ANSWERS: **Intermolecular forces**

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| **2019** | **Evidence** | **Achievement** | **Achievement with Merit** | **Achievement with Excellence** |
| (a)  (b) (i) (ii)  (iii) | NH3 Hydrogen bonding, (permanent dipoles), temporary dipoles.  C2H6 Temporary dipoles / instantaneous dipoles.  CH3NH2 Hydrogen bonding, permanent dipoles, temporary dipoles.  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.  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. | Two rows correct.  Identifies methanamine and  presence of hydrogen bonding as the reason for the higher boiling point  Identifies increase in size of  electron cloud / molar mass /  strength of temporary dipoles  as the reason for the higher  boiling point of methanamine. | Relates presence of temporary dipoles in both molecules and presence of H bonding in methanamine, creating stronger intermolecular forces in  methanamine and hence a higher boiling point.  Relates presence of H bonding in  both molecules and presence of  greater temporary dipoles in methanamine than in ammonia,  creating stronger intermolecular forces in methanamine and hence a higher boiling point. | Fully justifies why  methanamine has a higher boiling point than ethane and ammonia, including  reference to relative sizes and causes of temporary dipoles and H bonding for all molecules related to  energy requirements. |

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| **2018** | **Evidence** | **Achievement** | **Merit** | **Excellence** |
| (a) (i)  (ii) | 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.  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 attractions. | • TWO rows correct.  • Recognises that the magnitude of the enthalpy of vaporisation is related to the strength of the intermolecular attractions. | • Links the enthalpy of  vaporisation to attractive  forces for the three  molecules | • Fully compares and  contrasts the enthalpy of vaporisation of the three molecules. |

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| **2017** | **Evidence** | **Achievement** | **Achievement with Merit** | **Achievement with Excellence** |
| (a) (i)  (ii) | **Hydrazine** (N2H4) hydrogen bonding, (permanent dipole attractions) temporary dipole attractions.  For **iodomethane** (CH3I) permanent and temporary dipole attractions.  The hydrogen bonds between N2H4 molecules are stronger than the permanent dipole forces between CH3I 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 CH3I due to the greater molar mass.  **Iodomethane** (CH3I) has permanent and temporary dipole attractions.  **Decane** (C10H22) has temporary dipole attractions.  Despite the molecules having the same molar mass, decane C10H22 has stronger intermolecular attractions. Decane is a longer molecule, when compared to the spherical shape of iodomethane CH3I, 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. | • Correctly names all intermolecular forces for TWO of the three substances.  • ONE correct statement for  (i) excluding the naming of intermolecular forces.  • ONE correct statement for  (ii) excluding the naming of intermolecular forces. | • Links relative strengths of intermolecular forces of both molecules to energy required to boil.  • Links the size of the electron cloud / surface area of decane to stronger intermolecular forces. | • Justifies the boiling points  of hydrazine and iodomethane in terms of all the attractive forces involved.  • Justifies the boiling points  of iodomethane and decane in terms of all the attractive forces involved. |
| (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. | • ONE correct statement for  hydrazine or decane  regarding polarity / solubility. | • Explanation given for  both substances. |  |

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| **2016** | **Evidence** | **Achievement** | **Achievement with Merit** | **Achievement with Excellence** |
| (a) | NaCl: Ionic bonds.  HCl: Permanent dipole-dipole attractions, temporary dipole-dipole attractions.  CH3Cl: Permanent dipole-dipole attractions, temporary dipole-dipole attractions. | * Any two significant forces correct. |  |  |
| (b)(i)  (ii) | 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 CH3Cl, because NaCl has strong ionic bonding between its ions compared to weak intermolecular bonding between the HCl and CH3Cl molecules.  Both HCl and CH3Cl are polar molecules and therefore have permanent dipole-dipole attractions and temporary dipole-dipole attractions between their molecules. However, CH3Cl 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 CH3Cl molecules, so it has a higher Δvap*H*°. | * Recognises that NaCl has strong ionic bonding so requires more energy * Recognises that CH3Cl has a larger molar mass / stronger intermolecular attractions (stronger temporary dipole forces | * Links forces of NaCl and the two molecules to the energy required. * Links the larger molar mass of CH3Cl to its stronger intermolecular attractions. | * Full explanation for both (i) and (ii) which links to a correct table in (a). |

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| **2015** | **Evidence** | **Achievement** | **Merit** | **Excellence** |
| (i)  (ii) | FORCES • hydrogen bonding  • permanent dipoles  • instantaneous dipoles.  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. | * Lists two forces. * Two correct statements related to the forces of attraction between compounds. | * Explains correctly how two factors influence the boiling point. | * Explains fully and correctly how three factors influence boiling point. |

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