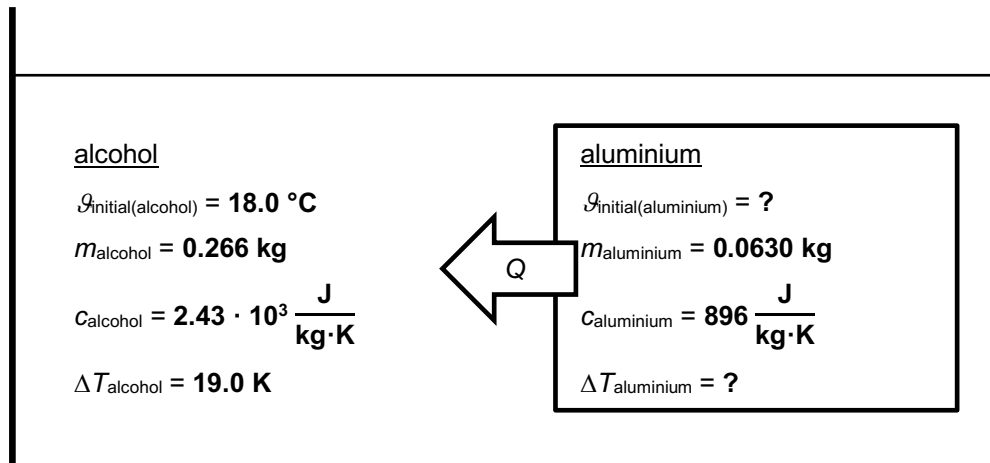


1. a) and b)



$$\vartheta_{\text{equilibrium}} = \vartheta_{\text{final(alcohol)}} = \vartheta_{\text{final(aluminium)}} = 37.0 \text{ }^\circ\text{C}$$

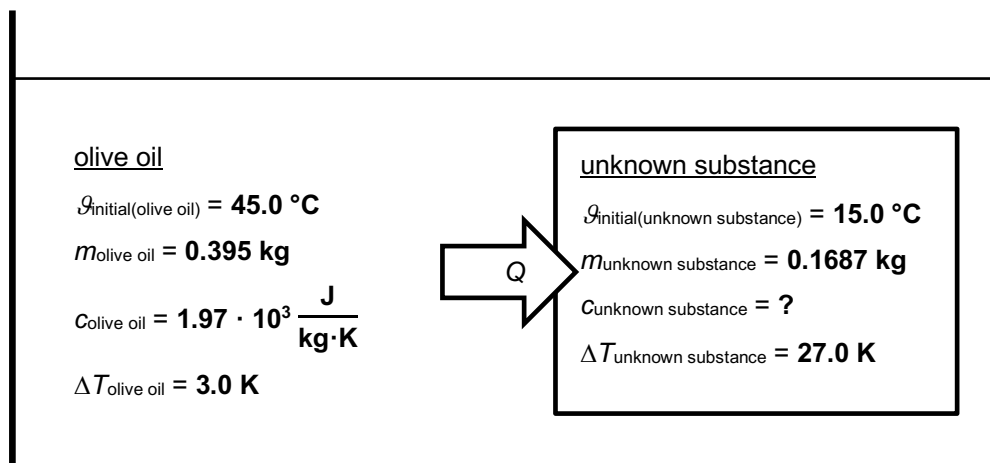
$$\text{c) } \Delta U_{\text{alcohol}} = c_{\text{alcohol}} \cdot m_{\text{alcohol}} \cdot \Delta T_{\text{alcohol}} = 2.43 \cdot 10^3 \frac{\text{J}}{\text{kg}\cdot\text{K}} \cdot 0.266 \text{ kg} \cdot 19.0 \text{ K} = 12'281 \text{ J} = \underline{12.3 \text{ kJ}}$$

$$\text{d) } \Delta U_{\text{aluminium}} = \Delta U_{\text{alcohol}} = \underline{12.3 \text{ kJ}}$$

