

Forces between particles and what they decide

AP Chemistry · Worksheet

Name: _____ Date: _____ Class: _____

These problems train you to name intermolecular forces, rank substances by boiling point and vapour pressure, link forces to properties of liquids and solids, and use the vapour pressure equation. They follow AP Chemistry unit 3.

Work from recall to multi-step reasoning. In the last five problems you must write short arguments in the style of a free-response answer, so always name the force and compare strengths.

Level: AP Chemistry · **Curriculum:** AP Chem Unit 3

Problem 1 Name the main force (easy)

Name the strongest intermolecular force present in each pure substance.

1. Argon, Ar
2. Hydrogen chloride, HCl
3. Ammonia, NH_3
4. Methane, CH_4

Problem 2 Which can hydrogen bond? (easy)

Aarav in Pune lists five molecules: CH_3OH , CH_3OCH_3 , HF, CH_3F and CH_3NH_2 .

1. Identify which molecules can form hydrogen bonds with molecules of the same kind.
2. State the rule you used.

Problem 3 Noble gas boiling points (easy)

Boiling points of four noble gases are 4 K, 27 K, 87 K and 120 K. They are He, Ne, Ar and Kr in some order.

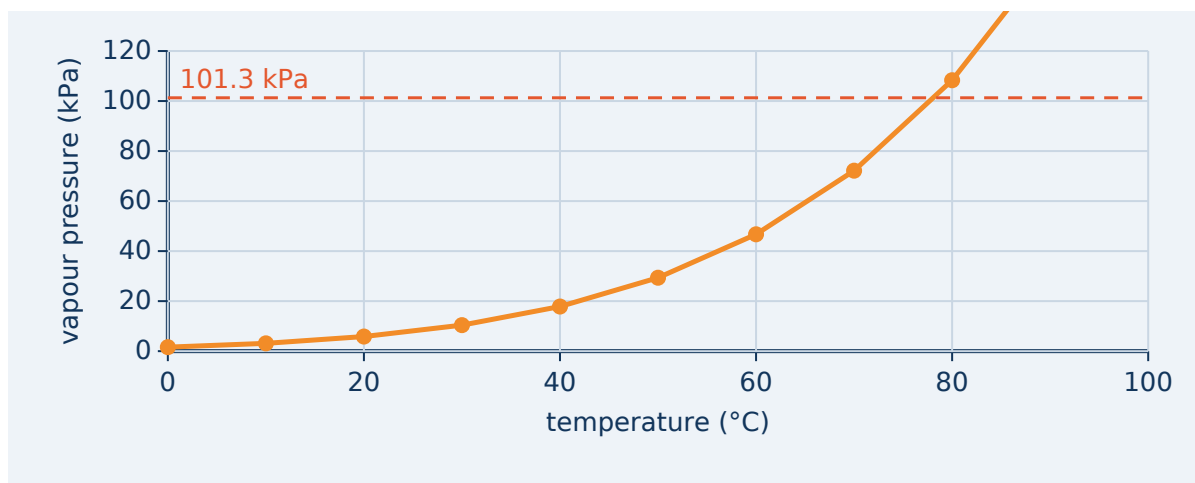
1. Match each gas to its boiling point.
2. Name the force involved and explain the trend.

Problem 4 Celsius and kelvin (easy)

Convert, using $T(\text{K}) = \theta(^{\circ}\text{C}) + 273.15$.

1. Water boils at 100°C .
2. Nitrogen boils at 77 K.
3. Ethanol boils at 78°C .

Problem 5 Reading a vapour pressure curve (easy)



Vapour pressure of liquid X.

The graph shows the vapour pressure of liquid X, which is ethanol.

1. Estimate the vapour pressure at 60 °C.
2. Estimate the normal boiling point.
3. Estimate the temperature at which the vapour pressure is 50 kPa.

Problem 6 Why ice floats (easy)

Wanjiru in Nairobi drops ice into a glass of water.

1. Explain, using hydrogen bonds, why ice is less dense than liquid water.
2. State what happens to the hydrogen bonds when ice melts.

