Year 11 Progress Check

Heat 2

Data

- Unless otherwise specified use the following values
- Specific heat capacity of aluminium = 910 J kg^{-1} K^{-1}.
- Specific heat capacity of water = 4200 J kg^{-1} K^{-1}
- Specific latent heat of fusion of ice = 335 000 J kg^{-1}
- Specific latent heat of evaporation of water 2.26 MJ kg^{-1}

Q1

- 12.9g of an unknown metal at 26.5°C is placed in a foam cup containing 50.0 grams of water at 88.6°C. The water cools down and the metal warms up until thermal equilibrium is achieved at 87.1°C. Assuming all the heat lost by the water is gained by the metal and that the cup is perfectly insulated, determine the specific heat capacity of the unknown metal. The specific heat capacity of water is 4.18 J/g/°C.

Q1

Q lost by water

Given

$m = 50 g$

$c = 4.18 \ J/g/°C$

$T_i = 88.6°C$

$T_F = 87.1°C$

$\Delta T = -1.5°C$

Solve for Q_{water}

$Q_W = m c \Delta T$

$= (50g)(4.18)(1.5°C)$

$= -313.5 \ J$

Value of C_{metal}

Given

$Q_m = 313.5 \ J$

$m = 12.9g$

$T_i = 88.6°C$

$T_F = 87.1°C$

Solve for C_{metal}

Rearrange

$Q_m = m_m \cdot C_m \cdot \Delta T_m$ to obtain

$C_m = Q_m / (m_m \cdot \Delta T_m)$

$= (313.5) / (12.9g \cdot 60.6°C)$

$= 0.40103 \ J/g/°C$

Q2

- Ruby places 48.2 grams of ice in her drink of water. What quantity of energy would be absorbed by the ice (and released by the water) during the melting process? The heat of fusion of water is 333 J/g.

$Q = m \cdot q_{fusion}$

$= (48.2\,g)(333\,J/g)$

$= 16050.6\,J$

Q3

- What is the minimum mass of liquid water at 26.5 degrees that would be required to completely melt 50.0 grams of ice? The specific heat capacity of liquid water is 4.18 J/g/°C and the specific heat of fusion of ice is 333 J/g.

Given: $m = 5\phi g$

Ice: $\Delta Q_{fussion} = 333\ J/g$

Water: $C = 4.18\ J/g/°C$

$T_i = 26.5°C$

$T_f = \phi.\phi\ °C$

$\Delta T = -26.5°C$

$Q_{ice} = Q_{water}$

$\therefore Q_{ice} = m\Delta Q_{fussion}$

$= (5\phi g)(333\ J/g)$

$= 1665\phi\ J$

$16650\ J = -Q_{water}$

$= (-m_{water})(C_{water})(\Delta T_{water})$

$= (-m_{water})(4.18\ J/g/°C)(-26.5°C)$

$= (-m_{water})(-11\phi.77\ J/°C)$

$m_{water} = (-1665\phi\ J)/(-11\phi.77\ J/°C)$

$= 15\phi.311\ g$

Q4

- An 11.98-gram sample of Zn metal is placed in a hot water bath and warmed to 78.4°C. It is then removed and placed into a foam cup containing 50.0 mL of room temperature water (T=27.0°C; density = 1.00 g/mL). The water warms to a temperature of 28.1°C. Determine the specific heat capacity of the Zn.

$Q_{water} = (m)(C_{water})(\Delta T)$

$= (50 g)(4.18 J/g/°C)(28.1°C - 27°C)$

$= 229.9 J \longrightarrow = -Q_{metal}$

SHC of metal $\therefore = -229.9 J = m C \Delta T$

$C = -229.9 J/(11.98 g)/(28.1°C - 78.4°C$

$= 0.382 J/g/°C$

Q5

- Josh grabs a can of cola from the cupboard and pours it over ice in a cup. Determine the amount of heat lost by the room temperature cola as it melts 61.9 g of ice (ΔH_{fusion} = 333 J/g).

$Q = m \Delta Q_{fusion}$

$= (61.9 g)(333 J/g)$

$= 20.6 kJ$

Q6

- The specific latent heat of fusion (melting) of ice is 330,000 J kg^{-1}. What is the energy needed to melt 0.65 kg of ice?

$\Delta Q = ml$

$= (0.65\ kg)(330\ 000\ J/kg$

$= 210\ 000\ J$

Q7

- Compare the energy needed to raise the temperature of 1kg of water from 20°C to 100°C and the energy needed to boil 1 kg of water at 100°C.

Energy to heat water

$= mc\Delta T$

$= 1 \times 4200 \times 80$

$= 336kJ$

Energy to boil water

$= mL = 1 \times 2260 kJ$

$= 2260 kJ$

7x's as much energy to boil water as to heat it up.

Q8

- 5kg block of Fe is heated to 800°C. It is placed in a tub containing 2 litre of water at 15°C. Assuming all the water is brought to the boil rapidly; calculate the mass of water which boils off.

- Energy given up by iron in cooling to 100°C

$= mC\Delta T$

$= 5 \times 700 \times 220$

$= 770 \text{ kJ}$

To heat 2 l of water from 15°C to 100°C requires $2 \times 4200 \times (100 - 15)$

$= 714 \text{ kJ}$

This leaves $770 - 714$

$= 56 \text{ kJ}$ to boil some of the water

Mass of water boiled away

$= 56/2260$ ← SLH of evaporation

$= 0.025 \text{ kg}$

Q9

- Sunlight of intensity 0.6 kW m^{-2} falls on a patch of ice. Assuming the ice absorbs 20% of the light; calculate what thickness of ice would melt in 1 minute. (Assume any water produced runs off).

1 minute $(600 \times 60 \times 0.20) = 7200$ J absorbed per 1 m^2

Let ice have area A m^2

Thickness of ice = depth = (A m^2 depth) ⟹ volume ∴ A m^2

Melted if mass × latent heat of fusion =

Mass of volume A depth = (density)(A)(depth) = 917 A d

$\therefore 7200 A = 917 A d \times 334000_{LHf}$

$t = \frac{7200}{917} = t \times 334000 = 2.35 \times 10^{-5}$ m

Q10

- How much heat energy is needed to heat 4 kg of aluminium by 8 ^{o}C?
- Specific heat capacity of aluminium = 910 J kg^{-1} K^{-1}.

$$Energy = mC\Delta T$$
$$= 4 \times 1200 \times 8$$
$$= 38400 \text{ J}$$

Q11

- If 48 000 J of heat energy are given off when a 2 kg block of metal cools by 12 °C, what is the specific heat capacity of the metal?

SHC = Q/(mΔT)
= 48000/(2×12)
= 2000 J/kg/°C