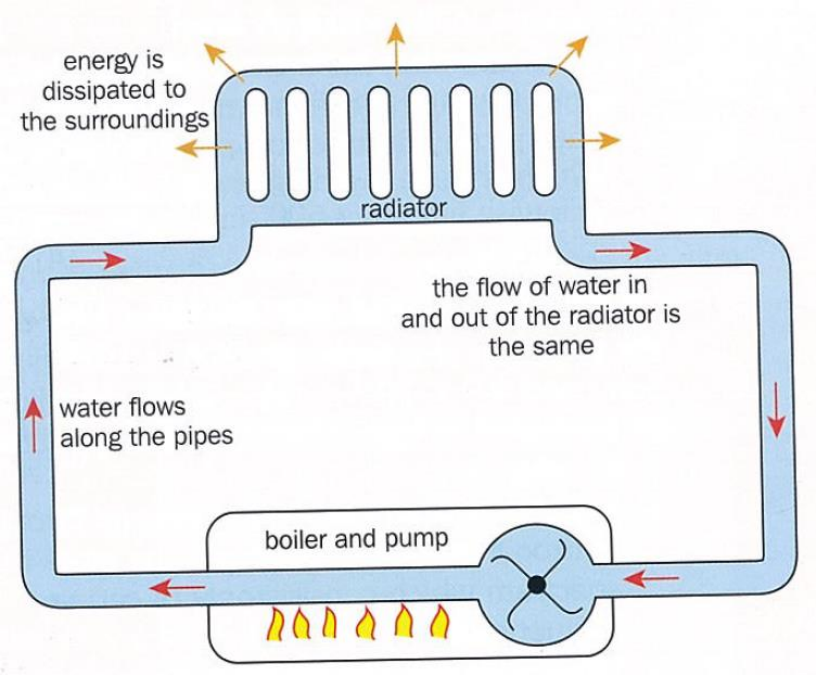
T3 Week 8

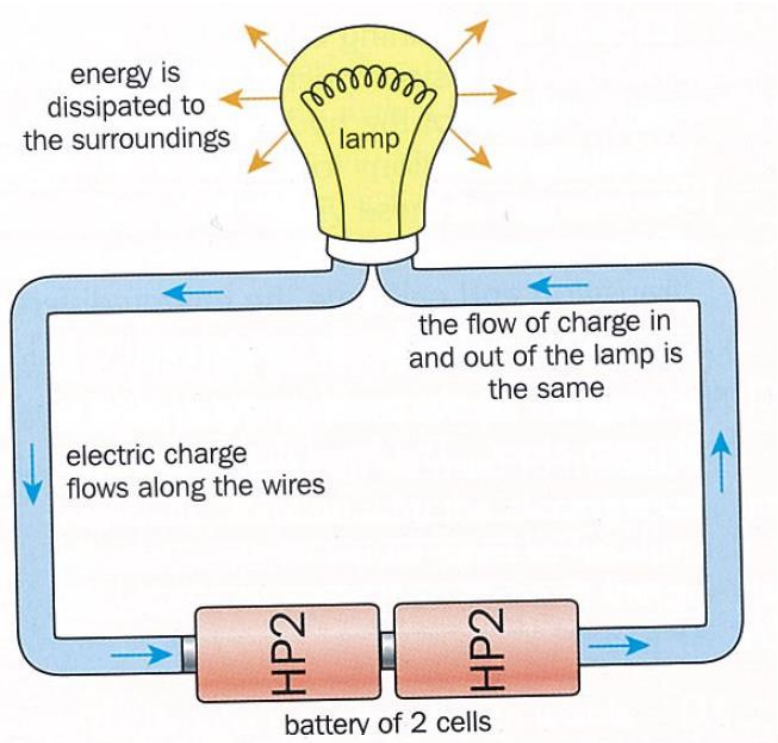
Current



Water flows around the complete loop of pipes.

The boiler transfers energy to the water and the pump keeps the water circulating round.

The radiator transfers energy from the hot water to the surroundings.



