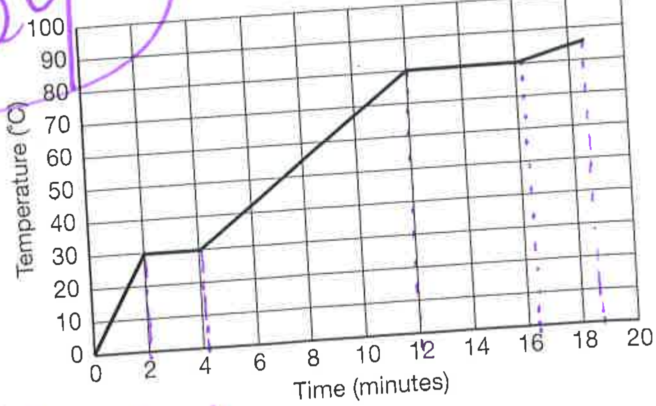
Key 3-23-18

3.2.8.8 A hypothetical temperature-time graph of a material is shown, from its state as a frozen solid to its state as a vapour. The material is being heated in a well-insulated container at a constant heating rate of 75.0 W. A mass of 500.0 g of the material is used and for this analysis, it is assumed that no mass or heat is lost.



(a) What is the latent heat of melting of the material?

$Q_{melt} = P \cdot t = (75.0\ W)(2\ min)(60\ s/min) = 9000\ J$ (acceptable = 9450 if t = 2.1 min)

$Q = mL_f \rightarrow (9000)/(0.500\ kg) = L_f = \boxed{1.8\times10^4\ J\cdot kg^{-1}}$

(b) Estimate the latent heat of vaporisation of the material.

$Q_{vap} = P \cdot t = (75.0\ W)(4.2\ min \times 60\ s/min) = 18900\ J$

$Q_{vap} = mL_v \rightarrow L_v = Q/m = 18900/0.500 = \boxed{3.78\times10^4\ J\cdot kg^{-1}}$

(c) What is the specific heat capacity of the material in the solid state?

$C = \frac{Q}{m\Delta T} = \frac{(75)(2\times60)}{(0.5)(30°)} = \boxed{600.\ J\cdot kg^{-1}\cdot°C^{-1}}$

(d) What is the specific heat capacity of the material in the liquid state?

$C = \frac{Q}{m\Delta T} = \frac{(75)(4.9\ min\times60\ s)}{(0.5)(50°)} = \boxed{1422\ J\cdot kg^{-1}\cdot°C^{-1}}$ acceptable: t = 8 min, c = 1440

(e) Estimate the specific heat capacity of the material in the vapour state.

$C = \frac{Q}{m\Delta T} = \frac{(75)(18.5-16.2)(60)}{(0.5)(6°)} = \boxed{3450\ J\cdot kg^{-1}\cdot°C^{-1}}$

Acceptable ranges: t → 2.1 min → 2.5; ΔT → 4-6 °C

(f) What is the total heat required to vaporise the 500.0 g of material from its solid form at 0°C?

$Q_a + Q_b + Q_c + Q_d + Q_e = 9000\ J + 18900\ J + 9000\ J + 35550 + 10350 = \boxed{8.28\times10^4\ J}$

Alternate: $Q_{Total} = P \cdot t_{Total} = (75.0\ W)(18.5\ min)(60\ s/min) = 83250\ J$

(g) What is the melting point of the material? 30 °C

(h) What is the boiling point of the material? 80 °C

3.2.8.9 On a warm summer's day Farmer Joe wishes to have a nice cool drink and decides to freeze some ice cubes with tap water at 20°C. Each ice cube is 10.0 g and the refrigerator can remove heat from the water at about 10 W.

How long will it take for 16 ice cubes to completely freeze?

$P = \frac{\Delta Q}{t} \Rightarrow t = \frac{\Delta Q}{P} = \frac{mc\Delta T + mL_f}{P} = \frac{16 \times (.010\,kg)(4186)(20°) + 16 \times (.01)(3.34 \times 10^5)}{10.\,W}$

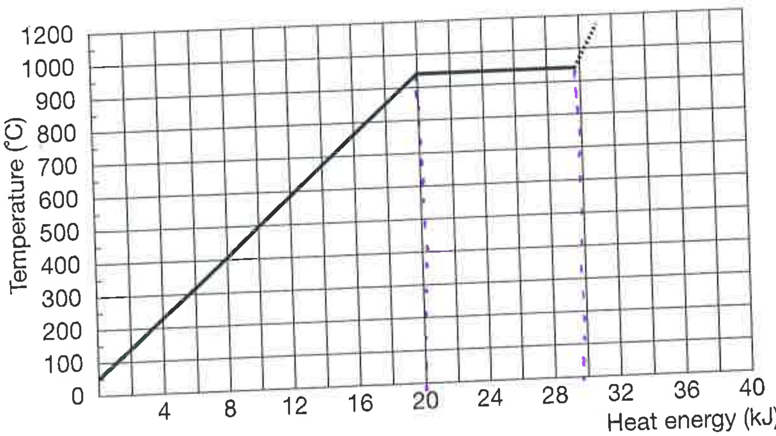
$t = \frac{16 \times 837.2 + 16 \times 3340}{10} = \frac{(1.34 \times 10^4 + 5.344 \times 10^4)}{10} = \frac{6.684 \times 10^4}{10} = 6684\,s$

$(6684\,s)\left(\frac{1\,min}{60\,s}\right) = 111.4\,min$

3.2.8.10 A student wishes to identify a sample of metal by graphing its temperature-heat graph from 50°C to melting. The 100.0 g sample contains a small amount of impurity.

Specific heat capacities of various metals are listed in the table.

Substance	Specific heat capacity ($J\,kg^{-1}\,K^{-1}$)
Iron	4.6×10^2
Copper	3.9×10^2
Zinc	3.7×10^2
Lead	1.3×10^2
Silver	2.3×10^2
Aluminium	8.9×10^2



(a) What is the melting point of the sample?

950°C

(b) As estimated by the student, what is the latent heat of melting of the metal?

$L_f = \frac{Q}{m} = \frac{9.5\,kJ}{.100\,kg} = \frac{9500}{.100} = 9.5 \times 10^4\ J \cdot kg^{-1}$

(c) Using the graphical data provided, calculate the specific heat capacity of the metal.

$Q = mc\Delta T \rightarrow c = \frac{Q}{m\Delta T} = \frac{20 \times 10^3\,J}{(0.1\,kg)(950-50)} = 222\ J \cdot kg^{-1} \cdot °C^{-1}$

(d) Which of the metals is most likely to be the largest component in the sample? Explain your answer.

Probably Silver, as it has the closest specific heat.

(e) Which of the other metals listed is most likely to be an impurity in the sample? Explain your answer.

Lead is the only other metal listed that could result in the specific heat being lower than expected.