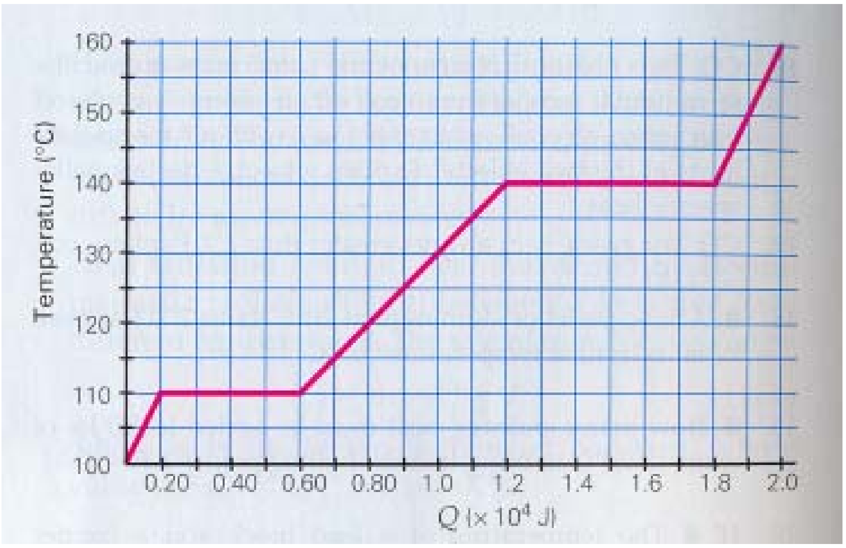
**Physics 151 Class Exercise: Calorimetry II**

1. A kilogram of a substance gives a T-versus-Q Graph as shown below.

(a) What are the melting and boiling points?

(b) What are the specific heats of the substance during its various phases ?

(c) What are the latent heats of the substance at the various phase changes?




Melting Point = 110ºC

Boiling Point = 140ºC

Specific Heat as Solid = $c = \frac{Q}{m\Delta T} = \frac{(0.1\times10^{4}J)}{(1kg)(10°C)} = 100\frac{J}{kg-°C}$

Specific Heat as Liquid = $c = \frac{Q}{m\Delta T} = \frac{(0.6\times10^{4}J)}{(1kg)(30°C)} = 200\frac{J}{kg-°C}$

Specific Heat as Gas = $c = \frac{Q}{m\Delta T} = \frac{(0.2\times10^{4}J)}{(1kg)(20°C)} = 100\frac{J}{kg-°C}$

Latent Heat of Fusion = $L_f = \frac{Q}{m} = \frac{(0.4\times10^{4}J)}{(1kg)} = 4000\frac{J}{kg}$

Latent Heat of Vaporization = $L_v = \frac{Q}{m} = \frac{(0.6\times10^{4}J)}{(1kg)} = 6000\frac{J}{kg}$

2. A 155-g aluminum cylinder is removed from a liquid nitrogen bath, where it has been cooled to $-196\ °C$. The cylinder is immediately placed in an insulated cup containing 80.0 g of water at 15.0 °C. What is the equilibrium temperature of this system? If your answer is 0 °C, determine the amount of water that has frozen. The average specific heat of aluminum over this temperature range is $653\ J/(kg \bullet K)$.

Assume that $T_f = 0$.

$$\begin{aligned} Q_{A1} &= \text{heat gained by aluminum} \\ &= m_{Al} c_{Al} \left( T_f - T_{Al,i} \right) \\ &= (0.155\ \text{kg}) \left( 653\ \frac{\text{J}}{\text{kg} \cdot \text{C°}} \right) [0\ °\text{C} - (-196\ °\text{C})] \\ &= 19{,}838\ \text{J} \end{aligned}$$

$$\begin{aligned} Q_{wb} &= \text{heat lost by water before it freezes} \\ &= m_w c_w \Delta T \\ &= (0.0800\ \text{kg}) \left( 4186\ \frac{\text{J}}{\text{kg} \cdot \text{C°}} \right) (15.0\ °\text{C}) \\ &= 5023\ \text{J} \end{aligned}$$

Since $Q_{Al} > Q_{wb}$, we know that $T_f \le 0°C$.

$Q_F$ = heat lost by 0 °C water during freezing = $m_w L_f = (0.0800\ \text{kg})(33.5 \times 10^4\ \text{J}) = 26{,}800\ \text{J}$

Since $Q_{Al} < Q_{wb} + Q_{wf}$, not all of the water freezes, so $T_f = \boxed{0°C}$.

Let $m_f$ = the mass of water that freezes.

$$\begin{aligned} Q_{Al} &= Q_{wb} + m_f L_f \\ m_f &= \frac{Q_{Al} - Q_{wb}}{L_f} \\ &= \frac{19{,}838\ \text{J} - 5023\ \text{J}}{33.5 \times 10^4\ \frac{\text{J}}{\text{kg}}} \\ &= \boxed{44.2\ \text{g}} \end{aligned}$$