C and D, ammonia molecules (in liquid state) gain kinetic energy, so the temperature increases. Due to the increase in kinetic energy, the ammonia molecules move faster (and further apart.)

2022:2

(c) (i) N_2H_4: Hydrogen bonding, permanent dipole, temporary dipole
BF_3: Temporary dipole
NOCl: Permanent dipole, temporary dipole

(ii) Due to the large electronegativity difference between N and H / N_2H_4 has strong N– H dipoles, so there is strong hydrogen bonding between hydrazine molecules. This is why hydrazine has the highest boiling point because the other two molecules only have weaker permanent and temporary dipole attractions / don't have hydrogen bonds.

(iii) BF_3 and NOCl have similar size electron clouds, so similar strength temporary dipole attractions. NOCl is a polar molecule, so also has stronger permanent dipole attractions present, so a higher boiling point than BF_3. BF_3 is a non-polar molecule, so has only the weak temporary dipole attractions between molecules and therefore has the lowest boiling point

2021:1

(b) (ii) Fusion (melting) requires only some intermolecular forces to be broken, whereas vaporisation requires all intermolecular forces to be overcome, so more heat energy is required.

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2021:3

(a) (i) Butanal: temporary dipole, permanent dipole
Propanoic acid: temporary dipole, permanent dipole, hydrogen bonding
Pentanoic acid: temporary dipole, permanent dipole, hydrogen bonding

(ii) Butanal and propanoic acid both have electron clouds of a similar size (similar molar mass), and therefore the temporary dipole attractions between the molecules are of similar strength. Both propanoic acid and butanal have permanent dipole attractions between their molecules due to the C=O dipole. However, propanoic acid also has hydrogen bonding between its molecules due to the strong O – H dipole, caused by the large difference in electronegativity between O and H. As a result, more heat energy is required to overcome the intermolecular forces between propanoic acid, so it has a higher $\Delta_{vap}H°$ than butanal. Like propanoic acid, pentanoic acid has hydrogen bonding between its molecules. However, pentanoic acid has a larger electron cloud. As a result, there are stronger temporary dipole attractions between pentanoic acid molecules, and therefore more heat energy is required to overcome its intermolecular forces.

2020:1

(a) (i) $CH_3Br(l)$: Permanent dipole, temporary dipole
$Br_2(l)$: Temporary dipole
$CaBr_2(l)$: Ionic bonds

(ii) Calcium bromide has strong ionic bonding between ions, whereas both CH_3Br and Br_2 only have weak (intermolecular) attractions between molecules. Therefore, a lot more heat energy is required to overcome the ionic bonds compared to the intermolecular bonds, so calcium bromide has a higher boiling point than both bromomethane and bromine.

(iii) Br_2 has a larger molar mass, and therefore a larger electron cloud than CH_3Br. Since more heat energy is required for Br_2 to reach its boiling point, this means the temporary dipole attractions between Br_2 molecules must be stronger than the sum of the temporary dipole and permanent dipole attractive forces between CH_3Br molecules.

2020:2

(a) (i) $SbH_3(l) \rightarrow SbH_3(g)$

(ii) Between A and B, stibine molecules (in liquid state) gain kinetic energy, so the temperature increases. Due to the increase in kinetic energy, the molecules are moving to a greater extent (and the intermolecular forces between them become weaker). Between B and C, the added heat energy is used to break intermolecular attractions between the stibine molecules and therefore separate the stibine molecules from one another in the change of state from a liquid to a gas. Since the kinetic energy of the stibine molecules remains constant, the temperature also remains constant. Between C and D, stibine molecules (in gas state) gain kinetic energy, so the temperature increases. Due to the increase in kinetic energy, the stibine molecules are moving very fast.

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2019:3

(a) NH_3 Hydrogen bonding, (permanent dipoles), temporary dipoles.
C_2H_6 Temporary dipoles / instantaneous dipoles.
CH_3NH_2 Hydrogen bonding, permanent dipoles, temporary dipoles.

(b) (i) (ii) Methanamine and ethane have electron clouds of similar size / similar molar mass and would therefore have intermolecular temporary dipole attractions of similar strength. However, methanamine also has hydrogen bonding due to the N–H bond. As this is the strongest intermolecular force, it requires a larger amount of heat energy to break. Therefore, methanamine has a higher boiling point than ethane.

(iii) Both methanamine and ammonia have intermolecular hydrogen bonding due to the N–H bond, which causes strongest type of intermolecular force. However, methanamine has a significantly larger electron cloud / larger molar mass. This means the temporary dipole attractions between methanamine molecules will be stronger, and will therefore require more heat energy to break. So, methanamine has a higher boiling point than ammonia.

2018:2

(a) (i) Methanol: hydrogen bonding, permanent dipole attractions, temporary dipole attractions.
Propan-1-ol: hydrogen bonding, permanent dipole attractions, temporary dipole attractions.
Propanal: permanent dipole attractions, temporary dipole attractions.

