

London, dipole and hydrogen bond attractions between molecules

Chemistry grades 11-12 (A Level · IB · Class 11-12) · Worksheet

Name: _____ Date: _____ Class: _____

These problems train you to identify London forces, permanent dipole-dipole forces and hydrogen bonds, to rank boiling points from the forces present, and to read graphs of boiling-point data for alkanes, hydrides and alcohols.

They suit A Level, IB Chemistry and CBSE Class 11-12. The first problems are recall, the middle ones compare pairs of substances, and the last five need extended reasoning and short calculations.

Level: Chemistry grades 11-12 (A Level · IB · Class 11-12) · **Curriculum:** IB S2.2

Problem 1 Bonds or forces? (easy)

Aarav in Pune melts a block of ice and then boils the water.

1. State which interactions are broken when ice melts.
2. State what happens to the covalent bonds when water boils.
3. Explain why changes of state need far less energy than bond breaking.

Problem 2 Names of the forces (easy)

Name the strongest intermolecular force in each substance.

1. argon, Ar
2. hydrogen chloride, HCl
3. water, H₂O
4. methane, CH₄

Problem 3 Origin of London forces (easy)

Put these statements in the correct order and number them: (A) the dipoles attract; (B) electrons move to one side of an atom; (C) the neighbouring atom is induced to have an opposite dipole.

1. Give the correct order.
2. Name the type of dipole formed in step B.

Problem 4 Counting electrons (easy)

Count the total electrons in each molecule (H 1, C 6, Cl 17, O 8).

1. CH₄

2. C_2H_6
3. H_2O
4. Cl_2

Problem 5 Who can form hydrogen bonds? (easy)

Decide whether molecules of each pure substance can form hydrogen bonds with each other: CH_4 , NH_3 , CH_3OH , CH_3OCH_3 , HF , H_2S .

1. List the substances that can.
2. State the condition that CH_3OCH_3 fails.

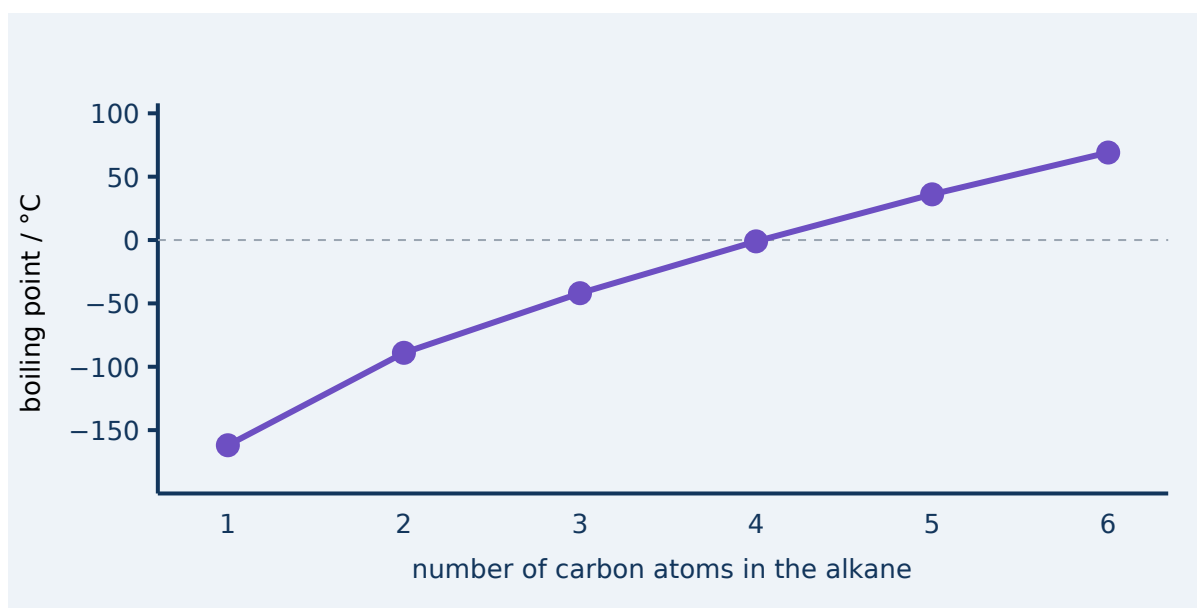
Problem 6 Kelvin and Celsius (easy)

The boiling points of three noble gases are 4 K (helium), 27 K (neon) and 165 K (xenon).

