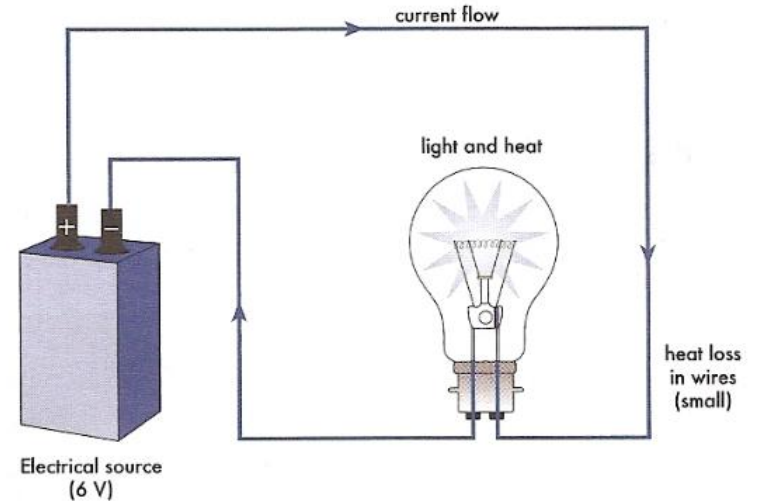


2015 Term 3 Week 9

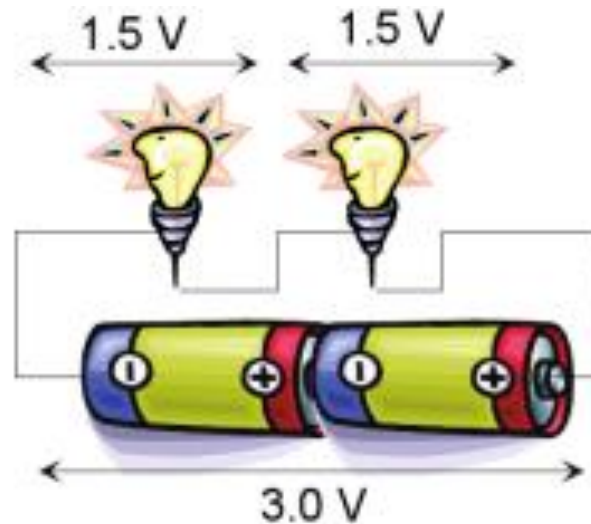
Electrical Energy

# Electrical Energy

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



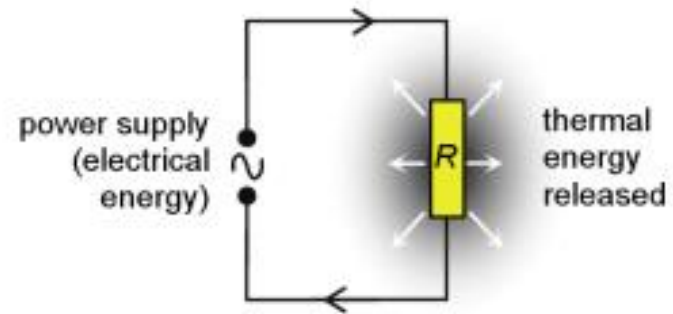
# Conservation of Energy



$$\Rightarrow \left[ \begin{array}{c} \mathbf{e.m.f.s} \\ \text{energy} \\ \text{per unit} \\ \text{charge} \\ \text{gained} \end{array} \right] = \left[ \begin{array}{c} \mathbf{p.d.s} \text{ across components} \\ \text{energy per unit charge} \\ \text{converted into other} \\ \text{forms in external circuit} \end{array} \right] + \left[ \begin{array}{c} \mathbf{lost voltages} \\ \text{energy per unit} \\ \text{charge wasted in} \\ \text{sources because of} \\ \text{internal resistances} \end{array} \right]$$

# Heating effect of electricity

Current flowing through a large resistor, converts electrical energy into heat (*thermal*) energy. This is the **heating effect of electric current**.



This *heating effect* concept is used in all the *heat-generating* household appliances such as electric kettle, ovens, heaters, iron, hair dryers, toasters and electric cookers etc.



# 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*

# Power

Power is the rate of doing work, which is a way of measuring the rate at which energy changes from one form into another. For example:

An electric aquarium heater gives out 12 J of heat energy every 2 s; its power output is  $6 \text{ J s}^{-1}$  or 6 W.

A 1000 W (1 kW) electric hair-drier converts 1000 J of electricity into heat every second.