(ii) Both methanol and propan-1-ol have temporary dipoles, permanent dipoles, and hydrogen bonding between the molecules. Since propan-1-ol has a larger electron cloud than methanol, it has stronger temporary dipole attractions. As a result, propan-1-ol has a higher enthalpy of vaporisation/ requires more energy to separate the molecules than methanol.

Propanal has temporary dipoles and permanent dipoles between the molecules. Permanent dipole attractions are weaker than hydrogen bonding, so propanal has a lower enthalpy of vaporisation/requires less energy to separate the molecules than methanol and propan-1-ol.

Even though propanal and propan-1-ol have electron clouds of similar size and would therefore have temporary dipole attractions of similar strength, the hydrogen bonding in propan-1-ol has more influence on the enthalpy of vaporisation of/energy required to separate than the permanent dipole

2017:2

(a) (i) Hydrazine (N_2H_4) hydrogen bonding, (permanent dipole attractions) temporary dipole attractions.
For iodomethane (CH_3I) permanent and temporary dipole attractions.
The hydrogen bonds between N_2H_4 molecules are stronger than the permanent dipole forces between CH_3I molecules therefore require more energy to break resulting in a higher boiling point. The presence of hydrogen bonding outweighs the expected higher temporary dipole in CH_3I due to the greater molar mass.

(ii) Iodomethane (CH_3I) has permanent and temporary dipole attractions. Decane ($C_{10}H_{22}$) has temporary dipole attractions. Despite the molecules having the same molar mass, decane $C_{10}H_{22}$ has stronger intermolecular attractions. Decane is a longer molecule, when compared to the spherical shape of iodomethane CH_3I, so it has a greater surface area / electron cloud / number of electrons meaning stronger temporary dipole attractions. Therefore, more energy is needed to break these attractions, resulting in a higher boiling point.

(b) Hydrazine is a polar molecule. Decane is non-polar. As water is a polar solvent, the hydrazine will be more soluble than the decane. The attractive forces between the molecules of hydrazine are less than the attractive forces between the hydrazine and water molecules, and therefore it is more soluble than decane, where the attractive forces between the decane molecules are greater than the attractive forces between the decane and water molecules.

2017:3

(a) (i) First box ticked (temporary dipole – dipole attractions).

(ii) Bromine is a larger molecule than chlorine so the temporary dipole intermolecular attractions are greater. Thus, more energy is required to separate the molecules and so Br_2 has a higher boiling point and is a liquid at room temperature

(b) (i) $I_2(s) \rightarrow I_2(g)$

(ii) This is the heat energy required to change one mole of a substance from solid state to gaseous state (at a given combination of temperature and pressure).

2016: 2

(a) NaCl: Ionic bonds.
HCl: Permanent dipole-dipole attractions, temporary dipole-dipole attractions.
CH_3Cl: Permanent dipole-dipole attractions, temporary dipole-dipole attractions.

(b) (i) Much more heat energy is required to overcome the attraction between its particles and convert NaCl from a liquid to a gas than HCl and CH_3Cl, because NaCl has strong ionic bonding between its ions compared to weak intermolecular bonding between the HCl and CH_3Cl molecules.

(ii) Both HCl and CH_3Cl are polar molecules and therefore have permanent dipole-dipole attractions and temporary dipole-dipole attractions between their molecules. However, CH_3Cl has a larger molar mass and therefore more electrons, so its temporary dipole-dipole attractions are stronger than between the HCl molecules. This means more heat energy is required to overcome the attractions between liquid CH_3Cl molecules, so it has a higher $\Delta_{vap}H°$.

(c) (i) Enthalpy of fusion is the energy required to change 1 mol of a substance (NaCl) from a solid to a liquid

(ii) Fusion of NaCl only requires sufficient heat energy to break / overcome some of the ionic bonds, whereas vaporisation requires much more heat energy to overcome all the ionic bonds, therefore the $\Delta_{vap}H°$ of NaCl is much greater than its $\Delta_{fus}H°$.

(iii) When solid NaCl dissolves in water, there is an increase in the entropy of the system since the ions in solution have greater entropy than in the solid lattice, i.e. more random / disordered arrangement. Although the ions in solution have more energy / energetically less stable than in the solid lattice (since the process is endothermic), the increase in entropy makes the process spontaneous.

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2015: 3

(i) FORCES
- hydrogen bonding
- permanent dipoles
- instantaneous dipoles.

(ii) The attractive forces due to the hydrogen bonding and permanent dipoles are similar between the molecules in both liquids, as they both have one OH group, which causes the molecule to be polar and take part in hydrogen bonding.
The two molecules have the same mass, and so the same number of electrons involved in the weak instantaneous dipoles.
However, the pentan-1-ol molecule has no side chains and so the main chains can get closer to each other (less steric hindrance, greater surface area), thus the instantaneous dipoles are stronger / greater in pentan-1-ol, and therefore the boiling point is higher.

