

Intermolecular Forces

Key ideas

Intermolecular forces (IMFs) act *between* molecules; intramolecular bonds hold atoms *inside* a molecule.

London dispersion (all molecules; stronger with more electrons) < **dipole-dipole** (polar molecules) < **hydrogen bonding** (H bonded to N, O or F).

Stronger IMFs → higher boiling point, higher melting point, higher surface tension, lower vapour pressure.

A Key terms

3 marks

Write the letter of the matching description (½ mark each).

- | | |
|----------------------------------|--|
| 1. _____ Intramolecular force | a. A strong dipole attraction between H bonded to N, O or F and a lone pair on another N, O or F |
| 2. _____ Intermolecular force | b. A force of attraction between separate molecules |
| 3. _____ London dispersion force | c. A molecule with an uneven distribution of charge (a δ^+ end and a δ^- end) |
| 4. _____ Dipole-dipole force | d. A bond holding atoms together inside a molecule |
| 5. _____ Hydrogen bond | e. An attraction between the positive end of one polar molecule and the negative end of another |
| 6. _____ Polar molecule | f. A weak, temporary attraction from shifting electrons; found between all molecules |

B Which forces are present?

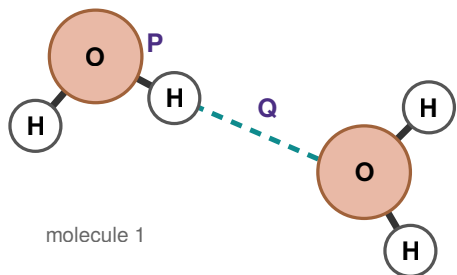
4 marks

Tick every force present between molecules of each substance (½ mark per row).

	Substance	London dispersion	Dipole-dipole	Hydrogen bonding
7.	CH ₄			
8.	HCl			
9.	H ₂ O			
10.	CO ₂			
11.	NH ₃			
12.	CH ₃ OH			
13.	CH ₃ Cl			
14.	Br ₂			

C Hydrogen bonding in water

2 marks

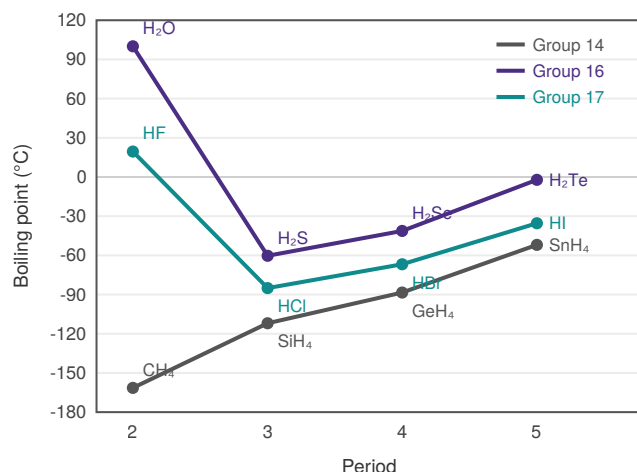


15. Which line, P or Q, is a hydrogen bond? Which is a covalent bond?

16. Write δ^+ or δ^- on the oxygen and hydrogen atoms of molecule 1. Explain your choice.

D Boiling point trends

4 marks



17. Why does boiling point increase from CH₄ to SnH₄?

18. Why are the group 14 hydrides the lowest on the graph?

19. H₂O and HF break the trend in their groups. Explain why.

20. Extend the H₂Te → H₂Se → H₂S trend back to period 2. Estimate the boiling point water would have without hydrogen bonding.

E Ranking boiling points

3 marks

21. Rank from lowest to highest boiling point and explain: CH₄, C₃H₈, C₂H₆

22. Rank from lowest to highest boiling point and explain: CH₃CH₂OH (ethanol), CH₃CH₂CH₃ (propane), CH₃OCH₃ (dimethyl ether)

23. Rank from lowest to highest boiling point and explain: I₂, F₂, Br₂, Cl₂

F IMFs in everyday life

2 marks

24. Explain why a steel paper clip can float on water (surface tension).

25. Explain why oil and water do not mix.

G Spot the mistake

2 marks

26. A student says: "When water boils, the O-H bonds in the molecules break." Explain the error and correct it.

27. A student says: "CH₄ forms hydrogen bonds because it contains hydrogen." Explain the error and correct it.

Intermolecular Forces

ANSWER KEY

Key ideas

Intermolecular forces (IMFs) act *between* molecules; intramolecular bonds hold atoms *inside* a molecule.

London dispersion (all molecules; stronger with more electrons) < **dipole-dipole** (polar molecules) < **hydrogen bonding** (H bonded to N, O or F).

Stronger IMFs → higher boiling point, higher melting point, higher surface tension, lower vapour pressure.

A Key terms

3 marks

Write the letter of the matching description (½ mark each).

