Energy transfers in everyday appliances

6.2.4.2 · Physics · revision notes

How everyday appliances transfer energy, and how to calculate the energy transferred using E = P t and E = Q V. Expect questions on the energy transfers in named appliances (motors and heaters) and 2 to 4 mark calculations with unit conversions.

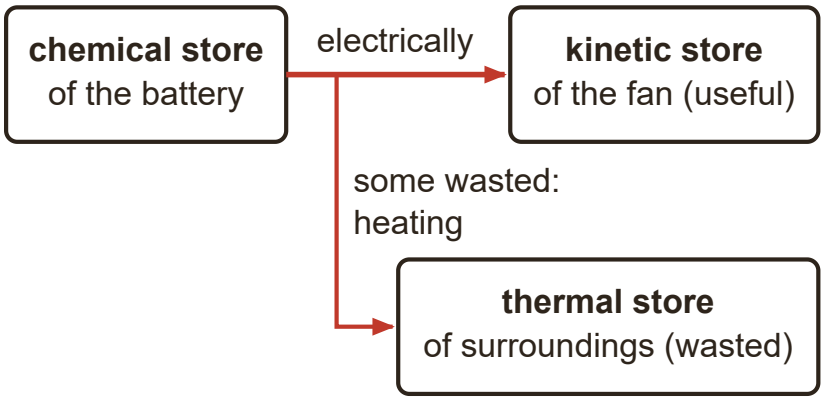
Key facts

- E = P t: energy (J) = power (W) × time (s)
- 1 V = 1 J of energy transferred per coulomb of charge
- Energy transferred depends on the power and the time switched on
- E = Q V: energy (J) = charge flow (C) × pd (V)
- Motor: energy to the kinetic store; heater: energy to the thermal store
- 1 kW = 1000 W; 1 kJ = 1000 J; 1 min = 60 s; 1 h = 3600 s

Notes

Energy transfers in appliances

- Everyday electrical appliances are designed to bring about energy transfers.
- Energy is transferred **electrically** (by electrical work) from batteries or the ac mains.
- Appliances with an **electric motor** (e.g. a fan, a drill or a food mixer) transfer energy to the **kinetic energy** store of the motor.
- **Heating devices** (e.g. a kettle, a toaster or an electric heater) transfer energy to the **thermal energy** store of the heating element and then of whatever is being heated.
- A battery-powered device transfers energy from the **chemical energy** store of the battery.
- Some energy is usually wasted, e.g. transferred to the thermal energy store of the surroundings.



A battery-powered fan: chemical store to kinetic store, with some energy wasted.

Power ratings

- The energy an appliance transfers depends on its **power** and on **how long** it is switched on for.
- The power rating is the energy transferred each second in normal use: a 2000 W kettle transfers 2000 J every second.
- A higher-power appliance on for the same time transfers more energy, so its energy stores change by more. For example, a 3 kW kettle can heat the same water faster than a 2 kW kettle.

Calculating energy transferred

- energy transferred = power × time: **E = P t** (E in J, P in W, t in s).
- **Work is done** when charge flows in a circuit. energy transferred = charge flow × potential difference: **E = Q V** (E in J, Q in C, V in V).
- So a pd of 1 volt means 1 joule of energy is transferred for each coulomb of charge that flows.
- Convert first: kW × 1000 = W, minutes × 60 = s, hours × 3600 = s.
- Multi-step: find the charge with Q = I t, then use E = Q V. Or find the power with P = V I, then use E = P t. Both give the same answer. Grade 7+ only

How to answer each type of question

Describe the energy transfer in an appliance 2 marks **Grade 4**

1. Say where the energy comes from: the mains (transferred electrically) or the chemical store of a battery.
2. Say which store it goes to: kinetic (motor) or thermal (heater).
3. Mention wasted energy to the surroundings if the question asks about it.

Example. A cordless drill is powered by a rechargeable battery.
Describe the energy transfer when the drill is being used.

Model answer. Energy is transferred electrically from the chemical energy store of the battery (1) to the kinetic energy store of the motor (and drill bit) (1).

Calculate energy using E = P t 3 marks **Grade 5**

1. Convert the power to watts and the time to seconds.
2. Write E = P t and substitute.
3. Give the answer in joules (or kJ if asked).

Example. A 1.5 kW microwave oven is used for 3.0 minutes.
Calculate the energy transferred by the microwave oven.

Model answer.

P = 1500 W and t = 180 s (1)
E = 1500 × 180 (1)
E = 270 000 J (1)

Calculate energy using E = Q V

2 marks | Grade 5

1. Write E = Q V.
2. Substitute the charge in coulombs and the pd in volts.
3. Give the answer in joules.

Example. A charge of 400 C flows through a lamp. The potential difference across the lamp is 12 V. Calculate the energy transferred by the lamp.

Model answer.

E = 400 × 12 (1)
E = 4800 J (1)

Multi-step energy calculation

4 marks | Grade 7

1. Convert the time to seconds.
2. Find the charge with Q = I t (or the power with P = V I).
3. Use E = Q V (or E = P t) to find the energy.

Example. A 6.0 V battery supplies a current of 0.50 A to a motor for 2.0 minutes. Calculate the energy transferred to the motor.

Model answer.

t = 2.0 × 60 = 120 s (1)
Q = I t = 0.50 × 120 = 60 C (1)
E = Q V = 60 × 6.0 (1)
E = 360 J (1)

Don’t lose marks

- Using minutes or hours in E = P t without converting to seconds.
- Using kW instead of W, giving an answer 1000 times too small.
- Writing that a heater transfers energy 'as heat' or 'as electricity'. Say energy is transferred electrically to the thermal energy store.
- Mixing up the letters: in E = Q V, Q is the charge (not the current).

More tips

Memory tricks

- E = P t is the definition of power turned around: power is energy per second, so energy = power × seconds.
- Remember what a volt is: joules per coulomb. So joules = coulombs × volts, E = Q V.
- E = P t, E = Q V, P = V I and Q = I t all fit together: E = V I t.

Exam technique

- Name energy stores correctly: chemical (battery), kinetic (motor), thermal (heater and surroundings).
- Practise choosing between E = P t and E = Q V using the quantities given.
- If a question uses kilowatt-hours (kWh), it will tell you how to work them out. Follow its method and units exactly.
- Large answers can be given in kJ or standard form, but check the unit matches the number.

What each grade needs

What you need to be able to do, from the first marks up to the top grade.

Grade 3 — **Describe energy transfers in simple appliances**
e.g. a kettle transfers energy electrically from the mains to the thermal energy store of the water.

Grade 4 — **State what affects the energy transferred**
The power of the appliance and how long it is switched on for.

Grade 4 — **Calculate energy using E = P t**
Power in watts × time in seconds gives energy in joules.

Grade 5 — **Calculate energy using E = Q V**
Charge in coulombs × pd in volts gives energy in joules.

Grade 5 — **Relate power ratings to energy transferred**
An appliance with a higher power rating transfers more energy each second.

Grade 7 — **Combine E = Q V with Q = I t**
Find the charge first, then the energy, in multi-step problems.

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