1.1 Water: a molecular cause for a biological property

Name: _____ Class: _____ Date: _____ **Total: 10 marks**

KEY WORDS cohesion • adhesion

Objective

Water: a molecular cause for a biological property. Original classroom practice for IB HL; not an official IB paper.

1 Key knowledge and worked examples

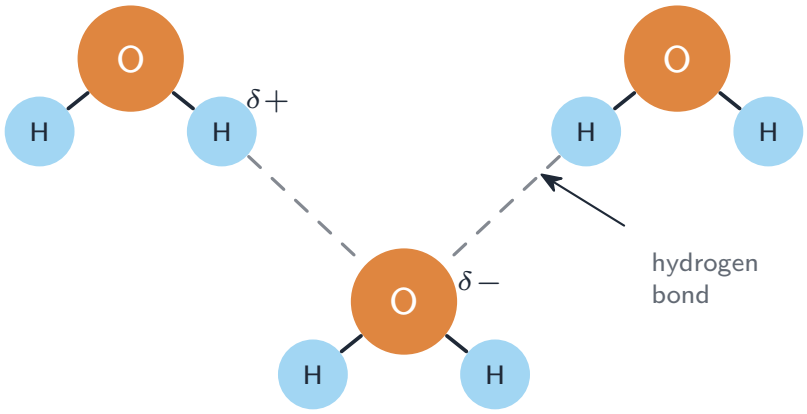
What would explain this observation?

- A water droplet holds together on a leaf. Its behaviour comes from interactions between molecules, not a skin made of solid water.

Build the model

- Water molecules are polar.
- Attraction between the partially positive hydrogen of one molecule and a partially negative oxygen of another gives hydrogen bonding.
- **Cohesion** is attraction between water molecules; **adhesion** is attraction to another surface.
- cohesion: Attraction between molecules of the same substance.
- adhesion: Attraction between different substances.

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Choose evidence that can test it

- The same intermolecular interactions help explain surface tension and the energy needed to change temperature.
- Heating changes molecular motion and interactions; it does not normally break the covalent O–H bonds.

In the lab: Compare equal drops on clean surfaces under fixed temperature. Measure contact angle or spreading consistently. A detergent changes the system, so record concentration rather than treating all liquids as equivalent.

Work from known quantities

- Known: 0.100 kg of water warms by 5.0 K; specific heat capacity is 4,180 J/(kg K).
- $Q = mc\Delta T = 0.100 \times 4{,}180 \times 5.0 = 2{,}090$ J.
- This calculation excludes energy absorbed by the container and lost to the surroundings.

Your turn: Use c = 4,180 J/(kg K). Calculate Q for 0.200 kg water heated through 5.0 K.

Check the conclusion and its limits

- Hydrogen bonds between molecules differ from covalent bonds within a water molecule.
- Polarity alone does not make every substance dissolve well in water.

Not true: Boiling water normally breaks its O–H covalent bonds. Boiling separates molecules from each other, overcoming intermolecular hydrogen bonds. The covalent O-H bonds inside each molecule survive - the steam is still H2O.

Key:

- Water molecules are polar.

- The same intermolecular interactions help explain surface tension and the energy needed to change temperature.
- Watch for: hydrogen bonds between molecules differ from covalent bonds within a water molecule.

■ Write from a heat transfer of 2508 J

- 0.200 kg of water is heated through 3.0 K. Use 4180 J per kilogram per kelvin.
- Find Q. Boiling separates molecules. It does not break the covalent O-H bonds.

2 Practice

2.1 What accounts for cohesion in liquid water? Choose one answer.

- **A** Intermolecular attractions including hydrogen bonding
- **B** Water having no molecular motion
- **C** Covalent bonds joining every molecule into one giant molecule [1]

2.2 Use c = 4,180 J/(kg K). Calculate Q for 0.200 kg water heated through 5.0 K. Show the relation, substitution and units. [2]

2.3 Decide whether this claim is true and justify: Boiling separates molecules from each other, overcoming intermolecular hydrogen bonds. [2]

2.4 Attraction between molecules of the same substance: write the technical term. [1]

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3 Exam-style questions

3.1 A fictional 0.200 kg water sample gains 4,180 J but the observed rise is 4.0 K. Compare with the no-loss prediction and identify what the discrepancy can and cannot show. [4]

Solutions

2.1 A Water molecules attract each other through hydrogen bonds between molecules, and that intermolecular attraction produces cohesion. The covalent O-H bonds sit INSIDE each molecule and are not what pulls molecules together.

2.2 $Q=mc\Delta T=(0.200\ \text{kg})\times(4{,}180\ \text{J/(kg K)})\times(5.0\ \text{K})=4{,}180\ \text{J}$.

2.3 True. True. Boiling separates molecules from each other, overcoming intermolecular hydrogen bonds. The covalent O-H bonds inside each molecule survive - the steam is still H2O.

2.4 cohesion. cohesion means Attraction between molecules of the same substance.

3.1 Ideal rise$Q/(mc)=5.0$ K. The observed rise is lower; container heating or loss can explain it. It does not prove which contribution dominates without measurements.

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