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| 2. <u>b</u> Intermolecular force | b. A force of attraction between separate molecules |
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| 4. <u>e</u> Dipole-dipole force | d. A bond holding atoms together inside a molecule |
| 5. <u>a</u> Hydrogen bond | e. An attraction between the positive end of one polar molecule and the negative end of another |
| 6. <u>c</u> Polar molecule | f. A weak, temporary attraction from shifting electrons; found between all molecules |

B Which forces are present?

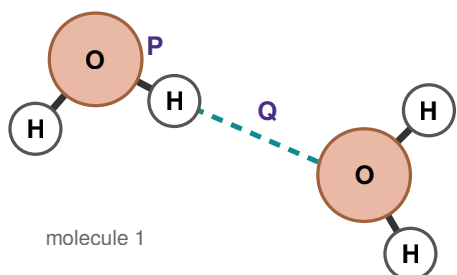
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Tick every force present between molecules of each substance (½ mark per row).

	Substance	London dispersion	Dipole-dipole	Hydrogen bonding
7.	CH ₄	✓		
8.	HCl	✓	✓	
9.	H ₂ O	✓	✓	✓
10.	CO ₂	✓		
11.	NH ₃	✓	✓	✓
12.	CH ₃ OH	✓	✓	✓
13.	CH ₃ Cl	✓	✓	
14.	Br ₂	✓		

C Hydrogen bonding in water

2 marks



15. Which line, P or Q, is a hydrogen bond? Which is a covalent bond?

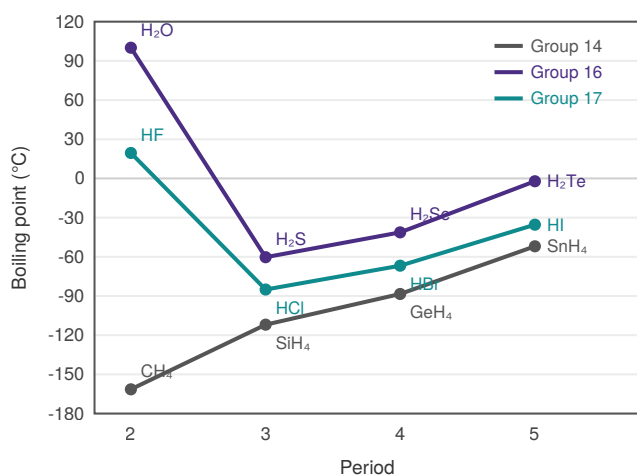
Q (dashed, between molecules) is a hydrogen bond; P is an O-H covalent bond inside molecule 1.

16. Write $\delta+$ or $\delta-$ on the oxygen and hydrogen atoms of molecule 1. Explain your choice.

O is $\delta-$ and each H is $\delta+$, because oxygen is more electronegative and pulls the shared electrons toward itself.

D Boiling point trends

4 marks



17. Why does boiling point increase from CH₄ to SnH₄?
Larger molecules have more electrons, so their London dispersion forces are stronger.

18. Why are the group 14 hydrides the lowest on the graph?

They are nonpolar, so they only have London dispersion forces.

19. H₂O and HF break the trend in their groups. Explain why.

They form hydrogen bonds (H bonded to highly electronegative O or F), which are much stronger than other IMFs.

20. Extend the H₂Te → H₂Se → H₂S trend back to period 2. Estimate the boiling point water would have without hydrogen bonding.

About -93 °C (accept -70 to -95 °C), instead of 100 °C

E Ranking boiling points

3 marks

21. Rank from lowest to highest boiling point and explain: CH₄, C₃H₈, C₂H₆

CH₄ < C₂H₆ < C₃H₈. Bigger molecules have more electrons and stronger London dispersion forces.

22. Rank from lowest to highest boiling point and explain: CH₃CH₂OH (ethanol), CH₃CH₂CH₃ (propane), CH₃OCH₃ (dimethyl ether)

propane < dimethyl ether < ethanol. Propane has only LDF; dimethyl ether is polar (dipole-dipole); ethanol has an O-H group and forms hydrogen bonds.

23. Rank from lowest to highest boiling point and explain: I₂, F₂, Br₂, Cl₂

F₂ < Cl₂ < Br₂ < I₂. All nonpolar; London dispersion forces increase with the number of electrons.

F IMFs in everyday life

2 marks

24. Explain why a steel paper clip can float on water (surface tension).

Hydrogen bonds pull surface water molecules tightly together, forming a "skin" strong enough to support the clip.

25. Explain why oil and water do not mix.

Water molecules attract each other strongly by hydrogen bonding; nonpolar oil can't form these attractions, so the two separate ("like dissolves like").

G Spot the mistake

2 marks

26. A student says: "When water boils, the O-H bonds in the molecules break." Explain the error and correct it.

Boiling only overcomes the intermolecular forces (hydrogen bonds) between molecules. The O-H covalent bonds stay intact; the gas is still H₂O.

27. A student says: "CH₄ forms hydrogen bonds because it contains hydrogen." Explain the error and correct it.

Hydrogen bonding needs H bonded to N, O or F. In CH₄ hydrogen is bonded to carbon, so it only has London dispersion forces.