1. Convert each to $^{\circ}\text{C}$ using $T(\text{K}) = \theta(^{\circ}\text{C}) + 273$.
2. State which gas has the strongest London forces and why.

Problem 7 Boiling points of alkanes (medium)

The graph shows boiling points of straight-chain alkanes.



Boiling points of the first six straight-chain alkanes.

1. Describe the trend.
2. Explain it using London forces.
3. Predict the boiling point of heptane (7 carbons) to the nearest 10°C .

Problem 8 Branched isomers (medium)

Pentane boils at 36°C . Its isomer 2,2-dimethylpropane boils at 9.5°C .

1. State the type of force in both.
2. Explain why the branched isomer has the lower boiling point.

Problem 9 The halogens at room temperature (medium)

Chlorine is a gas, bromine a liquid and iodine a solid at 25 °C (Cl 17, Br 35, I 53 electrons per atom).

1. Calculate the total electrons in Cl₂, Br₂ and I₂.
2. Explain the change of state in terms of London forces.

Problem 10 Fluorine and hydrogen chloride (medium)

F₂ and HCl both have 18 electrons. F₂ boils at −188 °C and HCl at −85 °C.

1. Explain why their London forces are similar.
2. Explain why HCl boils higher.

Problem 11 Propanone and butane (medium)

Propanone, CH₃COCH₃, has 32 electrons and boils at 56 °C. Butane has 34 electrons and boils at −1 °C.

1. Identify the extra force in propanone.
2. Explain why propanone has the higher boiling point despite fewer electrons.
3. Explain why propanone cannot form hydrogen bonds with itself.

Problem 12 Ethanol and methoxymethane (medium)

Both have the formula C₂H₆O. Ethanol boils at 78 °C and methoxymethane at −24 °C.

1. Draw the structural formulae.
2. Identify the strongest force in each.
3. Explain the difference in boiling points.

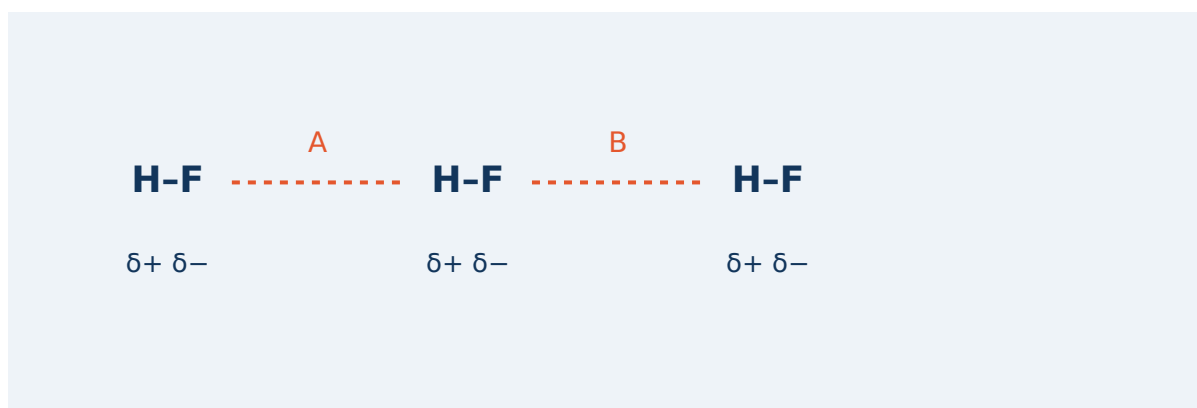
Problem 13 Hydrogen halides (medium)

Boiling points: HF 20 °C, HCl −85 °C, HBr −67 °C, HI −35 °C.

1. Explain the trend from HCl to HI.
2. Explain why HF is out of line.

Problem 14 A hydrogen-bonded chain (medium)

The diagram shows three HF molecules.



Three hydrogen fluoride molecules, with attractions A and B shown as red dashes.

1. Name the attractions A and B.
2. Mark the $\delta+$ and $\delta-$ atoms along A.
3. State the angle of $\text{H-F}\cdots\text{H}$ that gives the strongest bond.

Problem 15 Glycerol and propan-1-ol (medium)

Glycerol, $\text{HOCH}_2\text{CH}(\text{OH})\text{CH}_2\text{OH}$, is far more viscous than propan-1-ol, $\text{CH}_3\text{CH}_2\text{CH}_2\text{OH}$, although the two molecules are similar in size.

