2.6 Power and energy transfers in appliances

Name: _____ Class: _____ Date: _____ **Total: 31 marks**

KEY WORDS potential difference

Objective

Use $P = VI$, $P = I^2R$, $E = Pt$ and $E = QV$, chain them in two-step calculations, and describe how appliances' power ratings relate to energy transfers. Original questions for spec statements 4.2.4.1–4.2.4.2.

1 Key knowledge and worked examples

Everyday appliances transfer energy from mains or battery to kinetic energy (motors), heating (kettles, heaters) or light (lamps). **Work is done whenever charge flows.**

$$P = VI \qquad P = I^2R \qquad E = Pt \qquad E = QV$$

Equation	Use it when you know
$P = VI$	potential difference and current
$P = I^2R$	current and resistance (no V given)
$E = Pt$	power and time (seconds!)
$E = QV$	charge flow and potential difference

$P = I^2R$ is $P = VI$ with $V = IR$ substituted – say that when asked to *show* it.

Worked example – AQA June 2023 8463/1H Q06.3. A lamp carries 0.21 A at 6.0 V for 30 minutes. Find the energy.

- Convert time: 30 min = 1800 s.

$$P = VI = 6.0\ \text{V} \times 0.21\ \text{A} = 1.26\ \text{W}$$

$$E = Pt = 1.26\ \text{W} \times 1800\ \text{s} = 2268\ \text{J} \approx 2300\ \text{J}$$

Worked example – AQA June 2025 8463/1H Q09.2. A pump motor of resistance 6.0 Ω draws 4.86 W. Find the charge flowing in 30 minutes, first calculating current. Use the question's prescribed resistive model for this calculation; do not infer that all input to every real running motor becomes resistance heating.

- Known: power and resistance; choose $P = I^2R$ because those are exactly the given quantities.

$$I = \sqrt{\frac{P}{R}} = \sqrt{\frac{4.86\ \text{W}}{6.0\ \Omega}} = 0.90\ \text{A}$$

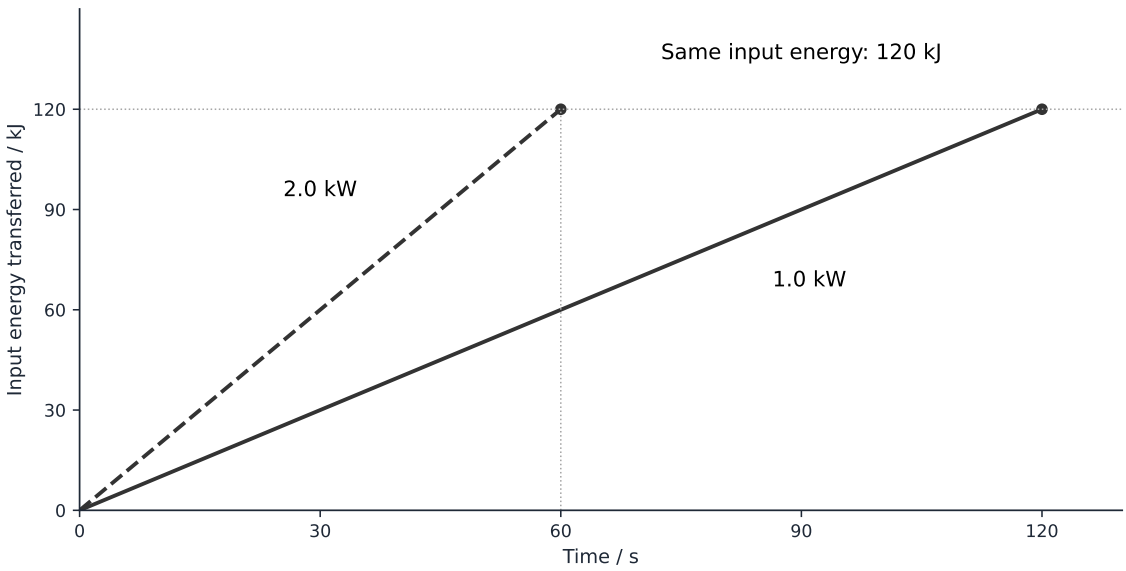
- Convert: 30 min = 1800 s; charge is current × time.

$$Q = It = 0.90\ \text{A} \times 1800\ \text{s} = 1620\ \text{C}$$

Power rating : watts describe energy transferred each second at the working pd, rather than total energy used. A 3 kW kettle running at constant input power for 2 minutes transfers:

$$E = Pt = 3000\ \text{W} \times 120\ \text{s} = 360\,000\ \text{J}$$

Teacher-written comparison. The graph shows constant-power devices transferring equal input energy. Use $t = E/P$: 1.0 kW takes 120 s to transfer 120 kJ, while 2.0 kW takes 60 s. Higher power means more energy at the same run time; total energy for a job also depends on duration. Faster useful heating requires comparable efficiency and losses.



2 Practice

2.1 A hairdryer draws 4.0 A from the 230 V mains. Calculate its power. [2]

2.2 A 1500 W heater runs for 5.0 minutes. Calculate the energy transferred in kJ. [3]

2.3 A 12 V lamp transfers 360 J when 30 C flows through it. Calculate the charge's energy per coulomb and the lamp's current if it runs for 20 s. [3]

3 Exam-style questions

3.1 A hand warmer's heating pad is modelled as a resistor. The pad's resistance is 12 Ω and it carries 0.50 A.

(a) Calculate the power dissipated in the pad, using $P = I^2R$. [2]

(b) The hand warmer runs for 8.0 minutes. Calculate the energy transferred. [3]

(c) A second pad of resistance 6.0 Ω replaces it at the same current. Without full calculation, state and explain the change in power. [2]

3.2 A pavement tile generates electricity as people walk on it. At one moment the tile produces 4.4 W at 40 V.

(a) Which equation links current (I), potential difference (V) and power (P)? [1]

(b) Calculate the current in the tile. [3]

(c) The tile charges a battery. In one hour the charge flow is 396 C. Show that the average current is about 0.11 A. [2]

3.3 A hair straightener and a travel kettle both run from the 230 V mains.

Hair straightener: 120 W. Kettle: 2000 W.

(a) Calculate the current drawn by each appliance. [4]

(b) The straightener reaches working temperature after transferring 3.6 kJ. Calculate the time it takes. [3]

(c) Explain, in terms of energy per second, why the kettle's cable is thicker than the straightener's. [3]