Solutions to Short Answer Questions – Water Energy & Phase Changes

**1.**

**a.** *Energy required to raise the temperature of 1 kg of a substance by 1 °C.*
*1-----mark Water has a specific heat capacity of 4.18 kJ/kg·°C. Heating 1 kg of water by 1 °C requires 4.18 kJ*
*1-----mark*.

**b.** *The energy required to convert 1 kg of liquid water into gas at 100 °C without a change in temperature. 1-----mark*

*Data Booklet gives the latent heat of vaporization at 100°C as 40.7kJ/mol*
*Water has a latent heat of vaporisation of 2261 kJ $kg^{-1}$.*
*This means 2261 kJ of energy is required to vaporise 1 kg of water at 100 °C.*
*Or*
*2.26kJ $g^{-}$*
*1----mark for either answer.*

**2.** *Energy is used to break hydrogen bonds between water molecules rather than increasing kinetic energy. 1-----mark*

*Temperature remains constant until all ice melts 1-----mark*

**3.** *Step 1: Heat the ice to 0 °C*

$$Q = mc\Delta T$$

*Values (from Data Booklet):*

*Q = 0.100 kg x 2.1 KJ $Kg^{-}$ X 25 = 5.3 kJ* 1-----mark

*Step 2 : Liquefy the 0.100kg of $H_2O$*

*$Q = mL_f$ = 0.100kg X 344 kJ/Kg =34.4 kJ* 1-----mark

*Total energy needed (kJ) = 40 kJ* 1-----mark

$$Q_{total} = Q_1 + Q_2 = 5.25 + 33.4 = \boxed{38.65\ kJ}$$

**4.** *$Q = mc\Delta T$* *1-----mark for correct formula*

*$= 0.050 \times 4.18 \times 10 = 2.09$ kJ* *1-----mark for correct calculation*

*1-----mark for correct sig figs.*

**5.** *Transpose the following formula to make mass the subject.*

*=> $Q = m \times c \times \Delta T$* *1-----mark correct formula*

*=> 1200 /(4.18 X 50.0)* *1-----mark correct value*

**6.** *Q =0.100 X 4.18 X 90 = 37.62 kJ* *1-----mark for correct amount of energy to change the temperature to 100°C*

*Q = 40.7 kJ /0.018 kg* *1-----mark for correct conversion of latent heat of vaporisation from 40.7 kJ/mol to 2.26kJ/kg*

*Q = 0.100 kg X 2260 kJ/kg =226kJ* *1-----mark for correct amount of energy needed to vaporize 100g of water.*

*Total amount of energy, in kJ, needed*

*=> 37.6 + 226 = 264* *1-----mark*

**7.** *Strong intermolecular boning composed of hydrogen bonds, present in water require greater energy to overcome. 1-----mark (mention of intermolecular forces must be made)*

*Molecules of similar size without hydrogen bonds need less energy to increase temperature. 1-----mark*

**8.** *Energy is used to break intermolecular bonds 1-----mark*

*rather than increase kinetic energy. Temperature stays constant until all liquid vaporises. 1-----mark*

**9.** *$Q = 10.0\ g \times 4.18\ kJ/kg \times \Delta T$*

*=> $\Delta T = 0.400\ kJ / (0.0100 \times 4.18)$* *1-----mark for correct formula*

=> *$\Delta T = 9.57$* *1-----mark for correct change in temp*

*=> Final temp = initial + $\Delta T$*

*=> $25.0 + 9.6 = 34.6\ ^\circ C$* *1-----mark correct final answer.*

**10.** *Parts A (solid heating), C (liquid heating) and E (gas heating)* *1-----mark*

*A, B and E represent temperature change of a single phase. Addition of heat energy is converted to a greater kinetic energy of the particles.* *1----mark*

*The increase in kinetic energy shows up as a temperature increase and the relationship between temperature and energy is given by the formula $Q = m \times C \times \Delta T$*
*1-----mark (to get the mark the student must have described the formula as the relationships between energy and temperature rise)*

**11.** *The formula $Q = m\ X\ L$ applies to the flat (horizontal) sections of the phase-change curve, where temperature remains constant namely sections B (melting) and D (fusion)*
*1-----mark.*

*During these phases, energy is used to overcome intermolecular forces (break hydrogen bonds or other attractions) rather than increasing kinetic energy, which would lead to a temperature increase.* *1-----mark*

**12.**
*Water has a high specific heat capacity (4.18 J/g·°C), it absorbs or releases large amounts of energy with only small changes in temperature.* *1----mark*

*Melbourne is near the ocean, so the surrounding water absorbs heat during the day and releases heat at night, moderating air temperatures.* *1----mark*

*Alice Springs is inland, far from large bodies of water, so there is no moderating effect, and temperatures change more drastically.* *1----mark*

*Hydrogen bonds are stronger than dipole-dipole and dispersion forces, so water absorbs more energy to increase temperature or vaporise. This absorbed energy buffers temperature changes, moderating coastal climates.* *1----mark (to get this mark some distinction must be made between h-bonding and other forms eg dipole-dipole in the capacity of water to absorb a large amount of energy before an increase in temperature).*

**13.** *Hydrogen bonding is a particularly strong form of intermolecular bonding, which increases the energy required to change temperature (specific heat) and to vaporize water (latent heat). 1-----mark*

*High specific heat stabilizes aquatic temperatures, preventing sudden changes 1-----mark*

*High latent heat makes it harder for water to evaporate and dry out inland aquatica ecosystems. 1-----mark*

*Stable environment allows survival of aquatic life by reducing the damage from sudden temperature changes that may reduce the amount of available oxygen in the water as well as do structural damage to the organism through heat stress. 1----mark (any other plausible temperature dependent stress or harm can be awarded the mark.)*