Specific Heat Capacity

Thermal Physics Lesson 1

Learning Objectives

- Define specific heat capacity.
- Perform calculations using $\Delta Q = mc\,\Delta\theta$.
- Describe how specific heat capacity can be measured in the lab.

Homework

- Complete worksheet to practice calculations we will look at today.

Why do we care

- The large SHC of water is particularly important for the development and maintenance of life on Earth.

Why are we learning this?

- Historical Context
- Images of Joule, Kelvin
- Steam engines
- Thermal physics in stars

Which is hotter? Bath water or a lit match? Which needed more energy to heat it?

Heat vs. Temperature

- Heat as water and temperature as wetness analogy

- 'Heat' is not an entity but a short hand name for a process (heating as oppose to working).

State vs. Phase

- Solids, liquids and gases are three of the different phases of matter (superfluids and plasmas are two others. Thus melting, boiling etc are changes of ***phase***.
- Each phase can exist in a variety of states depending upon e.g. the temperature and pressure.
- → However, the exam board uses “state” to mean phase.

Specific Heat Capacity

- Definition:-

- The specific heat capacity (c) of a substance is the amount of energy needed to raise the temperature of 1kg of the substance by 1K (or 1 °C)

$E = mc\Delta\theta = 5.0\ \text{kg} \times 4200\ \text{J kg}^{-1}\ \text{K}^{-1} \times 10\ \text{K} = 210\ \text{kJ}.$

Specific Heat Capacity

Equation:

$$\Delta Q = mc\Delta\theta$$

where:-

ΔQ is the energy change in J

m is the mass in kg

c is the specific heat capacity in J K^{-1} kg^{-1}

$\Delta\theta$ is the temperature change in K

Worked Example 1

- A bucket containing 11.5 litres of cold water at 10°C is taken into a house at a warmer temperature and left inside until it has reached thermal equilibrium with it new surroundings.
- If 504 kJ of energy is absorbed from the surroundings to heat the water, what is the temperature of the room?

Worked Example 1

- A bucket containing 11.5 litres of cold water at 10°C is taken into a house at a warmer temperature and left inside until it has reached thermal equilibrium with it new surroundings.
- If 504 kJ of energy is absorbed from the surroundings to heat the water, what is the temperature of the room?

- ΔQ =504 kJ
- m=11.5 kg
- c = 4200 J kg^{-1} $°C^{-1}$
- Δθ = ?

$$\Delta Q = mc\Delta\theta$$

$$\Delta\theta = \frac{\Delta Q}{mc}$$

Using

$\Delta\,\theta = 504{,}000\ \text{J} \,/\, (11.5\text{kg} \times 4200\ \text{J}\ \text{K}^{-1}\ °\text{C}^{-1}) = 10.4\ °\text{C}$ (to 3 s.f.)

So temperature of the water = 10°C + 10.4 °C = 20.4 °C

Temperature of the room = T of water in thermal eqm. = 20.4 °C

Worked Example 2

- A 60 W immersion heater takes 2.5 minutes to heat 0.5 kg of water from 21 to 25, what is the specific heat capacity of the water.

- P = 60 W
- Δt = 2.5 minutes = (2.5 × 60)s = 150 s
- $\Delta\theta = \theta_2 - \theta_1$ = 4 °C = 4 K
- m=0.5 kg
- c =?

$$P = \frac{Energy}{\Delta t}$$

- ΔQ = P Δ t = 60 W × 150 s = 9,000 J
- c = 9,000 J / (0.5 kg × 4 K) = 4,500 J kg^{-1} K^{-1}

$$c = \frac{\Delta Q}{m\Delta\theta}$$

- Why is it higher than the accepted value of c = 4200 J kg^{-1} K^{-1}?

Note

- If a question includes heating and then melting a substance then use:-

$$\Delta Q = mc\Delta\theta + ml$$