

Question 1 1996

1. The unique properties (characteristics) of water make life possible on Earth. Select three properties of water and:  
 a) for each property, identify and define the property and explain it in terms of the physical/chemical nature of water.  
 b) for each property, describe one example of how the property affects the functioning of living organisms.

Identification [1 pt]	Definition [2 pts]	Elaboration	Example [1 pt]
polarity	unequal charge distribution	electronegativity, tetrahedron, $H^{\delta+}$ , $O^{\delta-}$ , unequal sharing	various
hydrogen bonding	weak, intermolecular, transient, electrostatic attraction	attraction between $H^{\delta+}$ and $O^{\delta-}$	various
cohesion	attraction of water molecules for each other	H-bonding explained	transpiration, surface tension, e.g., water striders
surface tension	resistance to being stretched	H-bonding explained	water walking; water held by soil particles
adhesion	attraction of water molecules for other molecules	H-bonding explained	capillarity, transpiration
high specific heat	absorbs 1 cal/g°C (or K)	water $\Delta$ temp slowly, absorbs heat, heat buffering, many H-bonds; high boiling point	moderates temperature effects on organisms (circadian/seasonal) and environmental temperature
high heat of vaporization	energy reqd for liquid $\rightarrow$ gas: 540 cal/g°C	breaking H-bonds; good coolant; high boiling point	sweating, evaporation from body surfaces results in cooling; water cycles/rain; transpiration
versatile solvent	dissolves many compounds	dissolves by ionization; ionization shells; spheres of hydration	any valid biological example, e.g., salts, minerals, gases, bioorganics, etc.; acid rain effects; hydrophobic/hydrophilic
unusual phase change characteristics	solid $\rightarrow$ liquid $\rightarrow$ gas at same temperature	ice floats (less dense); change in crystal lattice; water molecules farther apart; more H-bonds/molecule; 4°C most dense	thermal mixing; nutrient upwelling; insulation of ice layer on ponds/ocean; snow effects on organisms
dissociation/ionization	$2H_2O \leftrightarrow H_3O^+ + OH^-$ $H_2O \leftrightarrow H^+ + OH^-$	pH scale based on $H_2O$ $H_2O$ pH = 7.0 (neutral)	buffers work; specific cellular or organismal example; metabolic water; e <sup>-</sup> source in photosynthesis; hydrolysis rxns

**Less Commonly Cited Properties**

<b>Identification (1 pt)</b>	<b>Definition</b>	<b>[2 pts]</b>	<b>Elaboration</b>	<b>Example (1 pt)</b>
incompressibility	resists changes in volume due to pressure		H-bond influence	hydrostatic skeleton; amniotic fluid; CSF; blood pressure sound conduction; turgor
viscosity	resistance to flow			fish swimming; aquatic propulsion
poor conductivity	ability to allow e <sup>-</sup> flow		requires conducting solutes	electric fish, eel
heat of fusion	80 cal/g°C			
size	3 atoms; diagram of water molecule		rapid diffusion (osmosis)	various; imbibition; turgor, osmoregulation; contractile vacuole
chemically stable (good place for reactions)				
light penetration				
<b>Other Properties (Ablotic)</b>		.....melting point	heat of fusion	specific gravity

**Question Overview**

**A. Standards /criteria for judging students responses**

Question 1 was composed of two parts... Part a asked for the student to identify, define and explain (in terms of the physical/chemical nature of water) three properties of water. Part b asked the student to describe one example of how the selected property affects the functioning of living organisms. For convenience of grading the question was divided into four parts; **identification, definition, elaboration, and example**, and each part was awarded 1 point. (3 properties x 4 parts x 1 pt each = 12 possible ways to achieve a score of 10).