# 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.

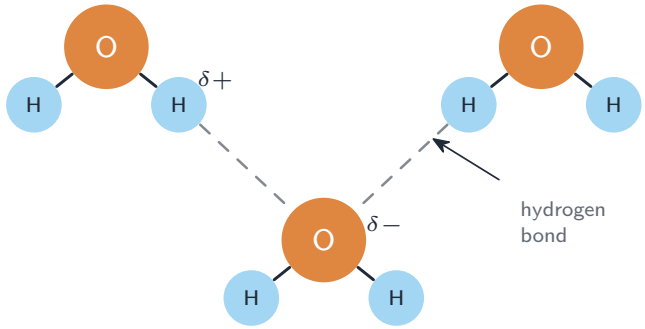
## 1 Key knowledge and worked examples

### 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.




### 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]

## 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 kg)$\times$(4,180 J/(kg K))$\times$(5.0 K)=4,180 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 riseQ/(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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