Carnot and heat engine efficiency

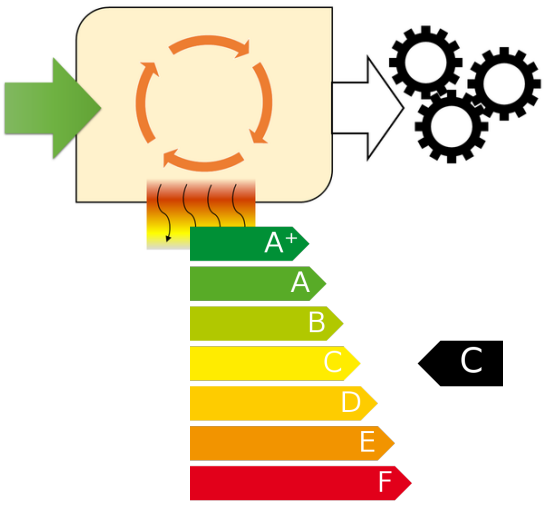
In 1824, a young engineering officer in the French army was credited as being the father of thermodynamics. Nicholas Leonard Sadi Carnot became fascinated by the steam engines that had been invented and developed in the UK; he was keen to improve the output energy of engines and studied them in depth.
He proposed a theory that if steam were replaced a fluid or gas, that the engine could be far more efficient in the use of energy, and conserve more of that energy and reach 100% efficiency. His mathematical calculations for the idealised heat engine became known as the Carnot engine cycle.

The efficiency of an energy system is determined by how much useful energy is transferred

$$\text{efficiency} = \frac{\text{useful energy output transfer}}{\text{total input energy transfer}}$$

or

$$\text{efficiency} = \frac{\text{useful power output}}{\text{total power input}}$$



Question:

A kettle transfers 1,500 J of energy, 1,200 J to a thermal energy store in the water and 300 J to the air as sound. How efficient is the kettle?

Example:
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$$\text{efficiency} = \frac{\text{useful energy output transfer}}{\text{total input energy transfer}}$$

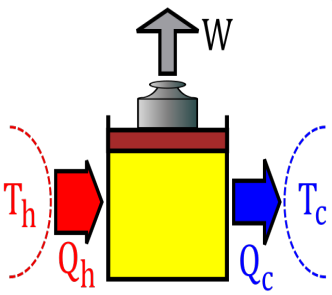
$$\text{efficiency} = 0.8 \times 100 = 80\%$$

Practice

1. What is the energy efficiency of a car that transfers 15kJ of the chemical energy stored in its petrol into 3,000J of kinetic energy stored in its movement?

2. Rachel uses 24kJ of energy drying her hair with a hairdryer. The hairdryer is 45% efficient. How much energy is wasted as sound?

3. Playing on an Xbox 360 uses 102J of electric and magnetic energy each second. 9J of this energy is transferred to a thermal energy store. How efficient is the Xbox?



4. Discuss whether it is possible practically to have a machine that is 100% efficient. Justify your answer, including reference to the principle of conservation of energy.

Efficiency

Look at the diagram, fill in the energy type in the boxes

Complete the table below

appliance	energy in (J)	useful energy out (J)	efficiency (%)
A	100	20	
B	200	50	
C	350	280	
D	2800	70	
E	100		50
F		40	25
G	45		30
H	33	30	95