# Thermal Equilibrium Calculations

This sheet can help you practise how to determine the required calculation for thermal equilibrium problems. *Remember: Determine the objects which are losing energy and those which are gaining energy. The energy lost equals the energy gained.*

$c_{water}$ = 4200 J/kgK $c_{ice}$ = 2100 J/kgK $c_{copper}$ = 390 J/kgK $L_{f,\ ice}$ = $3.34*10^5$ J/kg

1) What is the final temperature of 0.1 kg of ice at 0°C added to an insulated container filled with 4.5 kg of water at 20°C?

2) What is the final temperature of 10g of ice at -15°C added to a styrofoam cup filled with 220 ml of water at 32°C?

3) An unknown metal weighing 900 g at an initial temperature of 140°C is placed into an insulated container holding 3L of water at an initial temperature of 60°C. The water rose to 65°C. What is the specific heat capacity of the metal?

4) How much ice is needed to cool 150 ml of water from 60°C to 40°C if it is in a copper cup weighing 100g?

The **solutions** are on the next page. It is a better learning strategy to try the question before looking at the solution.

Developed by Mr D. Patterson

## SOLUTIONS

1) What is the final temperature of 0.5 kg of ice at 0°C added to an insulated container filled with 4.5 kg of water at 20°C?

$Heat\ loss\ of\ water = heat\ to\ melt\ ice + heat\ gained\ by\ melted\ ice$

$m_{water}c_{water}\Delta T = m_{ice}L + m_{ice}c_{water}\Delta T$

$4.5 * 4200 * (20 - T_F) = 0.1 * \ 3.34 * 10^5 + 0.1 * 4200 * (T_F - 0)$

$T_F = 17.8\ ^0C$

2) What is the final temperature of 100g of ice at -15°C added to a styrofoam cup filled with 220 ml of water at 32°C?

$Heat\ gained\ by\ ice + heat\ to\ melt\ ice + heat\ gained\ by\ melted\ ice = heat\ lost\ by\ water$

$m_{ice}c_{ice}\Delta T + m_{ice}L_f + m_{ice}c_{water}\Delta T = m_{water}c_{water}\Delta T$

$0.01 * 2100 * (0 - (-15)) + 0.01 * 3.34 * 10^5 + \ 0.01 * 4200 * T_F = 0.22 * 4200 * (32 - T_F)$

$T_F = 26.8\ ^0C$

3) An unknown metal weighing 900g at an initial temperature of 140°C is placed into an insulated container holding 3L of water at an initial temperature of 60°C. The water rose to 65°C. What is the specific heat capacity of the metal?

$Heat\ gained\ by\ water = heat\ lost\ by\ metal$

$m_{water}c_{water}\Delta T = m_{metal}c_{metal}\Delta T$

$3 * 4200 * (65 - 60) = 0.9 * c_{metal} * (140 - 65)$

$c_{metal} = 933\ J\ kg^{-1}\ K^{-1}$

4) How much ice at 0 °C is needed to cool 150 ml of water from 60°C to 40 °C to if it is in a copper cup weighing 100g?

$Heat\ to\ melt\ ice + heat\ gained\ by\ melted\ ice = heat\ lost\ by\ water + heat\ lost\ by\ cup$

$m_{ice}L_f + \ m_{ice}c_{water}\Delta T = \ m_{water}c_{water}\Delta T + m_{copper}c_{copper}\Delta T$

$m_{ice} * 3.34 * 10^5 + m_{ice} * 4200 * (40 - 0) = \ 0.15 * 4200 * (60 - 40) + 0.1 * 390 * (60 - 40)$

$m_{ice} = 0.027\ kg$