Problem 7 Viscosity of two liquids (medium)

Hexane, C_6H_{14} , flows like water, but ethane-1,2-diol, $HOCH_2CH_2OH$, is thick and syrupy at the same temperature.

1. Name the strongest force in each liquid.
2. Explain the difference in viscosity.

Problem 8 Pentane and neopentane (medium)

Pentane and neopentane, $C(CH_3)_4$, both have formula C_5H_{12} and mass 72.2 g/mol, but they boil at 36 °C and 9.5 °C.

1. Name the force that explains both boiling points.
2. Explain why neopentane boils lower.

Problem 9 Capillary action (medium)

Water climbs up a thin glass tube and its surface curves upward at the edges. Mercury in the same tube forms a surface that curves downward and sits below the outside level.

1. Define cohesive and adhesive forces.

2. Explain the difference between water and mercury.

Problem 10 Classify the solids (medium)

Four white solids were tested in a school lab.

Solid	Melting point	Conducts as solid	Conducts as liquid or in water	Solubility in water
W	801 °C	no	yes	soluble
X	1710 °C	no	no	insoluble
Y	1085 °C	yes	yes	insoluble
Z	95 °C	no	no	insoluble

1. Classify W, X, Y and Z as ionic, metallic, molecular or covalent network.
2. Give one piece of evidence for each.

Problem 11 Rank vapour pressures (medium)

Rank propanone (CH_3COCH_3), ethanol, water and ethane-1,2-diol from highest to lowest vapour pressure at 25 °C, and justify the order.

Problem 12 Energy to vaporise ethanol (medium)

Chiamaka in Lagos evaporates 25.0 g of ethanol, $\text{C}_2\text{H}_5\text{OH}$ (46.07 g/mol), with $\Delta H_{\text{vap}} = 38.6$ kJ/mol.

1. Calculate the amount of ethanol in mol.
2. Calculate the energy absorbed.

Problem 13 Sweat and cooling (medium)

During a match, Kofi in Accra loses 150 g of sweat by evaporation. Treat it as water with $\Delta H_{\text{vap}} = 40.7$ kJ/mol (18.02 g/mol). His body mass is 60.0 kg and its specific heat capacity is $3.5 \text{ J}/(\text{g}\cdot^\circ\text{C})$.

1. Calculate the energy removed.
2. Calculate the temperature drop if this energy were taken from his body with no heat gained.

Problem 14 Spot the error (medium)

A student writes: "When water boils, the O-H bonds break because boiling needs a lot of energy."

1. Identify the error.
2. Rewrite the sentence correctly.

Problem 15 Salt in water and in hexane (medium)

Bilal in Lahore stirs table salt into water and into hexane. It dissolves in water only.

1. Name the force between Na^+ and water molecules.
2. Explain why NaCl does not dissolve in hexane.

Problem 16 Boiling in Kathmandu (hard)

In Kathmandu the air pressure is about 70.0 kPa. Use $\Delta H_{\text{vap}} = 40.7 \text{ kJ/mol}$ for water and $R = 8.314 \text{ J/(mol}\cdot\text{K)}$.

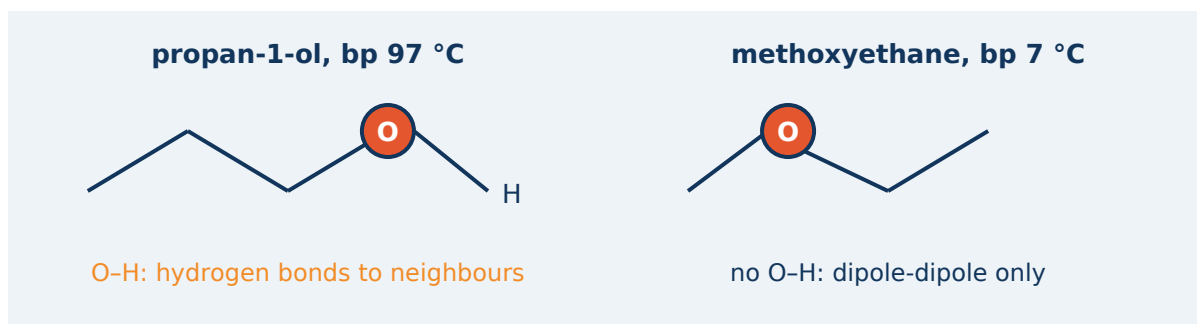
1. Explain why water boils at a lower temperature there.
2. Calculate the boiling temperature in $^{\circ}\text{C}$.

