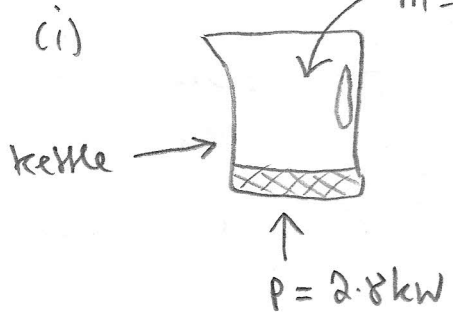


# SPECIFIC HEAT CAPACITY, LATENT HEAT & NEWTON'S LAW OF COOLING

Q1 (i)  $m = 1.23 \text{ kg}$  of water at  $T_0 = 18^\circ\text{C}$



$$\Delta E = cm\Delta T$$

$$\Delta E = Pt$$

$$\Delta T = 100^\circ\text{C} - 18^\circ\text{C}$$

$$= \boxed{82^\circ\text{C}} = 82 \text{ K}$$

$$c = 4.187 \text{ kJ/kg/K}$$

$$\therefore t = \frac{cm\Delta T}{P} = \frac{4.187 \text{ kJ/kg/K} \times 1.23 \text{ kg} \times 82 \text{ K}}{2.8 \text{ kJ/s}}$$

$$= \boxed{151 \text{ s}} \quad (2 \text{ minutes, } 31 \text{ seconds})$$

$$\text{or } \approx 2\frac{1}{2} \text{ minutes.}$$

(ii) let  $(1.23 - 0.20) \text{ kg}$  of water be vaporized.

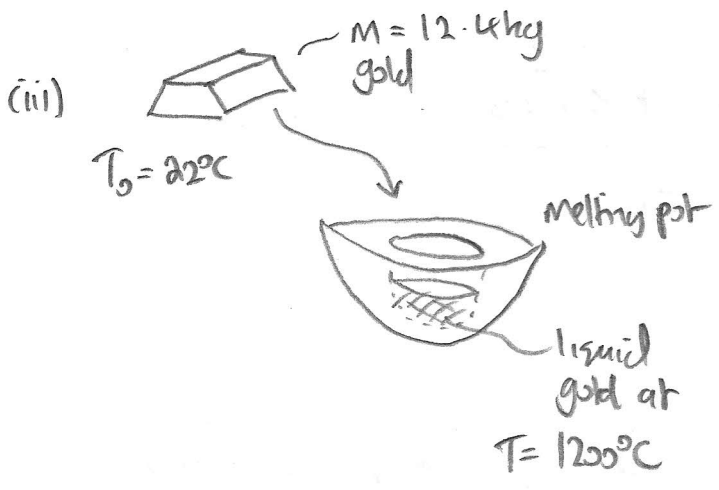
$$\therefore Pt = \Delta m L_{\text{vap}}$$

$$\therefore t = \frac{\Delta m L_{\text{vap}}}{P}$$

$$t = \frac{1.03 \text{ kg} \times 2260 \text{ kJ/kg}}{2.8 \text{ kJ/s}}$$

$$t = 231 \text{ s}$$

$$= \boxed{13 \text{ minutes, } 51 \text{ seconds}}$$



$$\Delta E = c_s m (T_{\text{melt}} - T_0) + mL_{\text{fus}} + c_L m (T - T_{\text{melt}})$$

$$= 0.129 \times 12.4 \times (1063 - 22)$$

$$+ 12.4 \times 62.8$$

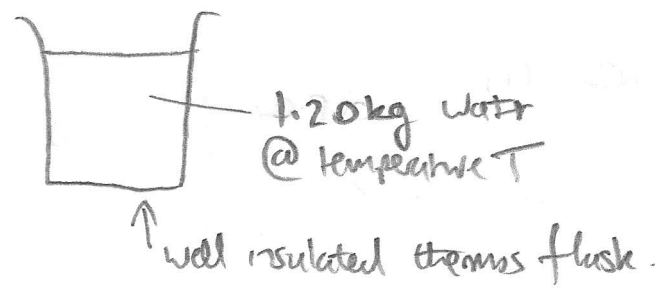
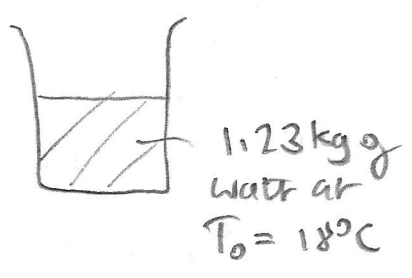
$$+ 0.115 \times 12.4 \times (1200 - 1063) \quad (\text{kJ})$$

$$= 1665.2 + 778.7 + 254.8 \quad (\text{kJ})$$

$$= \boxed{2699 \text{ kJ}}$$

(iv)

