

Calculation of Electrical Energy

Energy

On-page 157 we dealt with power and noted that power is the rate at which energy is transferred from one place to another or from one form to another

The formula that links energy and power is:

$$\text{Energy} = \text{Power} \times \text{Time}.$$

The unit of energy is the joule, the unit of power is the watt, and the unit of time is the second.

If we know the power in watts of an appliance and how many seconds it is used we can calculate the number of joules of electrical energy which have been converted to some other form.

E.g. If a 40 watt lamp is turned on for one hour, how many joules of electrical energy have been converted by the lamp?

$$\begin{aligned} \text{Energy (w)} &= \text{Power} \times \text{Time} \\ \text{Energy} &= 40 \times 3600 \\ &= 14,400 \text{ joules} \end{aligned}$$

Note: if an appliance has a rating of one watt it means it converts one joule of electrical energy to some other form every second.

Because the joule is such a small unit, quantities of energy are often given in kilojoules. I.e, thousands of joules.

Therefore the above answer could be written as 14.4 kJ.

The Kilowatt Hour (kWh)

Because the joule is so small, electrical energy supplied to consumers is bought by the UNIT. The UNIT is the kilowatt hour (kWh). One kilowatt hour is the amount of energy that would be converted by a one thousand watt appliance when used for one hour

Example

A consumer uses a 6 kW immersion heater, a 4 kW electric stove and three 100 watt lamps for 10 hours. How many units (kWh) of electrical energy have been converted.

$$\begin{aligned} \text{Total power in kilowatts} &= 6 + 4 + 300/1000. \\ &= 10.3\text{kW}. \end{aligned}$$

$$\begin{aligned} \text{Energy in kilowatt hours} &= \text{Power in watts} \times \text{time in hours} \\ &= 10.3 \times 10 \\ &= 103 \text{ kilowatt hours} \end{aligned}$$

Electrical supply authorities use the kWh as the unit for measuring electrical energy to householders.

Revision Exercise

- 1 How much heat energy is converted by a 1kw heater in half a minute?
- 2 An electric toaster is rated at 500 watts. Determine the amount of heat energy it converts to heat in one minute.

In the calculations of energy so far the values of the power have been given.

However, if enough information is given the value of the power can be calculated first and then the value put into the energy formula.

Worked Example - Number 1

- Calculate the heat produced by an electric iron, which has a resistance of 30 ohms and takes a current of 3 amperes when it is switched on for 15 seconds.

$$\text{Energy} = \text{Power} \times \text{Time}$$

$$\begin{aligned}\text{Power} &= I^2 R \\ &= 3^2 \times 30 \\ &= 270 \text{ watts}\end{aligned}$$

$$\text{Energy} = \text{Power} \times \text{Time}$$

$$\begin{aligned}&= 270 \times 15 \\ &= 4050 \text{ joules}\end{aligned}$$

Worked Example - Number 2

A d-c generator has an e.m.f of 200 volts and provides a current of 10 amps. How much energy does it provide each minute?

$$\text{Energy} = \text{Power} \times \text{Time}$$

$$\begin{aligned}\text{Power} &= V \times I \\ &= 200 \times 10 \\ &= 2000 \text{ watts}\end{aligned}$$

$$\begin{aligned}\text{Energy} &= 2000 \times 60 \\ &= 120,000 \text{ Joules or } 120 \text{ kJ.}\end{aligned}$$