Problem 17 Estimate ΔH of vaporisation (hard)

Ethanol has a vapour pressure of 8.0 kPa at 25°C (298.15 K) and 101.3 kPa at 78.4°C (351.55 K).

1. Calculate ΔH_{vap} .
2. Compare with the data-book value, 38.6 kJ/mol, and suggest a reason for the difference.

Problem 18 Two isomers, two boiling points (hard)

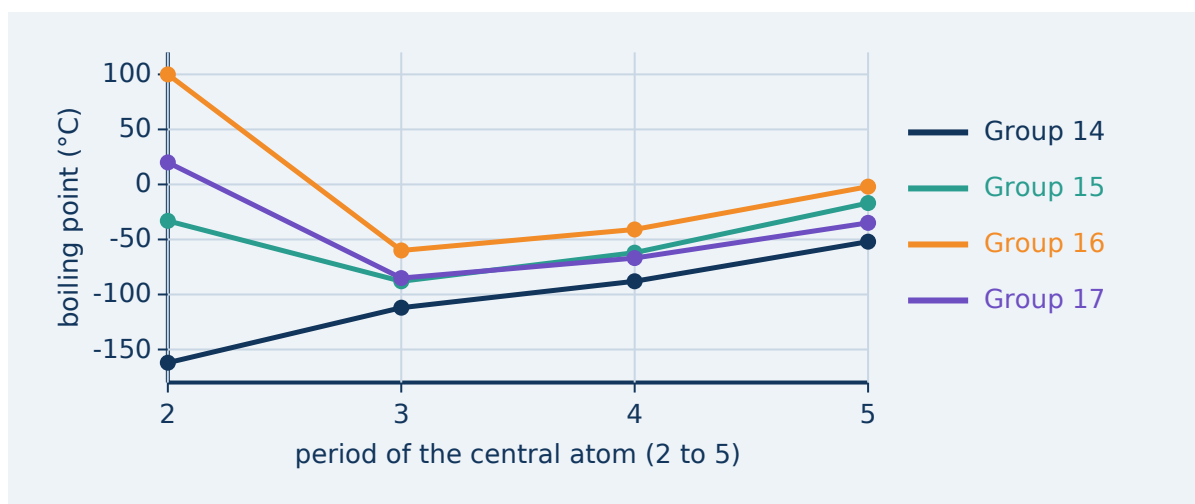


Two isomers with formula $\text{C}_3\text{H}_8\text{O}$.

Both liquids have formula $\text{C}_3\text{H}_8\text{O}$ and molar mass 60.1 g/mol.

1. Explain, with reference to the structures, why propan-1-ol boils 90°C higher than methoxyethane.
2. Predict which has the higher vapour pressure at 20°C .

Problem 19 Hydride trends (hard)



Boiling points of the hydrides of groups 14 to 17.

The graph shows the boiling points of the hydrides of groups 14 to 17, with the period of the central atom on the x-axis (period 2 is NH_3 , H_2O , HF , CH_4).

1. Describe the trend for group 14.
2. Identify the anomalies and explain them.
3. Explain why group 14 does not show an anomaly.

Problem 20 Design a comparison of IMFs (hard)

Mei in Singapore wants to compare the strength of intermolecular forces in water, ethanol and propanone by measuring how much each liquid cools a thermometer bulb as it evaporates.

1. Describe the procedure and name two variables to control.
2. Predict the order of temperature drops with a reason.
3. State one safety precaution.