1. Count the O-H groups in each molecule.
2. Explain the difference in viscosity.

Problem 16 Hydrogen fluoride, water and ammonia (hard)

Boiling points: HF 20 °C, H_2O 100 °C, NH_3 -33 °C. Each molecule has about 10 electrons.

1. Compare the number of hydrogen atoms and lone pairs available for hydrogen bonding in each molecule.
2. Explain why water has the highest boiling point.
3. Explain why NH_3 has the lowest.

Problem 17 Energy to boil water (hard)

The energy to vaporise one mole of water at 100 °C is 40.7 kJ. The O-H bond enthalpy is about 463 kJ per mole of bonds. Use $M(\text{H}_2\text{O}) = 18.0 \text{ g mol}^{-1}$.

1. Calculate the energy to vaporise 250 g of water.
2. Calculate the energy to break all the O-H bonds in one mole of water molecules.
3. Use your answers to explain what is broken on boiling.

Problem 18 Mixing ethanol, water and hexane (hard)

Ethanol mixes completely with water, but hexane does not mix with water.

1. Name the strongest intermolecular force between water molecules and between hexane molecules.
2. Explain why ethanol and water mix.
3. Explain why hexane and water separate into layers.

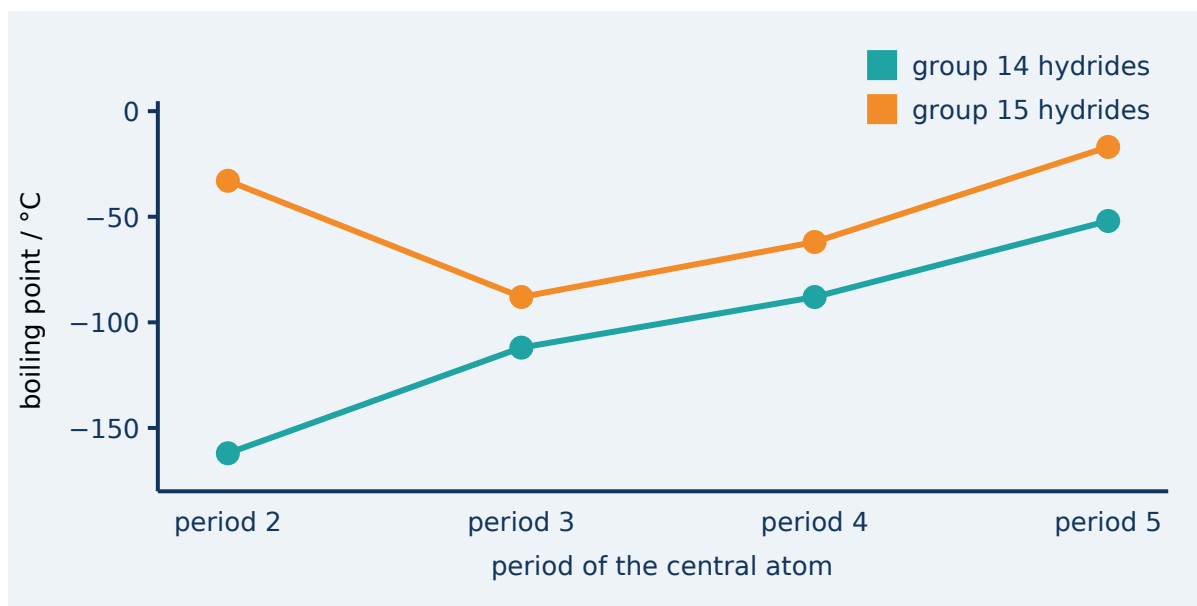
Problem 19 Ranking three liquids (hard)

Butane (58 g mol^{-1}), propanone (58 g mol^{-1}) and propan-1-ol (60 g mol^{-1}) have almost the same number of electrons. Their boiling points are -1°C , 56°C and 97°C in some order.

1. Match each boiling point to its liquid.
2. Justify each match by the forces present.

Problem 20 Groups 14 and 15 (hard)

The graph compares the hydrides of groups 14 and 15.



Boiling points of group 14 and group 15 hydrides.

1. Describe the trend for group 14 and explain it.
2. Identify the anomaly in group 15 and explain it.
3. Explain why no group 14 hydride shows an anomaly.