$$\text{e) } \Delta T_{\text{aluminium}} = \frac{\Delta U_{\text{aluminium}}}{c_{\text{aluminium}} \cdot m_{\text{aluminium}}} = \frac{12'281 \text{ J}}{896 \frac{\text{J}}{\text{kg}\cdot\text{K}} \cdot 0.0630 \text{ kg}} = 218 \text{ K}$$

$$\vartheta_{\text{initial(aluminium)}} = \vartheta_{\text{final(aluminium)}} + \Delta T_{\text{aluminium}} = 37 \text{ }^\circ\text{C} + 217 \text{ K} = \underline{255 \text{ }^\circ\text{C}}$$

2. a) and b)



$$\vartheta_{\text{equilibrium}} = \vartheta_{\text{final(alcohol)}} = \vartheta_{\text{final(aluminium)}} = 42.0 \text{ }^\circ\text{C}$$

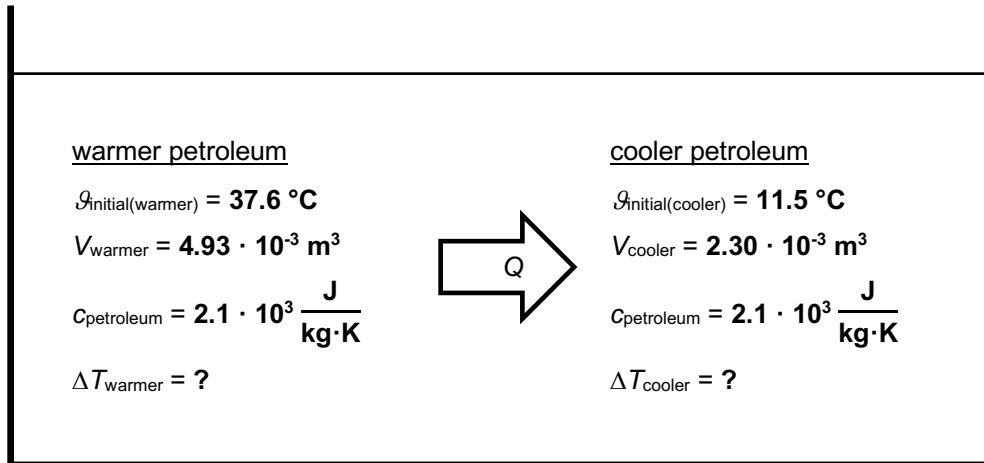
$$\text{c) } Q = \Delta U_{\text{unknown substance}} = \Delta U_{\text{olive oil}}$$

$$c_{\text{unknown substance}} \cdot m_{\text{unknown substance}} \cdot \Delta T_{\text{unknown substance}} = c_{\text{olive oil}} \cdot m_{\text{olive oil}} \cdot \Delta T_{\text{olive oil}}$$

$$c_{\text{unknown substance}} = \frac{c_{\text{olive oil}} \cdot m_{\text{olive oil}} \cdot \Delta T_{\text{olive oil}}}{m_{\text{unknown substance}} \cdot \Delta T_{\text{unknown substance}}} = \frac{1.97 \cdot 10^3 \frac{\text{J}}{\text{kg}\cdot\text{K}} \cdot 0.395 \text{ kg} \cdot 3.00 \text{ K}}{0.192 \text{ kg} \cdot 27.0 \text{ K}}$$

$$= \underline{450 \frac{\text{J}}{\text{kg}\cdot\text{K}}} \quad (\text{iron})$$

