

Exercise walk-through

9.5

Specific Heat and Thermal Conductivity

AP Physics 2

Specific heat and conductivity

Warming a material

$$Q = mc\Delta T$$

Specific heat

c : heat to warm 1 kg by 1 K.

Water has a large c (≈ 4186) – it resists temperature change, so coasts stay mild.

Rate of conduction

$$\frac{Q}{t} = \frac{kA\Delta T}{L}$$

- high k – a metal **conductor**
- low k – an **insulator** (air, foam)

Worked example – heating water, and how heat travels

How much heat raises 2.0 kg of water from 20 °C to 80 °C? ($c = 4186 \text{ J/(kg K)}$)

- $Q = mc\Delta T = (2.0)(4186)(60)$
- $= 5.0 \times 10^5 \text{ J}$
- the three transfer modes: **conduction** (through a solid), **convection** (bulk fluid motion), **radiation** (electromagnetic, needing no medium)

A temperature *difference* in kelvin equals the same difference in Celsius, so ΔT needs no conversion – unlike an absolute temperature.

Exercises 2.1-2.3

2.1 Find the heat needed to raise 0.50 kg of water by 20 K (take $c = 4200 \text{ J kg}^{-1} \text{ K}^{-1}$). [2]

2.2 State what a high thermal conductivity means for the rate of heat transfer. [1]

2.3 Two blocks receive the same heat. State which has the greater temperature rise – the one with the larger or smaller specific heat. [1]

Exercises 2.1-2.3

2.1 Find the heat needed to raise 0.50 kg of water by 20 K (take $c = 4200 \text{ J kg}^{-1} \text{ K}^{-1}$). [2]

2.1

- $Q = mc\Delta T = 0.50 \times 4200 \times 20 = 4.2 \times 10^4 \text{ J}$

2.2 State what a high thermal conductivity means for the rate of heat transfer. [1]

2.2

- heat is transferred quickly (a fast rate)
-

2.3 Two blocks receive the same heat. State which has the greater temperature rise – the one with the larger or smaller specific heat. [1]

2.3

- the one with the smaller specific heat

Exercises 3.1-3.2

3.1 The equation $Q = mc\Delta T$ gives the

[1]

☐

A power

B heat transferred

C temperature

D conductivity

3.2 A good thermal insulator has a

[1]

☐

A high thermal conductivity

B low thermal conductivity

C high specific heat only

D zero mass

Exercises 3.1-3.2

3.1 The equation $Q = mc\Delta T$ gives the

[1]

☐

- A power
- B heat transferred
- C temperature
- D conductivity

3.1 B

- heat transferred.

3.2 A good thermal insulator has a

[1]

☐

- A high thermal conductivity
- B low thermal conductivity
- C high specific heat only
- D zero mass

3.2 B

- low thermal conductivity.

Exercise 3.3 (a)

3.3 A 0.30 kg metal block ($c = 900 \text{ J kg}^{-1} \text{ K}^{-1}$) is heated from 20°C to 70°C .

(a) Find the heat needed.

[3]

Exercise 3.3 (a)

3.3 A 0.30 kg metal block ($c = 900 \text{ J kg}^{-1} \text{ K}^{-1}$) is heated from 20°C to 70°C .

(a) Find the heat needed.

[3]

(a)

- $Q = 0.30 \times 900 \times 50 = 1.35 \times 10^4 \text{ J}$

Exercise 3.3 (b)

3.3 A 0.30 kg metal block ($c = 900 \text{ J kg}^{-1} \text{ K}^{-1}$) is heated from 20°C to 70°C .

(b) State the heat needed if the mass were doubled.

[1]

Exercise 3.3 (b)

3.3 A 0.30 kg metal block ($c = 900 \text{ J kg}^{-1} \text{ K}^{-1}$) is heated from 20°C to 70°C .

(b) State the heat needed if the mass were doubled.

[1]

(b)

- $2.7 \times 10^4 \text{ J}$ (double)