$$P=IV$$

**P** is the power in watts (W)

**I** is the current in amperes (A)

**V** is the potential difference in volts (V)

# Combining

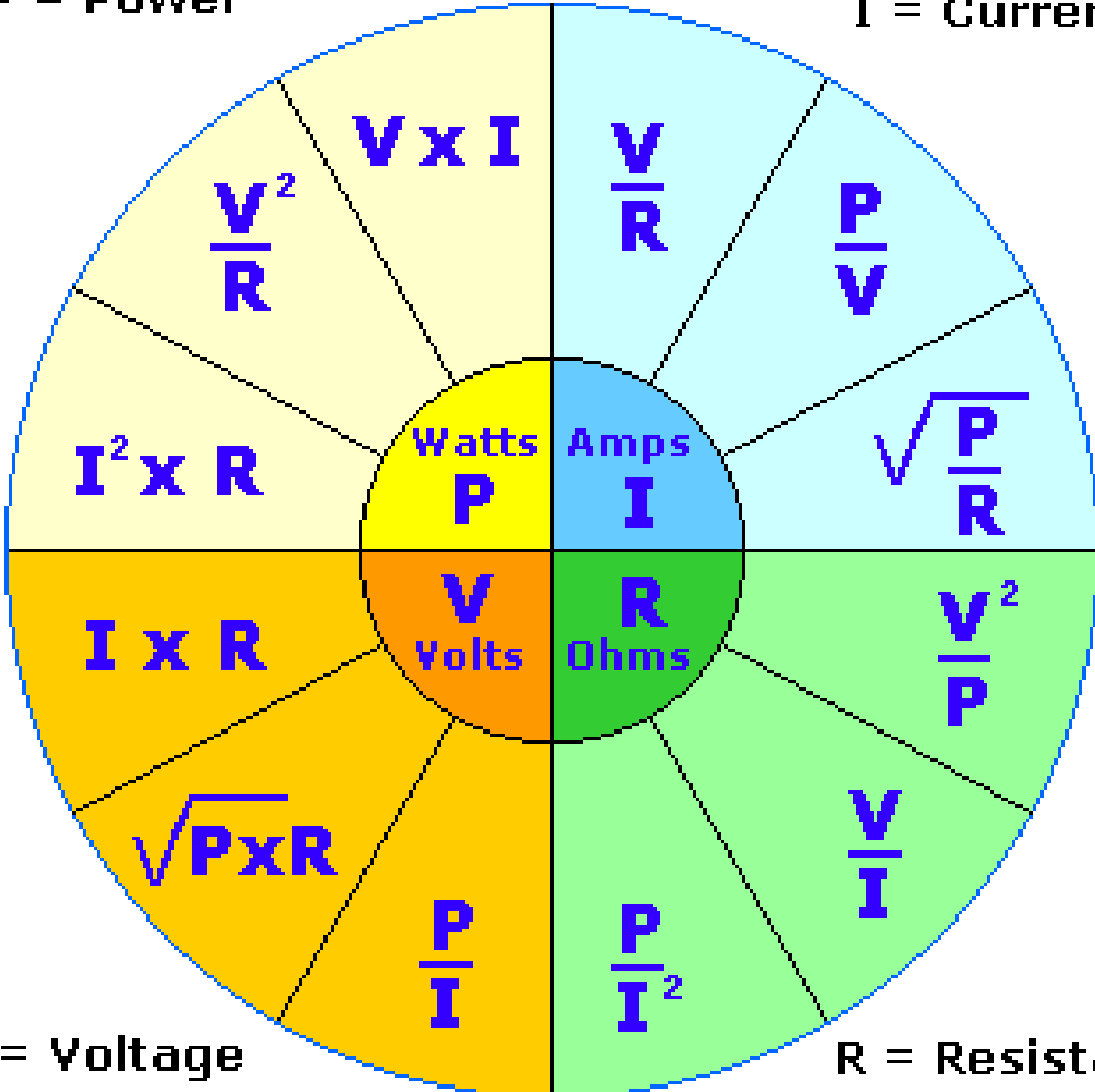
Combining with Ohm's Law,  $V = IR$ ,

$$P = I^2 R$$

$$P = \frac{V^2}{R}$$

**P = Power**

**I = Current**



**V = Voltage**

**R = Resistance**

# Electrical Energy

**Electrical energy = Power x Time:**

$$\mathbf{E = Pt}$$

$$\mathbf{E = IVt} \quad \mathbf{E = \frac{V^2 t}{R}} \quad \mathbf{E = I^2 Rt}$$

t is the time in seconds (s)

E is the energy in joules (J)

# 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,  $\text{Js}^{-1}$  or watts (W)

$V$  = Voltage supplied, volts (V)

$t$  = Time, seconds (s)

$$E = VIt$$

$V$  = Voltage supplied, volts (V)

$I$  = Current, amperes (A)

# Energy converted ( $E$ )

$$E = P \times t = I^2 R \times t = \frac{V^2}{R} \times t = VI \times t$$

$V$  = voltage applied across appliance

$I$  = current flowing through appliance

$R$  = total resistance of appliance

$t$  = total time taken

*kilowatt-hour* [kWh]

1 kWh  $\equiv$  (1000 W)  $\times$  (60  $\times$  60 s) = 3 600 000 J  $\equiv$  3600 kJ  
 $\equiv$  3.6 MJ *i.e.*, a power output of 1 kW operated for 1 hour.

# 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.

Time = 2hrs

$$P = 50.0 \text{ W each light}$$

$$V = 12.0 \text{ V}$$

$$I = ?$$

$$q = ?$$

$$t = 2.00 \text{ h}$$

$$P = VI$$

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

The charge passing through each globe every second.

$$q = It = (4.17)(1) = 4.17 \text{ C}$$

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

$$\begin{aligned} E &= Pt = (50)(2)(2.0 \times 60 \times 60) \\ &= 7.20 \times 10^5 \text{ J} \end{aligned}$$

## Example 2

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

$$P = 1500 \text{ W}$$

$$V = 240 \text{ V}$$

$$t = 4.5 \text{ min}$$

$$= 270 \text{ s}$$

$$P = VI$$

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

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

Calculate the cost of the energy used

$$E = Pt$$

$$= (1500)(270)$$

$$= 4.05 \times 10^5 \text{ J}$$

Calculate the cost of the energy used

$$1 \text{ kWh} = 3.6 \times 10^6 \text{ J}$$

No. of units of electricity used (kWh)

$$= \frac{4.05 \times 10^5}{3.6 \times 10^6} = 0.113 \text{ kWh} \quad \therefore \text{Cost} = (\text{units}) \times (12.67\text{¢})$$
$$= (0.113) \times (12.67\text{¢}) = 1.43\text{¢}$$