

Solutions

2.1 Known: mass, c , temperature change.

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

(substitution 1, answer with unit 1.)

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

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

(rearrangement 1, answer with unit 1.)

2.3

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

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

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 temperature; calculate $\Delta\theta$; calculate $c = \Delta E / (m\Delta\theta)$; repeat for a mean / plot temperature against energy. Level 3 (5–6): a valid method in logical order with the calculation of c stated and at least one accuracy step (insulation, stirring, lid, repeats). Level 2 (3–4): most steps present but the processing incomplete or sequencing unclear. Level 1 (1–2): isolated relevant steps. (b) Hot water / heater can burn: keep the heater in the water when hot, lid on, allow to cool before handling (any one sensible hazard with control). (c) Insulate the beaker (further) / use a lid / surround with a jacket – any one change.

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).

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

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

(rearrangement C1, substitution C1, answer A1; more than 3 s.f. allowed, fewer than 3 is not.)