3. a)



$$\vartheta_{\text{equilibrium}} = \vartheta_{\text{final(petroleum)}} = ?$$

b) Heat flows from the warmer petroleum (V_{warmer} , $\vartheta_{\text{warmer}}$) to the cooler petroleum (V_{cooler} , $\vartheta_{\text{cooler}}$). After a while, at equilibrium, the temperature is ϑ_{final} . The transferred heat is:

$$\Delta U_{\text{warmer}} = c_{\text{petroleum}} \cdot m_{\text{warmer}} \cdot \Delta T_{\text{warmer}} = Q = \Delta U_{\text{cooler}} = c_{\text{petroleum}} \cdot m_{\text{cooler}} \cdot \Delta T_{\text{cooler}}$$

$$\text{while } m_{\text{warmer}} = \rho_{\text{petroleum}} \cdot V_{\text{warmer}} \text{ and } m_{\text{cooler}} = \rho_{\text{petroleum}} \cdot V_{\text{cooler}}$$

$$\text{and } \Delta T_{\text{warmer}} = \vartheta_{\text{initial(warmer)}} - \vartheta_{\text{final}} \text{ and } \Delta T_{\text{cooler}} = \vartheta_{\text{final}} - \vartheta_{\text{initial(cooler)}}$$

substituting m_{warmer} and m_{cooler} yields:

$$c_{\text{petroleum}} \cdot \rho_{\text{petroleum}} \cdot V_{\text{warmer}} \cdot \Delta T_{\text{warmer}} = c_{\text{petroleum}} \cdot \rho_{\text{petroleum}} \cdot V_{\text{cooler}} \cdot \Delta T_{\text{cooler}}$$

$$V_{\text{warmer}} \cdot \Delta T_{\text{warmer}} = V_{\text{cooler}} \cdot \Delta T_{\text{cooler}}$$

substituting ΔT_{warmer} and ΔT_{cooler} yields:

$$V_{\text{warmer}} \cdot (\vartheta_{\text{initial(warmer)}} - \vartheta_{\text{final}}) = V_{\text{cooler}} \cdot (\vartheta_{\text{final}} - \vartheta_{\text{initial(cooler)})}$$

$$V_{\text{warmer}} \cdot \vartheta_{\text{initial(warmer)}} - V_{\text{warmer}} \cdot \vartheta_{\text{final}} = V_{\text{cooler}} \cdot \vartheta_{\text{final}} - V_{\text{cooler}} \cdot \vartheta_{\text{initial(cooler)}}$$

$$V_{\text{warmer}} \cdot \vartheta_{\text{initial(warmer)}} + V_{\text{cooler}} \cdot \vartheta_{\text{initial(cooler)}} = V_{\text{cooler}} \cdot \vartheta_{\text{final}} + V_{\text{warmer}} \cdot \vartheta_{\text{final}} = \vartheta_{\text{final}} \cdot (V_{\text{cooler}} + V_{\text{warmer}})$$

$$\vartheta_{\text{final}} = \frac{V_{\text{warmer}} \cdot \vartheta_{\text{initial(warmer)}} + V_{\text{cooler}} \cdot \vartheta_{\text{initial(cooler)}}}{V_{\text{warmer}} + V_{\text{cooler}}}$$

$$= \frac{4.93 \cdot 10^{-3} \text{ m}^3 \cdot 37.6 \text{ }^\circ\text{C} + 2.30 \cdot 10^{-3} \text{ m}^3 \cdot 11.5 \text{ }^\circ\text{C}}{4.93 \cdot 10^{-3} \text{ m}^3 + 2.30 \cdot 10^{-3} \text{ m}^3} = \underline{\underline{29.3 \text{ }^\circ\text{C}}}$$

$$4. \quad a) \quad Q = \Delta U_{\text{water}} = c_{\text{water}} \cdot m_{\text{water}} \cdot \Delta T_{\text{water}} = 4'182 \frac{\text{J}}{\text{kg} \cdot \text{K}} \cdot 112 \text{ kg} \cdot 2.0 \text{ K} = 936'768 \text{ J}$$

$$\Delta U_{\text{porcelain}} = c_{\text{porcelain}} \cdot m_{\text{porcelain}} \cdot \Delta T_{\text{porcelain}} = Q = \Delta U_{\text{water}}$$

