

Intermolecular forces

1) Arrange the following in terms of increasing strength:

Hydrogen bonding London dispersion forces Dipole-dipole forces

2) Identify the **strongest** type of intermolecular forces in the following molecules:

a) Cl₂

b) HCl

c) HF

d) CH₄

e) CCl₄

f) CH₃Cl

g) H₂O

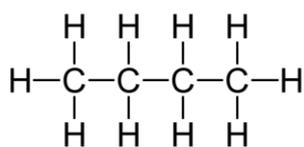
h) CH₃OH

i) C₂H₆

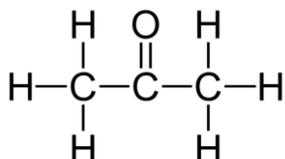
j) NH₃

3) Explain why at room temperature, F₂ and Cl₂ are gases, Br₂ is a liquid and I₂ is a solid.

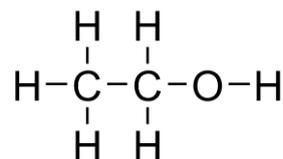
4) The structures of butane, propanone, and ethanol can be seen below. They have similar molar masses, but different boiling points. Explain the difference in boiling point between the three molecules.



Butane B.P -1°C



Propanone B.P 56°C



Ethanol B.P 78°C

Answers:

1) London dispersion forces < Dipole-dipole forces < Hydrogen bonding

2) Non-polar molecules have London dispersion forces, polar molecules have dipole-dipole forces and molecules with H-O, H-N or H-F have hydrogen bonding as the **strongest** intermolecular force between molecules.

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| a) Cl ₂ London dispersion forces | f) CH ₃ Cl Dipole-dipole forces |
| b) HCl Dipole-dipole forces | g) H ₂ O Hydrogen bonding |
| c) HF Hydrogen bonding | h) CH ₃ OH Hydrogen bonding |
| d) CH ₄ London dispersion forces | i) C ₂ H ₆ London dispersion forces |
| e) CCl ₄ London dispersion forces | j) NH ₃ Hydrogen bonding |

3) F₂, Cl₂, Br₂ and I₂ are non-polar molecules, therefore they have London dispersion forces between molecules. The molar mass increases from F₂ to I₂, therefore the strength of the London dispersion forces also increases. Stronger London dispersion forces result in a higher boiling as more energy is required to overcome the forces between the molecules.

4) Butane is a non-polar molecule therefore it has London dispersion forces between molecules. These are the weakest type of intermolecular force, therefore it has the lowest boiling point.

Propanone is a polar molecule (due to the polar C=O bond) therefore it has dipole-dipole forces between molecules. They are stronger than London dispersion forces, therefore it has a higher boiling point than butane.

Ethanol has an OH group (O bonded to H) which means that it can form hydrogen bonds between molecules. Hydrogen bonding is the strongest type of intermolecular force, therefore ethanol has the highest boiling point.