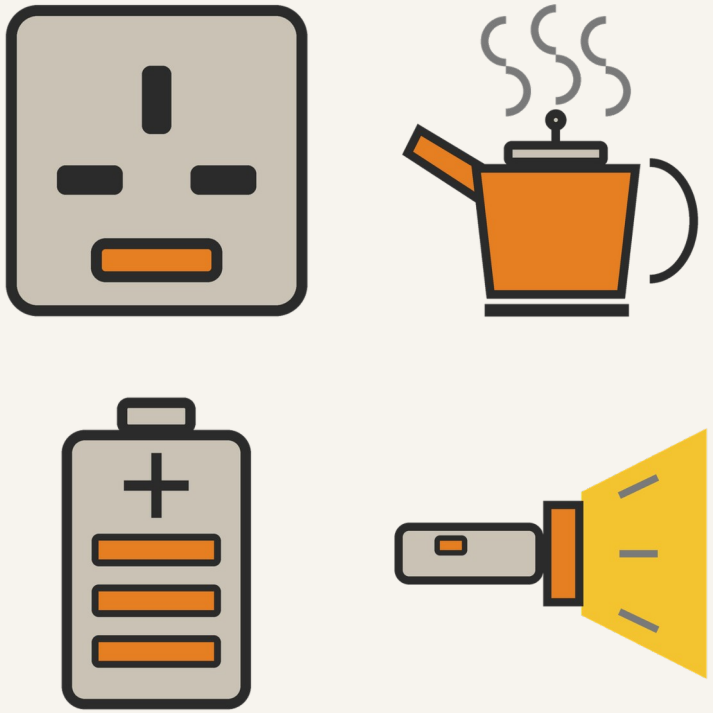
BOOKLET 2 · ENERGY AND EFFICIENCY

Electrical and Heat Energy (p10)



Two formulae, two classic traps: the clock and the thermometer.

National 5 Engineering Science

LEARNING INTENTION

To calculate electrical energy using $E_e = V\ I\ t$ and heat energy using $E_h = c\ m\ \Delta T$.

Daily Review

SHOW ME BOARDS

1. State the law of conservation of energy.
2. A trolley of mass 8 kg moves at 5 m/s. Calculate its kinetic energy.
3. A crane lifts 200 kg through 4 m. Calculate the potential energy gained.
4. Name one form of wasted energy from an electric motor.
5. State the unit of work done.

By the end of this lesson…

1. I can state $E_e = V\,I\,t$ and $E_h = c\,m\,\Delta T$ with their units.
2. I can change minutes and hours into seconds before I substitute.
3. I can use the temperature change ΔT, not the final temperature.
4. I can give an answer in kJ when the question asks for it.

Electrical Energy

The energy an electric current delivers depends on the voltage, the current and the time.

$$E_e = V\ I\ t$$

E_e	V	I	t
electrical energy (J)	voltage (V)	current (A)	time (s)

Booklet rule: always change the time into seconds before you substitute.

Worked Example — Motor

A motor runs at 12 V, drawing a current of 3 A, for 5 minutes.

Calculate the electrical energy supplied.

$V = 12\ V$

$I = 3\ A$

$t = 5\ min = 300\ s$

$E_e = ?$

$E_e = V\ I\ t$

$E_e = 12 \times 3 \times 300$

$\underline{E_e = 10\ 800\ J}$

Watch Out — The Time Must Be in Seconds

THE MISTAKE

- “It says 5 minutes, so $t = 5$”
- “It says 1 hour, so $t = 1$”
- “The unit does not matter, the number does”

THE CORRECT ANSWER

- 5 minutes = 5 × 60 = 300 s. Convert first, every time.
- 1 hour = 60 × 60 = 3 600 s.
- Joules only come out if seconds went in.

Show Me — Electrical Energy

SHOW ME BOARDS

1. Write the formula for electrical energy.
2. State the unit of current.
3. 6 V, 2 A, 10 s — calculate E_e.
4. Change 3 minutes into seconds.
5. 12 V, 2 A, 1 minute — calculate E_e.

Show Me — More Electrical Energy

SHOW ME BOARDS

EXTRA PRACTICE

1. What does the I stand for in $E_e = V\ I\ t$?
2. Change 4 minutes into seconds.
3. 5 V, 3 A, 20 s — calculate E_e.
4. 9 V, 2 A, 2 minutes — calculate E_e.
5. Change half an hour into seconds.