0.200 kg of ice



Energy balance: 
$$m_{ice} L_{fus} + c_L m_{ice} T = c_L m_w (T_0 - T)$$

energy gain by ice
energy loss from water

$$T (c_L m_{ice} + c_L m_w) = c_L m_w T_0 - m_{ice} L_{fus}$$

$$T = \frac{c_L m_w T_0 - m_{ice} L_{fus}}{c_L m_{ice} + c_L m_w}$$

$$T = \frac{T_0 - \frac{m_{ice} L_{fus}}{c_L m_w}}{\frac{m_{ice}}{m_w} + 1} \quad (*)$$

$$T = \frac{18 - \frac{0.200 \times 335}{4.187 \times 1.23}}{\frac{0.200}{1.23} + 1}$$

$$T = 4.29^\circ\text{C}$$

Now in order to melt all the ice by cooling the water, it is assume the remaining water must be liquid, i.e.  $T > 0^\circ\text{C}$

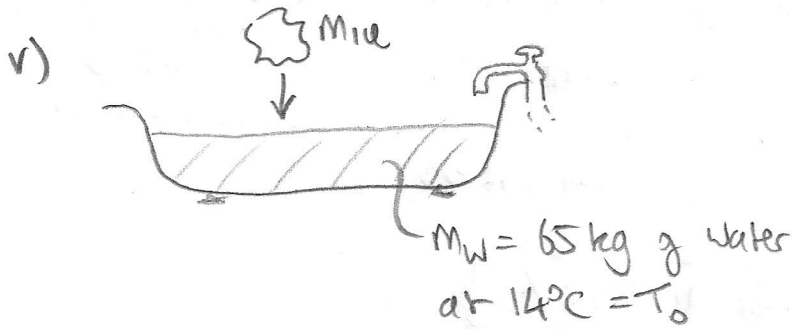
From (\*)  $\Rightarrow T_0 > \frac{m_{ice} L_{fus}}{c_L m_w} \Rightarrow m_w > \frac{m_{ice} L_{fus}}{c_L T_0}$

(2)

So the minimum mass of water is  $\frac{0.200 \times 335}{4.187 \times 18}$  kg

$$= \boxed{0.889 \text{ kg}}$$

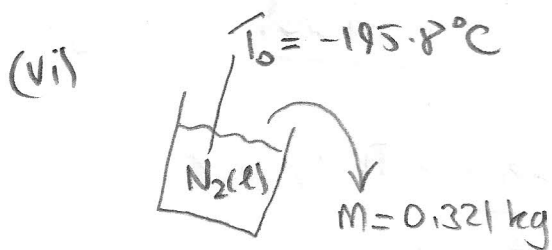
If less water is used, then we assume not all the ice will be melted. There will be a mixture of ice and water (at  $0^\circ\text{C}$ ), if maintained isolated from the surroundings.



let final  $T$  be  $6^\circ\text{C}$ .

Energy transfer:  $M_{ice} L_{fus} + c_L M_{ice} T = c_L M_w (T_0 - T)$

$$\therefore M_{ice} = \frac{c_L M_w (T_0 - T)}{L_{fus} + c_L T} = \frac{4.187 \times 65 \times (14 - 6)}{335 + 4.187 \times 6} = \boxed{6.05 \text{ kg}}$$



$$T_a = 25^\circ\text{C}$$

$$\begin{aligned} \Delta E_{\text{vap}} &= m L_{\text{vap}} \\ &= 0.321 \times 200 \quad (\text{kJ}) \\ &= \boxed{64.2 \text{ kJ}} \end{aligned}$$

$$\begin{aligned} \Delta E_g &= m c_g (T_a - T_0) \\ &= 0.321 \times 1.040 \times (25 - -195.8) \\ &= \boxed{73.7 \text{ kJ}} \end{aligned}$$

So  $\Delta E_g$  is only 15% larger than  $\Delta E_{\text{vap}}$ .