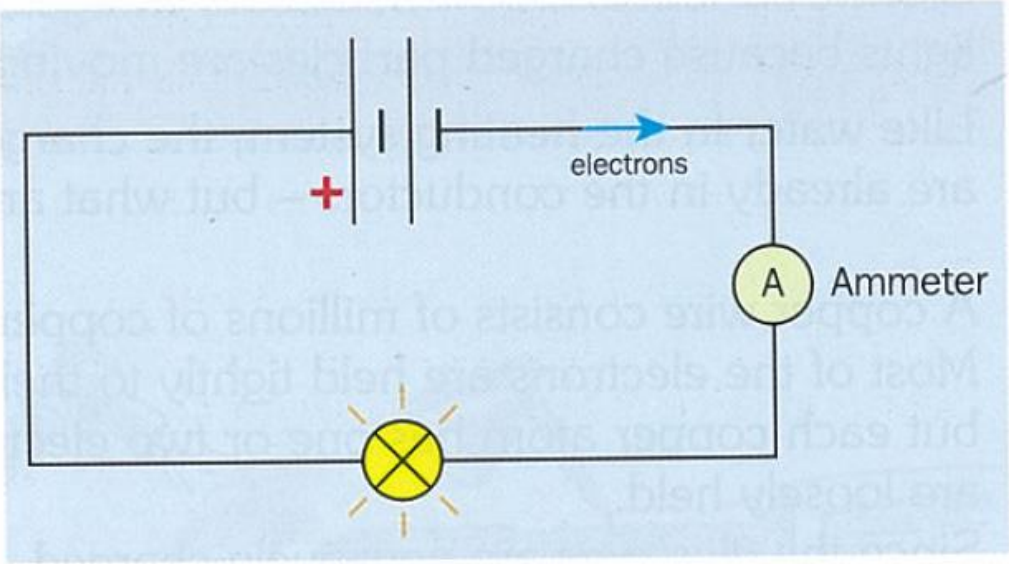
Charge flows around the complete conducting path.

The battery transfers energy to the charge and keeps it circulating round the circuit.

The lamp transfers energy to the surroundings as heat and light.

Electric Current

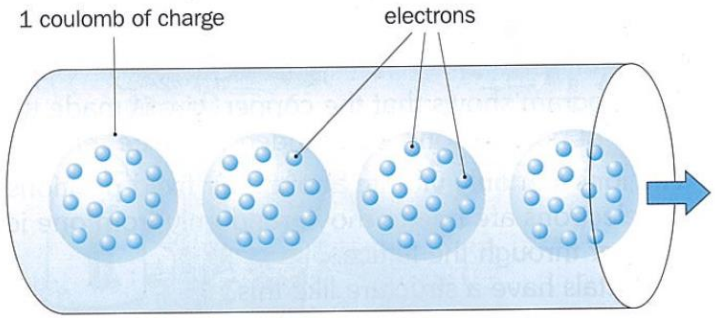
Current is measured in **amperes** (A)



The current throughout the circuit is the same.

1 amp is a flow of about 6×10^{18} electrons in each second

The charge on 1 electron is only $\mathbf{1.6 \times 10^{-19}\ C}$



Electric Current

$$\text{Current } I \text{ (amps)} = \frac{\text{charge } Q \text{ (coulombs)}}{\text{time } t \text{ (seconds)}} \quad \text{so} \quad Q = I\,t$$

1 coulomb is the amount of charge that passes a point when a current of 1 ampere flows for 1 second.

