EFFICIENCY

Setting out is really important and marks are allocated as to how you set out your answers.
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The steps you should use to complete all calculations are as follows:

Step 1: Write down what you need to find.
Step 2: Write down the information given.
Step 3: Select the appropriate equation from the Formula And Data Sheet and write this down
Step 4: Substitute the given quantities into the equation
Step 5: Simplify the equation
Step 6: Express the answer in the appropriate units and significant figures

$$\text{Efficiency (\%)} = \frac{\text{Output Energy} \times 100}{\text{Input Energy}}$$

Efficiency applies in the area of heating and cooling when energy is transferred from one substance to another or energy is converted from one form into another.

Example 1:

Find the efficiency of an electric kettle if 500 J of electrical energy is converted into 350 J of heat energy.

Solution:

Efficiency = ? Input Energy = 500 J Output Energy = 350 J

$$\text{Efficiency (\%)} = \frac{\text{Output Energy} \times 100}{\text{Input Energy}}$$

$$= \frac{350 \times 100}{500}$$

$$= 70\ \%$$

Example 2

2.00 L of water is placed in a plastic kettle and the element is switched on. If the element operates at 1000 W and at 90 % efficiency for 10 s and assuming no heat transfer to the kettle, find the rise in the water temperature.

Solution

P = 1000 W t = 10 s Efficiency = 90 % m = 2 L = 2 kg C = 4180 J kg^{-1} K^{-1} ΔT = ?

Q = E = P x t = 1000 x 10 = 10000 J

If 90 % efficiency then only 90 % of Q is transferred

$$Q_{effective} = \frac{90 \times Q}{100} = \frac{90 \times 10000}{100} = 9000\ J$$

$$Q = m \times C \times \Delta T$$

$$9000 = 2 \times 4180 \times \Delta T$$

$$\Delta T = \frac{9000}{2 \times 4180} = \frac{9000}{8360} = 1.08\ K$$

Example 3

The element of an urn operates at 2.00 kW in heating water. If 1.00 L of water is placed in a copper urn with a copper element (total mass = 1.00 kg). The water was originally at 0 ^{o}C. and reached 100 ^{o}C in 3600 s. What is the efficiency of the element? (C_{water} = 4200 J kg^{-1} K^{-1} C_{copper} = 400 J kg^{-1} K^{-1})

Solution

Find the input energy

P = 2 kW = 2000 W t = 3600 s Q_{input} = ?

Q_{input} = P x t = 2000 x 3600 = 7200000 J

Find the output energy

M_{water} = 1 l = 2.00 kg M_{copper} = 1.00 kg
C_{water} = 4200 = 4200 J kg^{-1} K^{-1} C_{sopper} = 400 J kg^{-1} K^{-1}
ΔT = 100 - 0 = 100 K ΔT = 100 - 0 = 100 K

Q_{output} = M_{copper} x C_{copper} x ΔT + M_{water} x C_{water} x ΔT

Q_{output} = 1 x 400 x 100 + 2 x 4200 x 100

Q_{output} = 40000 + 840000

Q_{output} = 880000 J

Find the efficiency

$$\text{Efficiency (\%)} = \frac{\text{Output Energy x 100}}{\text{Input Energy}}$$

$$= \frac{880000 \text{ x } 100}{7200000}$$

= 12.2 %

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