

Exercise walk-through

1.3

Energy changes in systems – specific heat capacity (4.1.1.3, RP1)

AQA · GCSE · Physics

Five situations the specification names

Rising and falling

Describing a change: an object projected upwards trades kinetic for gravitational potential.

A vehicle slowing down empties kinetic and fills the thermal store of the brakes.

Collisions and currents

A moving object hitting an obstacle: kinetic empties, thermal stores fill.

A kettle: electrical work fills the thermal store of the water.

A worked chain from spring to speed

- 1 **Known** $k = 50 \text{ N/m}$, $e = 0.12 \text{ m}$, $m = 0.020 \text{ kg}$; all base units.
- 2 **Store** $E_e = \frac{1}{2}ke^2 = \frac{1}{2} \times 50 \times 0.12^2 = 0.36 \text{ J}$.
- 3 **Transfer** at release all E_e becomes E_k .
- 4 **Rearrange** $v = \sqrt{2E_k/m} = \sqrt{2 \times 0.36/0.020}$.
- 5 **Answer** $v = 6.0 \text{ m/s}$, 2 s.f., unit from $\sqrt{\text{J/kg}}$.

The stairs question, start to finish

- 1 **Known** $m = 60.0 \text{ kg}$, $h = 175 \text{ cm} = 1.75 \text{ m}$, $t = 1.40 \text{ s}$, $g = 9.8 \text{ N/kg}$.
- 2 **Energy** $E_p = mgh = 60.0 \times 9.8 \times 1.75 = 1029 \text{ J}$.
- 3 **Power** $P = E_p/t = 1029/1.40$.
- 4 **Answer** $P = 735 \text{ W}$.
- 5 **Check** her total power is higher: her body also heats and pushes air.

Exercises 2.1·2.2

2.1 A 1.5 kg aluminium block ($c = 900 \text{ J/kg } ^\circ\text{C}$) rises in temperature by $24 \text{ } ^\circ\text{C}$. Calculate the energy transferred to the block. [2]

2.2 6.3 kJ raises the temperature of 0.25 kg of oil by $15 \text{ } ^\circ\text{C}$. Calculate the specific heat capacity of the oil. [3]

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2.1 Known: mass, c , temperature change.

$$\Delta E = mc\Delta\theta = 1.5 \text{ kg} \times 900 \text{ J/kg } ^\circ\text{C} \times 24 \text{ } ^\circ\text{C} = \mathbf{32\,400 \text{ J}}$$

(substitution 1, answer with unit 1.)

2.2 6.3 kJ raises the temperature of 0.25 kg of oil by $15 \text{ } ^\circ\text{C}$. Calculate the specific heat capacity of the oil. [3]

2.2 Convert: $6.3 \text{ kJ} = 6300 \text{ J}$ (C1).

$$c = \frac{\Delta E}{m\Delta\theta} = \frac{6300 \text{ J}}{0.25 \text{ kg} \times 15 \text{ } ^\circ\text{C}} = \mathbf{1700 \text{ J/kg } ^\circ\text{C}} \text{ (2 s.f.)}$$

(rearrangement 1, answer with unit 1.)

Exercise 2.3

2.3 A student's value for the specific heat capacity of water is $4410 \text{ J/kg } ^\circ\text{C}$. The accepted value is $4200 \text{ J/kg } ^\circ\text{C}$. Calculate the percentage difference between the two values. [2]

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$$\% \text{ difference} = \frac{4410 - 4200}{4200} \times 100 = \mathbf{5.0 \%}$$

(difference over accepted value 1, $\times 100$ with answer 1.)

Exercise 3.1

3.1 A heater of power 36 W runs for 8.0 minutes inside a 1.2 kg copper block ($c = 385$ J/kg °C). The block's temperature rises from 21 °C to 37 °C.

(a) Calculate the energy supplied by the heater. [3]

(b) Calculate the energy that actually raised the block's thermal store. [2]

(c) Use your answers to explain one way energy has been dissipated. [1]

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Full solution 3.1

3.1 (a) Convert time: $8.0 \text{ min} = 480 \text{ s}$ (C1). Energy from power and time.

$$E = Pt = 36 \text{ W} \times 480 \text{ s} = \mathbf{17\,280 \text{ J}}$$

(substitution 1, answer with unit 1.) (b) Use the block's own data.

$$\Delta E = mc\Delta\theta = 1.2 \times 385 \times (37 - 21) = \mathbf{7392 \text{ J}} \approx 7400 \text{ J}$$

(temperature change 1, answer with unit 1.) (c) About $17\,280 - 7400 \approx 9900 \text{ J}$ was transferred elsewhere: to the surroundings by heating, and to the heater itself and the insulation.

Exercise 3.2

3.2 A student determines the specific heat capacity of water using an immersion heater, a joulemeter and a thermometer in an insulated beaker.

(a) Describe a method the student could use. Your answer should include how the results are used to determine c . [6]

(b) Give one hazard in this investigation and how it is controlled. [1]

(c) Give one change to the apparatus that would reduce energy lost to the surroundings. [1]

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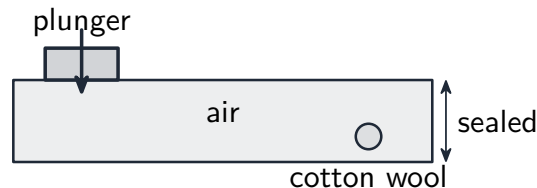
3.2 (a) Indicative content – measure the mass of the water with a balance (or measure its volume and use density); put the water in the insulated beaker with the heater and thermometer; record the starting temperature; switch on the heater and record the joulemeter reading and time (or record V and I and use $E = VIt$, or power $\times$ time); stir and record the temperature at regular intervals; switch off and record the highest tem-

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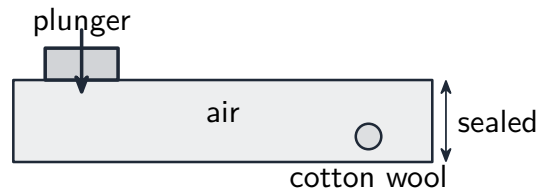
Exercise 3.3

3.3 A fire piston compresses air quickly so its temperature rises enough to ignite cotton wool. The energy transferred to the air is 0.0130 J . The mass of air is $2.60 \times 10^{-8} \text{ kg}$ and the specific heat capacity of air is $1.01 \text{ kJ/kg } ^\circ\text{C}$. Calculate the temperature change of the air. [4]



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3.3 Known: energy, mass, c – all in the equation, but c is not in base units.

- Convert: $c = 1.01 \text{ kJ/kg } ^\circ\text{C} = 1010 \text{ J/kg } ^\circ\text{C}$ (C1).

$$\Delta\theta = \frac{\Delta E}{mc} = \frac{0.0130 \text{ J}}{2.60 \times 10^{-8} \text{ kg} \times 1010 \text{ J/kg } ^\circ\text{C}}$$

$$\Delta\theta = \mathbf{495} \text{ } ^\circ\text{C}$$