current is the rate of flow of charge

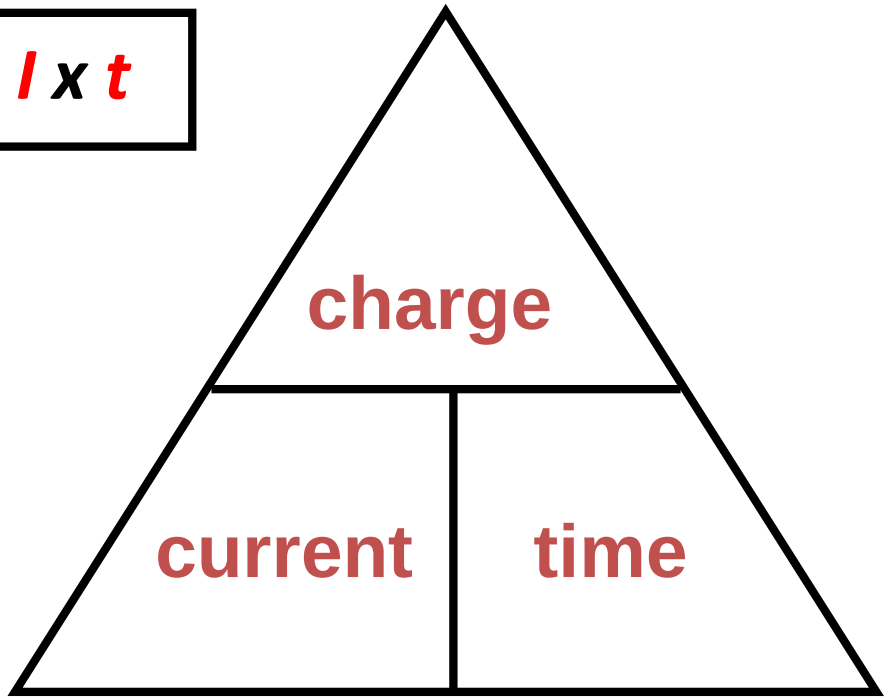
Charge-current equation

electric charge = current x time

$Q = I \times t$

also: $I = Q \div t$

and: $t = Q \div I$



Example

Calculate the charge passing through a device when a current of 500mA flows for 3 minutes.

Q = I x t

= 500 mA x 3 minutes

= 0.5A x 180s

charge = 90C

Example

Calculate the current flowing when a charge of 240C flows through a device in 80s.

I = Q ÷ t

$$\text{current} = \frac{240\ \text{C}}{80\text{s}}$$

current = 3A

Answers

Q	***I***	***t***
60 C	2 A	**30 s**
65 C	13 A	5 s
960 C	**3 A**	4 minutes
3 C	50 mA	**60 s**

Example

A current of 0.50 A passes through a lamp for 2.0 minutes.

a) How much charge passes through the lamp?

$Q = It$ (remember that t must be in seconds)

$Q = 0.50\ \text{A} \times 120\ \text{s} = 60\ \text{C}$

b) How many electrons pass through the lamp?