$$m_{\text{porcelain}} = \frac{Q}{c_{\text{porcelain}} \cdot \Delta T_{\text{porcelain}}} = \frac{c_{\text{water}} \cdot m_{\text{water}} \cdot \Delta T_{\text{water}}}{c_{\text{porcelain}} \cdot \Delta T_{\text{porcelain}}} = \frac{4'182 \frac{\text{J}}{\text{kg} \cdot \text{K}} \cdot 112 \text{ kg} \cdot 2.0 \text{ K}}{846 \frac{\text{J}}{\text{kg} \cdot \text{K}} \cdot 50.0 \text{ K}} = \underline{\underline{22.1 \text{ kg}}}$$

$$b) \quad \Delta U_{\text{iron}} = c_{\text{iron}} \cdot m_{\text{iron}} \cdot \Delta T_{\text{iron}} = Q = \Delta U_{\text{water}} = c_{\text{water}} \cdot m_{\text{water}} \cdot \Delta T_{\text{water}}$$

substituting

$$\Delta T_{\text{iron}} = \vartheta_{\text{initial(iron)}} - \vartheta_{\text{final}} \quad \Delta T_{\text{water}} = \vartheta_{\text{final}} - \vartheta_{\text{initial(water)}}$$

into the first equation yields

$$c_{\text{iron}} \cdot m_{\text{iron}} \cdot (\vartheta_{\text{initial(iron)}} - \vartheta_{\text{final}}) = c_{\text{water}} \cdot m_{\text{water}} \cdot (\vartheta_{\text{final}} - \vartheta_{\text{initial(water)}})$$

$$c_{\text{iron}} \cdot m_{\text{iron}} \cdot \vartheta_{\text{initial(iron)}} - c_{\text{iron}} \cdot m_{\text{iron}} \cdot \vartheta_{\text{final}} = c_{\text{water}} \cdot m_{\text{water}} \cdot \vartheta_{\text{final}} - c_{\text{water}} \cdot m_{\text{water}} \cdot \vartheta_{\text{initial(water)}}$$

$$c_{\text{iron}} \cdot m_{\text{iron}} \cdot \vartheta_{\text{initial(iron)}} + c_{\text{water}} \cdot m_{\text{water}} \cdot \vartheta_{\text{initial(water)}} = c_{\text{water}} \cdot m_{\text{water}} \cdot \vartheta_{\text{final}} + c_{\text{iron}} \cdot m_{\text{iron}} \cdot \vartheta_{\text{final}}$$

$$c_{\text{iron}} \cdot m_{\text{iron}} \cdot \vartheta_{\text{initial(iron)}} + c_{\text{water}} \cdot m_{\text{water}} \cdot \vartheta_{\text{initial(water)}} = \vartheta_{\text{final}} \cdot (c_{\text{water}} \cdot m_{\text{water}} + c_{\text{iron}} \cdot m_{\text{iron}})$$

$$\vartheta_{\text{final}} = \frac{c_{\text{iron}} \cdot m_{\text{iron}} \cdot \vartheta_{\text{initial(iron)}} + c_{\text{water}} \cdot m_{\text{water}} \cdot \vartheta_{\text{initial(water)}}}{c_{\text{water}} \cdot m_{\text{water}} + c_{\text{iron}} \cdot m_{\text{iron}}} =$$

$$= \frac{450 \frac{\text{J}}{\text{kg} \cdot \text{K}} \cdot 21.0 \text{ kg} \cdot (-12.0 \text{ } ^\circ\text{C}) + 4'182 \frac{\text{J}}{\text{kg} \cdot \text{K}} \cdot 112 \text{ kg} \cdot 40.0 \text{ } ^\circ\text{C}}{4'182 \frac{\text{J}}{\text{kg} \cdot \text{K}} \cdot 112 \text{ kg} + 450 \frac{\text{J}}{\text{kg} \cdot \text{K}} \cdot 21.0 \text{ kg}} = 38.97 \text{ } ^\circ\text{C} = \underline{\underline{39.0 \text{ } ^\circ\text{C}}}$$