Math-1003b Homework #6 Solutions

Reading

- Section 8.5

Problems

The amount of heat energy (Q) needed to change the temperature of an object (without going through a phase change like melting or boiling) is jointly proportional to the mass of the object (m) and the *change* in temperature (ΔT).

1). Write an equation that models this physical phenomenon. Use c for the constant of proportionality.

$$Q = cm(\Delta T)$$

2). The MKS unit for heat energy is the Joule (J). The constant of proportionality is specific to the substance being heated and is referred to as the *specific heat* of the substance. If Q is measured in Joules (J), m is measured in grams (g), and temperature is measured in Kelvin (K), what are the units of c?

In terms of units, we want:

$$J = \left(\frac{?}{?}\right) gK$$

So we want the grams and kelvin to cancel out, and joules to be introduced, so the units for c should be $\frac{J}{gK}$.

3). In the lab, it is found that 41 790 J of heat energy raises the temperature of 1 L of water by 10 K. What is the specific heat of water? (1 L of water$=$ 1000 g)

Note that 1 L of water has a mass of 1000 g, so:

$$\begin{aligned} 41\,790\ \text{J} &= c(1000g)(10K) \\ c &= \frac{41\,790\ \text{J}}{(1000g)(10K)} \\ c &= 4.1790\ \frac{\text{J}}{\text{gK}} \end{aligned}$$

4). How much energy (in Joules) is required to raise the temperature of 5 L of water by 5 K?

Since we now know c, we have an equation that we can use to calculate the needed heat energy for different masses and temperature changes:

$$Q = 4.1790m(\Delta T)$$

For 5 L $=$ 5000 g of water and a temperature change of 5 K:

$$Q = 4.1790(5000)(5) = 104\,475 \text{ J}$$