Each electron has a charge of 1.6×10^{-19} C

so 1 coulomb must contain $\frac{1}{1.6 \times 10^{-19}}$ electrons

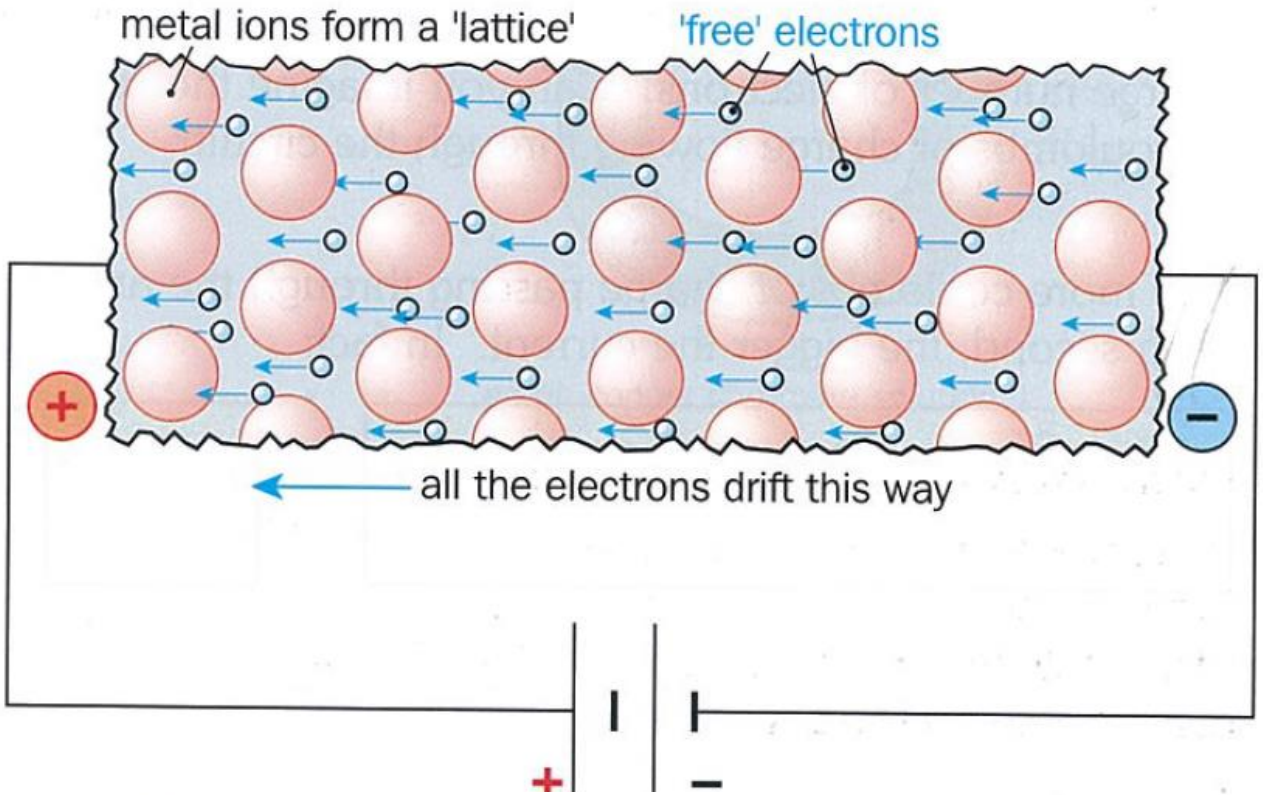
This is 6.25×10^{18} electrons

So in 60 C there are $60 \times 6.25 \times 10^{18}$ electrons

$= 3.8 \times 10^{20}$ electrons

What is Electric Current?

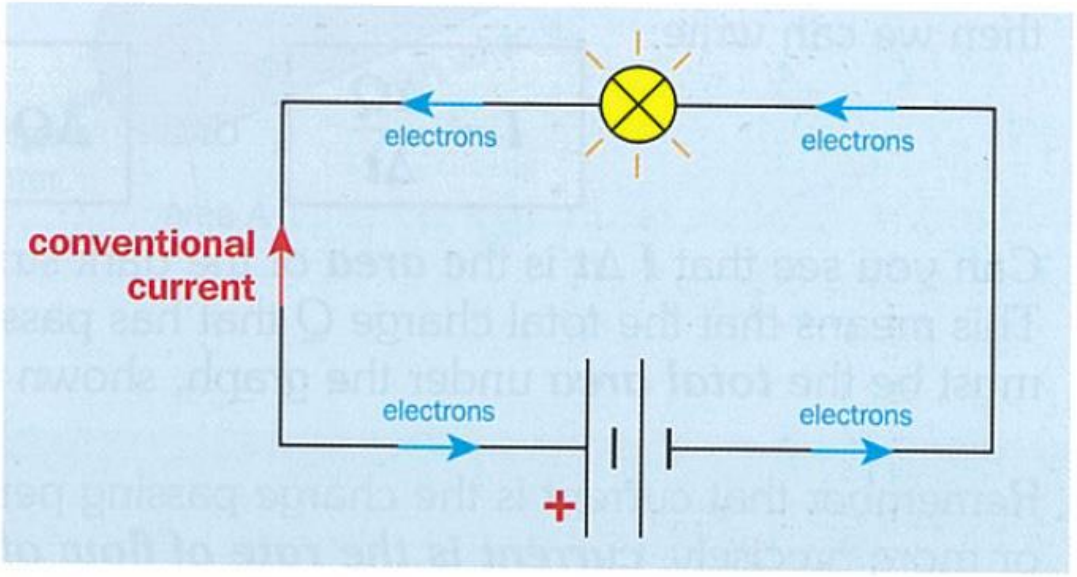
Electric current is a flow of electric charges.



drift velocity electric current

Which Way Do The Electrons Move?

- Orig. idea - current made up of positive charges mov. +ve to –ve
- JJ found that electrons flow the other way
- Conventional flow



Electrical conductors and insulators

An electrical conductor is a material through which electric current flows easily.

All metals are conductors.

Electrical insulators have a very high resistance to the flow of electric current.

Complete the table below:

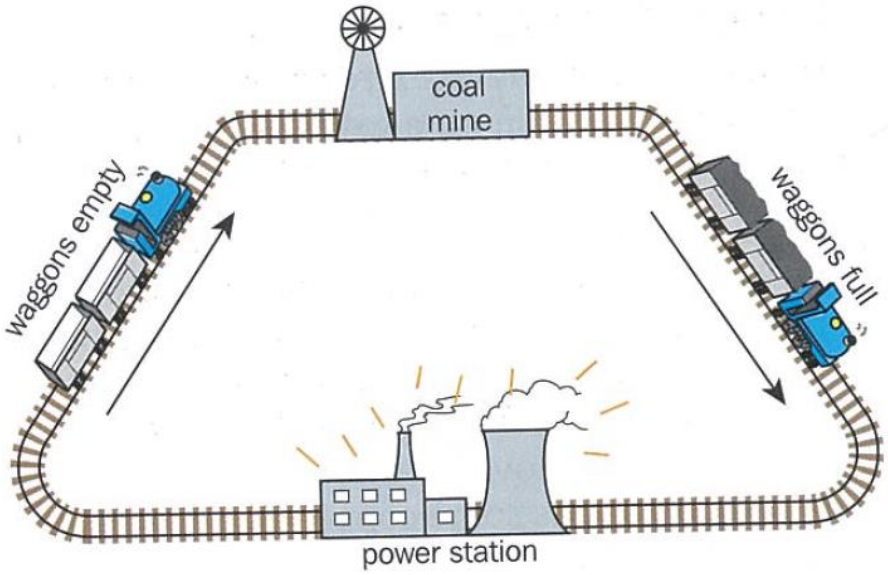
copper	conductor
rubber	1
steel	2
mercury	3
paper	insulator
plastic	4
diamond	5
graphite	6

