

Solutions

2.1 Convert: $7.2 \text{ kJ} = 7200 \text{ J}$ (C1); $4.0 \text{ min} = 240 \text{ s}$ (C1).

$$P = \frac{E}{t} = \frac{7200 \text{ J}}{240 \text{ s}} = \mathbf{30 \text{ W}}$$

(answer A1.)

2.2

$$P = \frac{W}{t} = \frac{2400 \text{ J}}{15 \text{ s}} = \mathbf{160 \text{ W}}$$

(substitution 1, answer with unit 1.)

2.3 828 J each second is a rate, so the useful power is **828 W**. Some input energy is dissipated – to thermal stores of the motor and by friction in the pipes – so the input power must exceed the useful output.

3.1 (a) $E = Pt$ (or $P = E/t$ in words: energy = power $\times$ time). (b) Convert: $500 \text{ MW} = 500\,000\,000 \text{ W} = 5 \times 10^8 \text{ W}$ (C1).

$$E = Pt = 5 \times 10^8 \text{ W} \times 3600 \text{ s} = \mathbf{1.8 \times 10^{12} \text{ J}}$$

(substitution C1, answer A1 – an unconverted 500 gives 1.8×10^9 for one substitution mark only.)

3.2 (a) Convert: $3.0 \text{ kW} = 3000 \text{ W}$ (C1). Rearrange first.

$$P = \frac{E}{t} \quad \Rightarrow \quad t = \frac{E}{P} = \frac{2.16 \times 10^7 \text{ J}}{3000 \text{ W}}$$

$$t = 7200 \text{ s} = \mathbf{7.2 \times 10^3 \text{ s}}$$

(rearrangement C1, substitution C1, value A1, standard form A1.) (b) Hydro and solar fail at different times – solar stops at night and on dull days, while the river keeps flowing – so combining them covers more of the day; but solar alone is not reliable because its output changes with the weather and the season.

3.3 (a) Known: mass, height, g .

$$E_p = mgh = 2500 \times 9.8 \times 94 = \mathbf{2.3 \times 10^6 \text{ J}} \text{ (2 s.f.)}$$

(substitution C1, answer A1, unit A1.) (b) Convert: $3.0 \text{ min} = 180 \text{ s}$ (C1).

$$P = \frac{E_p}{t} = \frac{2.303 \times 10^6 \text{ J}}{180 \text{ s}} = \mathbf{12\,800 \text{ W}} \approx 13 \text{ kW} \text{ (2 s.f.)}$$

(substitution C1, answer A1.) (c) Input power $21 \text{ kW} = 21\,000 \text{ W}$.

$$\% \text{ useful} = \frac{12\,800}{21\,000} \times 100 = \mathbf{61 \%} \text{ (2 s.f.)}$$

(fraction 1, $\times 100$ 1.) (d) Any two: friction in the cable and rails dissipates energy to thermal stores; air resistance on the moving carriage; the motor and gearbox heat up; energy is transferred to the thermal store of the surroundings.