2014:2

NH_3 = Hydrogen bonds AND instantaneous dipoles
F_2 = Instantaneous dipoles
HCl = Permanent dipoles AND instantaneous dipoles
NH_3 and HCl both have temporary and permanent dipoles, as they are polar molecules. However, NH_3 has H-bonding, which means the boiling point is higher due to these stronger forces of attraction. HCl has a permanent dipole, but not H-bonding.
F_2 has the lowest boiling point, due to having only temporary dipoles.

2013:3

N_2H_4 is a polar molecule. (Due the presence of the highly polar N-H bonds), there is hydrogen bonding between N_2H_4 molecules.
CH_3F is also a polar molecule. (Due to the presence of the C-F bond), there are permanent dipole attractions between the CH_3F molecules.
The attractive forces due to permanent dipoles in CH_3F must be weaker than the attractive forces due to hydrogen bonding in N_2H_4, because CH_3F boils at a lower temperature and they are similar masses so temporary dipole attractions are similar.
$C_{10}H_{22}$ is a non-polar molecule. The only attractive forces between the $C_{10}H_{22}$ molecules are due to temporary dipoles. However, since $C_{10}H_{22}$ is a significantly larger molecule than N_2H_4, and CH_3F, it is more polarisable / has more electrons / greater molar mass, so (the sum of) its temporary dipole attractions are even stronger than the hydrogen bonds in N_2H_4. As a result, $C_{10}H_{22}$ requires the most heat energy to break its intermolecular forces and therefore has the highest boiling point.

2012:4

(a) (ii) Less energy is required to overcome the attractive forces/ hydrogen bonds between the solid molecules to turn them into a liquid, as only some of these forces need to be broken. However, more energy is required to fully break all forces / hydrogen bonds between molecules in the liquid phase to vapourise the substance to turn them into a gas. Hence the $\Delta_{vap}H^o$ is always greater than the $\Delta_{fus}H^o$.

(b) The instantaneous-induced dipoles (temporary dipoles/ dispersion forces/ London forces) in each substance are the same as the molar mass and hence the size of the electron cloud is the same. $CH_3CH_2CH_2Cl$ is a polar molecule so also has permanent dipole force between the molecules. $HOCH_2CH_2Cl$ is a polar molecule, so also has permanent dipole forces between the molecules. $HOCH_2CH_2Cl$ has an H atom bonded to an atom of high electronegativity (oxygen), so can form hydrogen bonds (H bond) between the molecules. These are strongest of the intermolecular forces. So the forces of attraction between $HOCH_2CH_2Cl$ molecules are stronger thus this substance has a higher boiling point.

2011:3

H_2O

- has hydrogen bonding because it has H joined to atom of high electronegativity, causing attraction of H to O on another molecule
- strongest of the intermolecular forces
- more energy needed to break these bonds than other intermolecular forces, therefore higher boiling point.

H_2S to H_2Te

- going down a group molecules have greater molar mass/ more electrons
- stronger temporary dipoles / instantaneous dipoles / London's forces
- more energy required to break bonds, therefore higher boiling point.
- As the electronegativities of S > Se > Te decrease down the group, the permanent dipole-dipole interactions will decrease, so boiling points would be expected to decrease. However, as the mass increases, the temporary dipole interactions play a greater role and thus the boiling points increase.

2010:4

(b) The instantaneous-induced dipoles (temporary dipoles/ dispersion forces/ London forces) in each substance are the same as the molar mass and hence the size of the electron cloud is the same. $CH_3CH_2CH_3$ is a non-polar molecule so has temporary dipole intermolecular forces only. CH_3CH_2OH is the same size, so same temporary dipole forces. CH_3CH_2OH is a polar molecule so also has permanent dipole forces between molecules – these are stronger than the temporary dipoles. And CH_3CH_2OH also has an H atom bonded to an atom of high electronegativity, so can also form hydrogen bonds (H bond) between the molecules – these are strongest intermolecular force. So the forces of attraction between CH_3CH_2OH molecules are stronger thus this substance has a higher boiling point.

(c) Both molecules are polar, so same permanent dipole forces. Able to form same hydrogen bonds to other molecules (because the –O–H group is attracted to the O–H of adjacent molecules) so H bonding force the same. The difference in the boiling points is related to the shape of the molecule – one molecule having a straight chain, the other, a branched chain. The straight chain butan-1-ol molecules can pack together more closely / less stearic hindrance / more surface area for formation of temporary dipoles than the 2-methylpropan-2-ol molecules, so even though the molecules have the same molar mass (and so normally same temporary dipole forces) there will be stronger instantaneous / temporary dipole attraction in the straight chain molecule, thus increasing the boiling point.