

Core Equation:

$$\text{Efficiency} = \frac{\text{Useful energy transfer}}{\text{Total energy transfer}} \quad (\text{often expressed as a percentage: } \text{Efficiency} = \frac{\text{Useful energy transfer}}{\text{Total energy transfer}} \times 100\%)$$

Rearranged Forms:

$$\text{Useful energy transfer} = \text{Efficiency} \times \text{Total energy transfer}$$

$$\text{Total energy transfer} = \frac{\text{Useful energy transfer}}{\text{Efficiency}}$$

Units:

Useful output energy: **Joules (J)**

Total input energy: **Joules (J)**

Efficiency: **No units** (or %)

Section A: Formula Recall, Rearrangement & Units

1. Complete the following statements about efficiency:

- a) Efficiency is a measure of how much of the _____ energy input is converted into _____ energy output.
- b) Efficiency has _____ when expressed as a decimal, but can also be given as a _____.

2. Rearrange the efficiency formula to make the following the subject:

- a) Useful energy transfer: _____
- b) Total energy transfer: _____

3. Convert the following energy values to Joules (J) or power values to Watts (W):

- a) 15 kJ = _____
- b) 0.25 MJ = _____
- c) 500 W = _____
- d) 2.5 kW = _____
- e) 3 minutes = _____
- f) 0.5 hours = _____

Section B: Practice Calculations

4. Answer the following questions, showing your working clearly and stating appropriate units.

- a) An electric motor is supplied with 500 J of electrical energy and produces 400 J of useful kinetic energy. Calculate the efficiency of the motor as a decimal.

- b) A light bulb has an efficiency of 0.15. If it is supplied with 200 J of electrical energy, how much useful light energy does it produce?

- c) A car engine is 35% efficient. If it produces 70 kJ of useful kinetic energy, calculate the total energy supplied to the engine from the fuel. Give your answer in Joules.

- d) A solar panel receives 1.2 MJ of energy from the Sun. If its efficiency is 20%, how much useful electrical energy does it generate? Give your answer in Joules.

Section C: Challenge Context

5. An electric kettle is used to heat water. It has a power rating of 2.2 kW and is switched on for 3.0 minutes. During this time, 356.4 kJ of thermal energy is usefully transferred to the water.

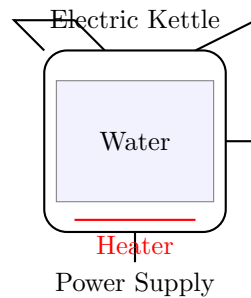


Figure 1: Electric Kettle

- a) Calculate the efficiency of the electric kettle. Give your answer as a percentage to 3 significant figures. Show your working clearly.

- b) Explain why the efficiency of the kettle is not 100%. In your answer, refer to energy transfers and the principle of conservation of energy.
