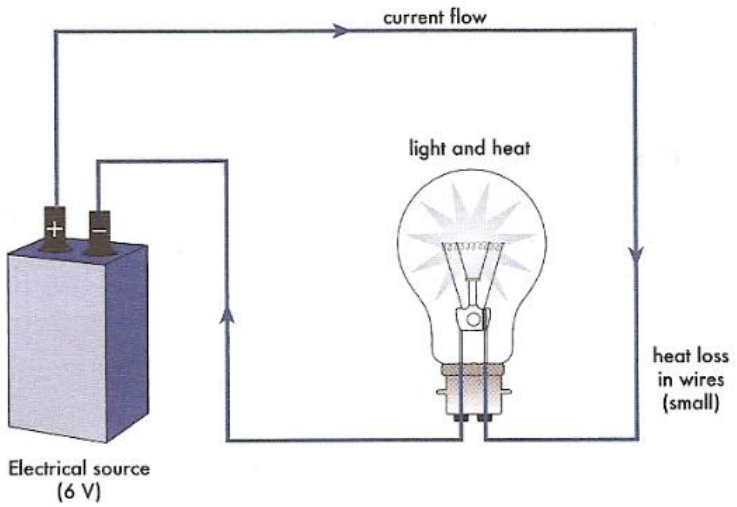
2012 Term 3 Week 7

Electrical Energy

Electrical Energy

- Chemical energy
- Electric potential energy
- KE due to attraction
- Collisions = vibrational energy
- Heat and light



Electrical Power

- Rate of doing work or releasing energy

$$P = VI$$

V = voltage (volts) *potential energy given to each coulomb of charge*

I = current (amperes) *number of coulombs of charge flowing per second*

P = power (watts) *rate of energy use*

Electrical Energy Used

- Energy consumed depends on:-
- Rate of energy use (rating)
- Time

$$E = Pt$$

E = Energy used (or work done), joules (J)

P = Power rating, Js^{-1} or watts (W)

V = Voltage supplied, volts (V)

t = Time, seconds (s)

$$E = VIt$$

V = Voltage supplied, volts (V)

I = Current, amperes (A)

kWh

- Kilowatt hours
- 13c per unit

$$1\ \text{kW} = 1000\ \text{J s}^{-1}$$

$$1\ \text{h} = 3600\ \text{s}$$

$$1\ \text{kWh} = 3600000\ \text{J}$$

$$= 3.60\ \text{MJ}$$

Example 1

A motor car's two headlights are each rated at 50.0 W and operate on a 12.0 V power supply. Calculate

The current flowing in each headlight when they are in use.

P = 50.0 W each light
V = 12.0 V
I = ?
q = ?
t = 2.00 h

$P = VI$

$I = \frac{P}{V} = \frac{50.0}{12.0} = 4.17\ A$ (for each light)

The charge passing through each globe every second.

$$q = It = (4.17)(1) = 4.17\ C$$

The total energy consumed by the two headlights during a 2.00 hour night journey.

$$E = Pt = (50)(2)(2.0 \times 60 \times 60)$$

$$= 7.20 \times 10^5\ J$$

Example 2 (4.5 mins)

What is the current drawn by a 1500 W electric kettle if it operates on a 240 V supply?

$P = 1500\ W$
$V = 240\ V$
$t = 4.5\ min$
$= 270\ s$

$P = VI$ $\qquad I = \frac{P}{V} = \frac{1500}{240} = 6.25\ A$

How much electrical energy (Joules) will it use if it is on for 4.50 minutes?

Calculate the cost of the energy used

$E = Pt$

$= (1500)(270)$

$= 4.05 \times 10^5\ J$

Calculate the cost of the energy used

$1\ kWh = 3.6 \times 10^6\ J$

No. of units of electricty used (kWh)

$= \frac{4.05 \times 10^5}{3.6 \times 10^6} = 0.113\ kWh$

$\therefore$ Cost = (units) $\times$ (12.67¢)

$= (0.113) \times (12.67¢) = 1.43¢$

Example 3

A 24 W car headlamp is connected to a 12 V car battery.
Assume the wires connecting the lamp to the battery have negligible resistance.

(a) How much energy will the lamp convert into light and heat energy in 2 hours?

(b) Find the total resistance of the lamp.

Number of seconds in 2 hours = 120 x 60 = 7200 s

$$E = P \times t = 24 \times 7200 = 172\,800 \text{ J} = \underline{\mathbf{172.8 \text{ kJ}}}$$

Rearrange the equation $P = \frac{V^2}{R}$, $R = \frac{V^2}{P}$ $= \frac{12^2}{24}$ $= \frac{144}{24} = \underline{6\,\Omega}$

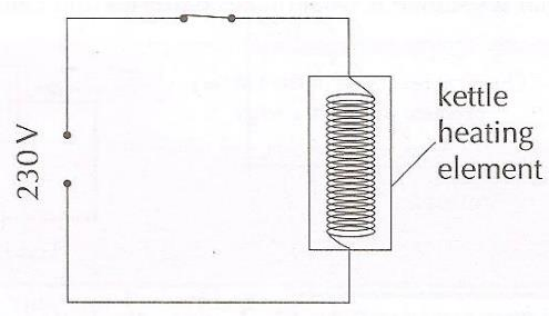
Example 5

Betty pops the kettle on to make a brew.
It takes 4.5 minutes for the kettle to boil the water inside it.

A current of 4 A flows through the kettle's heating element once it is connected to the mains (230 V).

(a) What is the power rating of the kettle?

(b) How much energy does the kettle's heating element transfer to the water in the time it takes to boil?



Example 5 continued

(a) What is the power rating of the kettle?

(a) Use $P = V \times I = 230 \times 4 = \underline{\mathbf{920\ W}}$

(b) How much energy does the kettle's heating element transfer to the water in the time it takes to boil?

Time the kettle takes to boil in seconds = $4.5 \times 60 = 270$ s.

Use the equation $E = Pt$ and your answer to part (a):

$E = 920 \times 270 = 248\,400$ J = $\underline{\mathbf{248.4\ kJ}}$

Example 6

- How much energy is dissipated by a resistor if a potential difference of 9.0V is applied to it for 331 seconds and a current of 0.23 A flows through it?

$$E = VIt$$

$$= 9.0 \times 0.23 \times 331$$

$$= \underline{\underline{690\ J}}$$

Example 7

- What is the current flowing through a bulb if it has a power of 100W when the potential difference supplied to it is 230V?

$$P = V I$$

$$I = \frac{P}{V} = \frac{100}{230} = \underline{\underline{0.43\ A}}$$

Example 8

- What is the power dissipated by a 32 ohm resistor when a current of 1.4 A flows through it?

$$P = I^2 R$$

$$= 1.4^2 \times 32$$

$$= \underline{\underline{63\ W}}$$