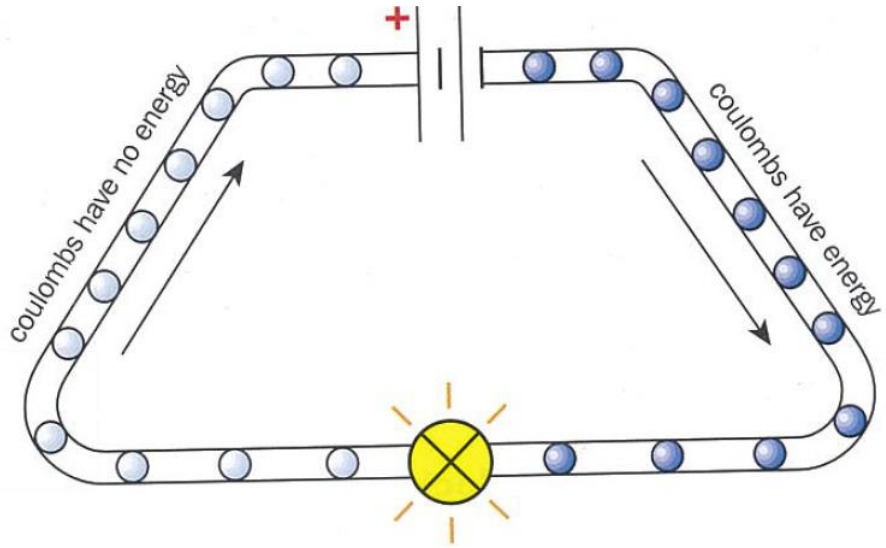
Conductors and Insulators

- Why? – the number of free electrons

Type of material	Number of free electrons per mm^3	n, number of free electrons per m^3
conductor	$\sim 1 \times 10^{20}$	$\sim 1 \times 10^{29}$
semiconductor	$\sim 1 \times 10^{10}$	$\sim 1 \times 10^{19}$
insulator	~ 1	$\sim 1 \times 10^{9}$

Energy Transfer & PD





In the circuit, each electron gains electrical potential energy as it moves through the battery. Each electron then transports this energy to the lamp.

The coulombs then return to the battery to collect more energy.

Voltage

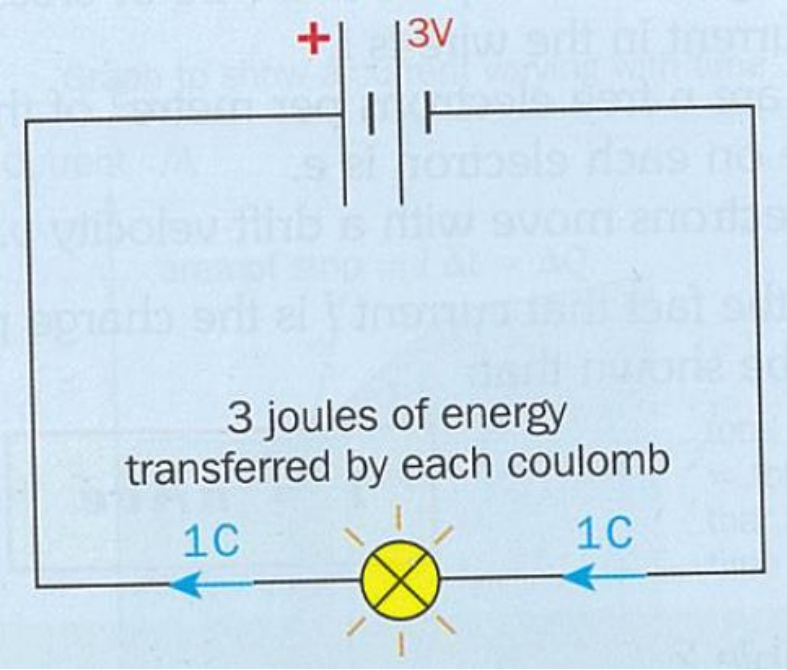
A battery gives electrical charge energy.