Task 1 — Electrical Energy

Three calculations in your jotter.
Set every one out the SQA way: what you know, then the equation, the numbers, and the answer underlined.

Booklet — “TRY THIS: Electrical Energy”

Heat Energy

The heat energy needed depends on the mass, the temperature change and the material.

$$E_h = c\,m\,\Delta T$$

E_h	c	m	ΔT
heat energy (J)	specific heat capacity	mass (kg)	temperature change (°C)

Use $c = 4180\ \text{Jkg}^{-1}\text{K}^{-1}$ for water, unless the question gives another value.

Worked Example — Kettle

A kettle heats 0.5 kg of water from 20 °C to 100 °C.

Calculate the heat energy needed.

$c = 4180$

$m = 0.5\ \text{kg}$

$\Delta T = 100 - 20 = 80\ °\text{C}$

$E_h = ?$

$E_h = c\ m\ \Delta T$

$E_h = 4180 \times 0.5 \times 80$

$\underline{E_h = 167\,200\ \text{J}}$

Watch Out — ΔT Is a Change

THE MISTAKE

- “Heated to 100 °C, so ΔT = 100”
- “ΔT = 20 + 100 = 120 °C”
- “Mass in grams is close enough”

THE CORRECT ANSWER

- ΔT is the change: 100 − 20 = 80 °C.
- Subtract, never add: final − start.
- Mass must be in kilograms before you substitute.

Show Me — Heat Energy

SHOW ME BOARDS

1. Write the formula for heat energy.
2. Water is heated from 10 °C to 50 °C. What is ΔT?
3. What value of c do we use for water?
4. m = 2 kg, ΔT = 10 °C, c = 4180 — calculate E_h.
5. State the unit of heat energy.

Show Me — More Heat Energy

SHOW ME BOARDS

EXTRA PRACTICE

1. Water goes from 15 °C to 35 °C. What is ΔT?
2. m = 1 kg, ΔT = 5 °C, c = 4180 — calculate E_h.
3. Why do we use ΔT and not the final temperature?
4. m = 0.5 kg, ΔT = 20 °C, c = 4180 — calculate E_h.
5. A question gives you $c = 386$. What does that tell you?

Task 2 — Heat Energy

Three more calculations, same layout every time. Question 3 is copper, not water — use the value of c that the question gives you.

Booklet — “TRY THIS: Heat Energy”

Checkpoint

1. Write both formulae from this lesson and give the unit of each answer.

2. A fan runs at 12 V drawing 5 A for 2 minutes. Calculate the energy supplied.

3. What + why: why must ΔT be a change, not the final temperature?

Exam Practice — Past Papers

2021 Q10(a) — cooking pot, c = 910 (3)
2021 Q10(b)(i) — slow cooker, 120 minutes (3)
2023 Q12(e) — washing machine (3)
2024 Q12(b) — mini fridge, 7.5 hours (2)
2025 Q12(b) — air fryer, c = 3400 (2)

Find the relationship in the data booklet

LOOKING AHEAD

Power

Two heaters deliver the same energy. One does it in half the time.

Plenary — Prove Your I Can… Statements

SHOW ME BOARDS

1. Write the formula for electrical energy.
2. Write the formula for heat energy.
3. Change 2 minutes into seconds.
4. 10 V, 2 A, 30 s — calculate E_e.
5. Water heated from 20 °C to 60 °C — what is ΔT?

Plenary — More Quick Checks

SHOW ME BOARDS

EXTRA PRACTICE

1. State the unit of voltage.
2. What is the value of c for water?
3. Change 1 hour into seconds.
4. 6 V, 5 A, 10 s — calculate E_e.
5. Write 5 000 J in kJ.

Extension — If You Finish Early

1. A charger supplies 5 V at 2 A for 1 hour. Give the energy in kJ.

2. A 2 kg aluminium part is heated by 50 °C. Use $c = 902$.

3. What + why: same water, same ΔT, but one kettle is slower. Does E_h change?

Extension — More Challenges

EXTRA PRACTICE

1. A heater uses 48 000 J in 4 minutes at 200 V. Calculate the current.

2. A radiator holds 12 kg of water and is heated by 40 °C. Find E_h.

3. What + why: why does the same ΔT need more energy for 10 kg than 1 kg?