Electrical energy and power

LEARNING INTENTION

We are learning to calculate electrical energy and power using the Data Booklet formulae.

SUCCESS CRITERIA – I CAN

- ☐ use $E_e = VIt$ with time in seconds
- ☐ use $P = VI$, $P = V^2/R$ and $P = I^2R$
- ☐ choose the right power formula from the values given
- ☐ give answers in J, kJ, W or kW to suit the values

Energy and power

Energy (E, joules J) is the ability to do work. **Power** (P, watts W) is how fast energy is transferred: 1 W = 1 J every second.

A 2 kW kettle transfers 2000 J of electrical energy every second.

DATA BOOKLET page 4

$E_e = VIt$
electrical energy

$P = E/t$
power

$P = VI = V^2/R = I^2R$
electrical power

$V = IR$
Ohm's law (page 5)

Electrical energy

WORKED EXAMPLE Energy from a battery heater

1 GIVEN	2 FIND	3 FORMULA	4 SUBSTITUTE	5 ANSWER + UNIT
V = 12 V I = 2.0 A t = 5 min	E_e	$E_e = VIt$ t in seconds	$t = 5 \times 60 = 300$ s $E_e = 12 \times 2.0 \times 300$	**E_e = 7200 J** = 7.2 kJ

Time must be in seconds to give joules.

SHORT CIRCUIT

× WHAT EXAMINERS SAW

Time left in minutes in $E_e = VIt$, giving answers 60 times too small, or no unit at all.

✓ THE FIX

Convert time to seconds first. Then E_e comes out in joules (J). Use kJ or MJ for big values.

Course reports 2025–26: the final unit must suit the values used.

Electrical energy and power

Electrical power

V and I	V and R	I and R
$P = VI$	$P = V^2/R$	$P = I^2R$

WORKED EXAMPLE **Power of a kettle element**

1 GIVEN	2 FIND	3 FORMULA	4 SUBSTITUTE	5 ANSWER + UNIT
$V = 230$ V $R = 46\ \Omega$	P	$P = V^2/R$	$P = 230^2 \div 46$ $P = 52\ 900 \div 46$	**$P = 1150$ W** $= 1.15$ kW

No current given, so use the formula with V and R.

SHORT CIRCUIT

× WHAT EXAMINERS SAW

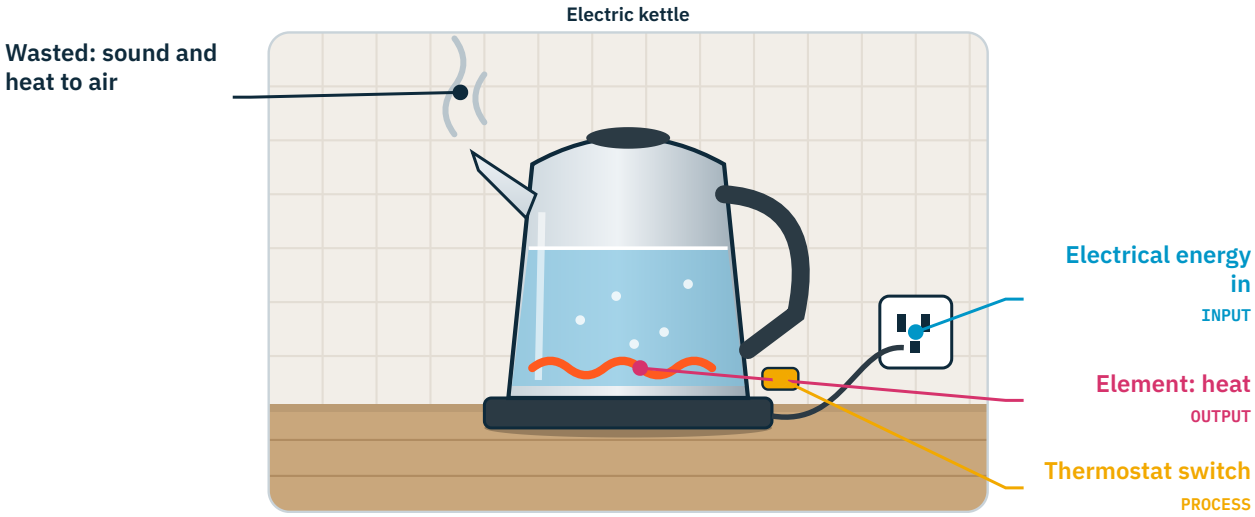
The wrong power formula chosen, e.g. $P = VI$ when only V and R were given, so an extra step was missed or the values were mixed up.

✓ THE FIX

List what you are given. V and I → $P = VI$. V and R → $P = V^2/R$. I and R → $P = I^2R$.

Data Booklet page 4 gives all three forms.

Power and energy in a real product



Electrical energy and power

FROM POWER TO ENERGY

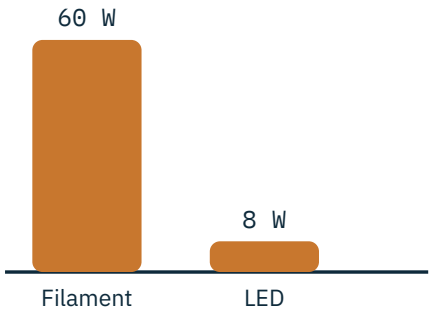
1. P = 2300 W
2. t = 3 min = 180 s
3. E = P × t
4. E = 414 000 J

Power: energy per second

Time in seconds

Energy = power × time

Answer with unit



Power for the same light

An LED gives the same light for far less power, so it uses far less energy every hour.

WORKED EXAMPLE Energy used by a hand dryer

1 GIVEN	2 FIND	3 FORMULA	4 SUBSTITUTE	5 ANSWER + UNIT
P = 1.8 kW = 1800 W t = 30 s	E_e	$E_e = Pt$	$E_e = 1800 \times 30$	**54 000 J = 54 kJ**

WORKED EXAMPLE Current from power

1 GIVEN	2 FIND	3 FORMULA	4 SUBSTITUTE	5 ANSWER + UNIT
P = 36 W V = 12 V	I	P = VI, so I = P/V	I = 36 / 12	**3 A**

Electrical energy and power

WORKED EXAMPLE Running cost in energy terms

1 GIVEN	2 FIND	3 FORMULA	4 SUBSTITUTE	5 ANSWER + UNIT
LED lamp 8 W, filament lamp 60 W both on for 5 h	energy saved	$E = Pt$	$t = 5 \times 3600 = 18\,000$ s saving $= (60 - 8) \times 18\,000$	**936 000 J = 936 kJ**

REAL ENGINEERING · BEN CORRACH SNOW CANNON

Each snow cannon at Ben Corrach (fictional) has a 15 kW fan motor. Running all night (10 hours = 36 000 s) it uses 15 000 × 36 000 = 540 MJ.

Engineers use E = Pt like this to budget the electricity for a snowmaking night.



PROBE · QUICK CHECKS

1. Unit of power? _____
2. 5 minutes in seconds? _____
3. Which formula: V and R given? _____

EXAM READY · 9 MARKS

1 A 9.0 V motor draws 0.15 A for 10 minutes. **Calculate** the electrical energy used. **[3]**

2 A 230 V heater draws 10 A. **Calculate** its power. **[2]**

3 A 20 mA current flows through a 350 Ω LED resistor. **Calculate** the power in the resistor. **[2]**

4 A 2.0 kW heater runs for 3 minutes. **Calculate** the energy transferred. **[2]**