The **voltage** of a battery is equal to the **energy** in **joules** provided when a **charge** of **one coulomb** passes through the battery.

voltage = energy ÷ charge

1 volt is the same as 1 joule per coulomb

Potential Difference



The coulombs entering the lamp have electrical potential energy; those leaving have very little potential energy.

There is a **potential difference** (or p.d.) ***across*** the lamp, because the potential energy of each coulomb has been transferred to heat and light within the lamp.

The p.d. between two points is the electrical potential energy transferred to other forms, per coulomb of charge that passes between the two points.

The greater the p.d., the more energy transferred

PD

$$\text{p.d., } V \text{ (volts)} = \frac{\text{energy transferred, } W \text{ (joules)}}{\text{charge, } Q \text{ (coulombs)}}$$

or $V = \frac{W}{Q}$

or $W = Q\,V$

Example

Calculate the voltage of a battery if it supplies 300 joules of energy to 50C of charge.

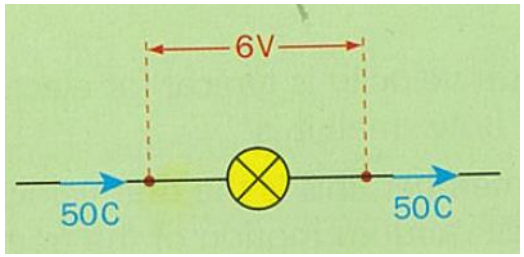
voltage = energy ÷ charge

$$= \frac{300\ \text{J}}{50\ \text{C}}$$

battery voltage = 6V

Example

In the circuit shown, the p.d. across the lamp is 6.0 V.
If 50 coulombs of charge pass through the lamp,
how much electrical energy is transferred to heat and light?



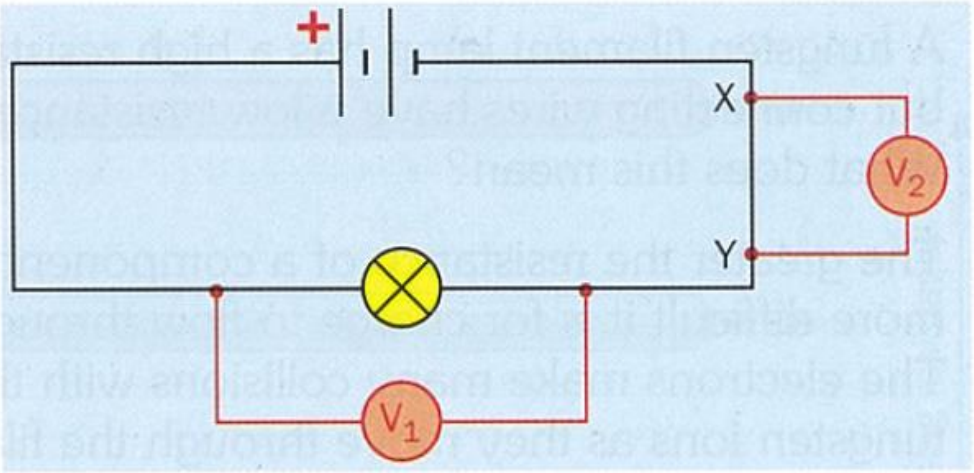
$$W = Q\,V$$

$$W = 50\ \text{C} \times 6.0\ \text{V} = 300\ \text{J}$$

Answers

Voltage	***Energy***	***Charge***
12V	480J	**40C**
20V	500J	25C
6V	**120J**	20C
230V	69kJ	**300C**

Measuring PD



voltmeter which is placed ***across*** the lamp

Voltmeter V_1 is measuring the difference in electrical energy between the coulombs entering the lamp and those leaving it.

The coulombs at Y have almost the same energy as those at X.

The moving electrons make far fewer collisions in the thick copper connecting wire than in the thin tungsten filament of the lamp, and so they don't lose much energy.

Choose appropriate words to fill in the gaps below:

Electric current is the rate of flow of electric charge **.**

Electric charge is measured in coulombs **.**

A battery provides electrical energy **. The amount of energy provided per** coulomb **of electric charge passing is equal to the** voltage **of the battery.**

The mains **supply gives 230** joules **to every coulomb of charge.**

WORD SELECTION:

coulombs charge mains joules

coulomb voltage energy