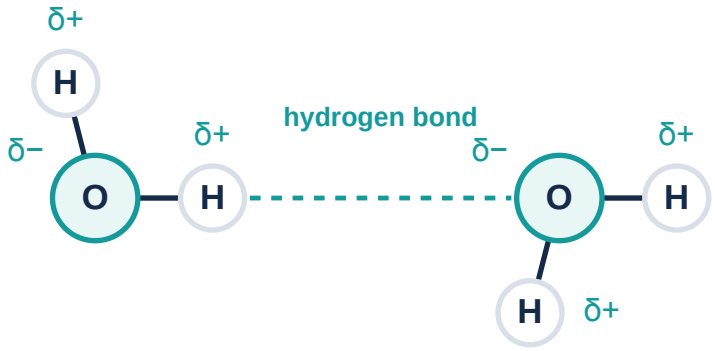
Uneven charge, useful attractions

Water is polar: its electrons are shared unequally. Oxygen attracts the shared electrons more strongly than hydrogen, so oxygen is partially negative and hydrogen is partially positive.

HYDROGEN BONDING BETWEEN TWO MOLECULES



Solid lines: O-H covalent bonds within each molecule.

Dashed line: attraction from Hδ+ to Oδ− on another molecule.

1. PARTIAL CHARGES ARE NOT FULL ION CHARGES

The symbol δ means partial. A water molecule is electrically neutral overall: it is not an oxygen ion joined to two hydrogen ions. Its bent shape means the bond polarities do not cancel.

2. MANY WEAK ATTRACTIONS HAVE A LARGE EFFECT

A hydrogen bond is weaker than an O-H covalent bond. In liquid water, hydrogen bonds continually break and reform. Together, these attractions strongly influence how water responds to energy and other substances.

This syllabus point focuses on solvent action and two thermal properties. Evaporation separates H_2O molecules; it does not split them into hydrogen and oxygen.

Supporting reading: OpenStax Biology 2e, section 2.2: Water.

Scope: Cambridge Biology 9700 syllabus, section 2.4, outcome 1, p. 19.

A medium for reactions and transport

A solvent dissolves a solute to form a solution. Water dissolves many ionic and polar substances, letting dissolved particles move, react and travel through living systems.

WHICH PART OF WATER FACES AN ION?



Water molecules surround ions in hydration shells. The attractions here are ion-dipole interactions. Water can also hydrogen-bond with suitable polar groups, such as the OH groups of glucose.

1. DISSOLVED PARTICLES CAN BE TRANSPORTED

Blood plasma carries dissolved glucose, amino acids and ions. In plants, xylem carries water with dissolved mineral ions. A moving aqueous solution can carry solutes without each solute needing its own transport vessel.

2. DISSOLVED REACTANTS CAN MEET

The aqueous cytoplasm is a medium for many metabolic reactions. Dissolved molecules and ions can move and encounter one another or an enzyme. Water is not itself a catalyst for every reaction occurring in it.

Water does not dissolve everything. Non-polar substances, such as oils, have low solubility. Dissolving glucose leaves its molecules intact; it does not hydrolyse their covalent bonds.

Supporting reading: USGS Water Science School: Water as a solvent.

Scope: Cambridge Biology 9700 syllabus, section 2.4, outcome 1, p. 19.

Two different ways to handle heat

Do not confuse warming liquid water with changing liquid water into vapour. Both involve energy, but the property and biological consequence are different.

HIGH SPECIFIC HEAT CAPACITY

A large energy input per unit mass is needed to raise water's temperature by 1°C. Energy changes the hydrogen-bond network as well as molecular motion, so a given heat input produces a relatively small temperature rise.

↓ Biological role: water-rich organisms and aquatic habitats resist rapid temperature fluctuations, helping maintain suitable conditions for cells and enzymes.

Definition: energy per kilogram per degree of temperature rise. Water is still liquid; no phase change is required.

HIGH LATENT HEAT OF VAPORISATION

A large energy input per unit mass is needed to turn liquid water into vapour. Escaping molecules must overcome attractions to neighbouring molecules. That energy can come from the surface and its surroundings.

↓ Biological role: evaporation of sweat removes heat from skin. Evaporation from moist leaf cell walls can also cool leaves as water vapour diffuses out.

Definition: energy per kilogram for the liquid-to-gas change at a given temperature. Evaporation can occur below boiling point; sweat must evaporate to provide this cooling.

Remember: high specific heat capacity buffers temperature change; high latent heat of vaporisation makes evaporation an effective way to remove heat.

Supporting reading: OpenStax Biology 2e, section 2.2: Water.

Scope: Cambridge Biology 9700 syllabus, section 2.4, outcome 1, p. 19.