FORM 5 SPM PHYSICS SHORTHAND NOTES
Chapter 5 Electronics
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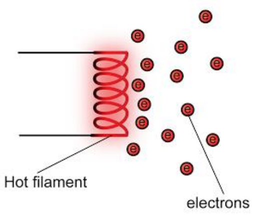
1.0 Electron

Cathode-ray tubes can be found in television screens and computer monitors. In laboratory, we use the crt in the oscilloscope to study waveforms. In SPM you must know

1) How crt is produced (Thermionic emission and electron gun)
2) The characteristics of crt
3) The structure of a Cathode Ray Oscilloscope
4) How to operate a Cathode Ray Oscilloscope
5) The uses of a Cathode Ray Oscilloscope

Thermionic Emission

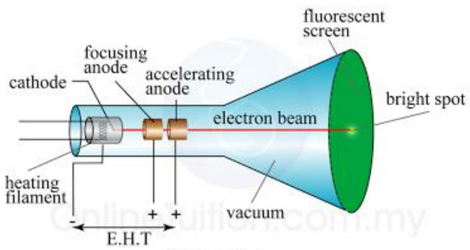


Thermionic emission is a process of emission of charge particle (known as thermion) from the surface of a heated metal. The charge particles are normally electrons.

Factors that affect the rate of thermionic emission:

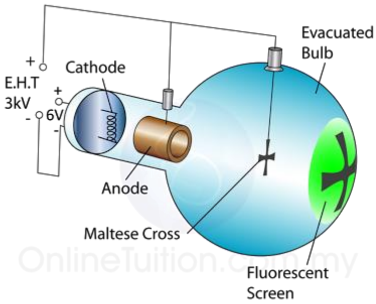
1) Surface area of metal
2) Temperature of metal
3) type of metal

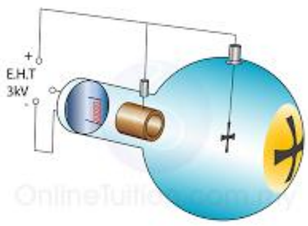
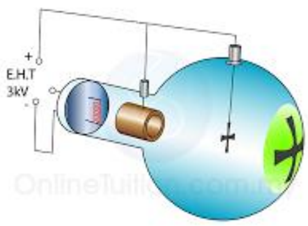
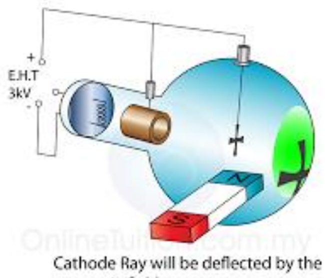
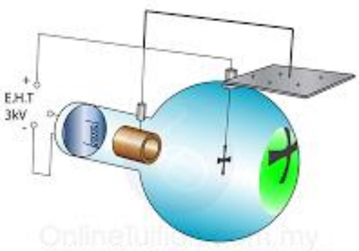
Electron Gun



Electron Gun

If a high positive (anode) is placed in front of the heated metal, the emitted electronics will accelerate and form a beam of electrons. The device is called an electron gun. The beam produced is called the cathode ray. We can use a Maltese cross tube to investigate the characteristics of cathode ray.

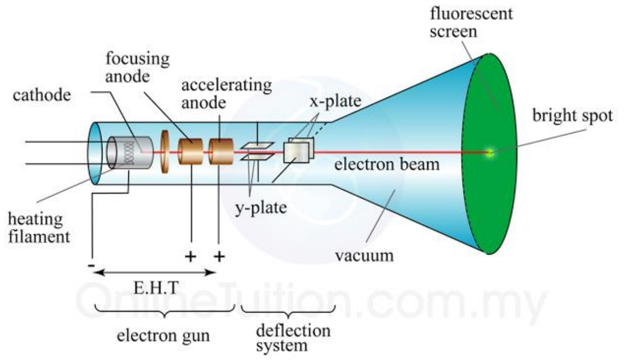


Action		Notes
6V DC Supply: ON 3kV EHT: OFF		The filament glows and emits light. The light is blocked by the cross and hence a shadow is formed on the screen
6V DC Supply: ON 3kV EHT: ON		The electrons are accelerated by the anode and hence produce a cathode ray. The cathode ray hit on the screen cause a fluorescent effect. The cathode ray is also block by the cross. Therefore, a shadow forms on the screen.
6V DC Supply: ON 3kV EHT: OFF with Magnet		The cathode ray can be deflected by the magnetic field. The direction of deflection can be determined by Fleming's LHR.
6V DC Supply: ON 3kV EHT: OFF with electric plate		The cathode can be deflected by an electric field.

Structure of CRO

3 main components:

1) The electron gun
2) The deflecting plates.
3) A fluorescent screen.



The electron gun

Parts of Electron Gun	Function
Filament	To heat the cathode
Cathode	Release electrons when heated by filament
Grid	The grid is connected to a negative potential. The more negative this potential, the more electrons will be repelled from the grid and fewer electrons will reach the anode and the screen. The number of electrons reaching the screen determines the brightness of the light. Hence, the negative potential of the grid can be used as a brightness control.
Focusing anode	The other feature in the electron gun is the use of the anode. The anode at positive potential accelerates the electrons and the electrons are focused into a fine beam as they pass through the anode
Accelerating anode	

The deflecting plates

Part of the deflecting system	Function
Y-plate	The Y-plates will cause deflection in the vertical direction when a voltage is applied across them.
X-plate	On the other hand, the X-plates will cause the electron beam to be defelctred in the horizontal direction if a voltage is applied across them.

The fluorescent screen

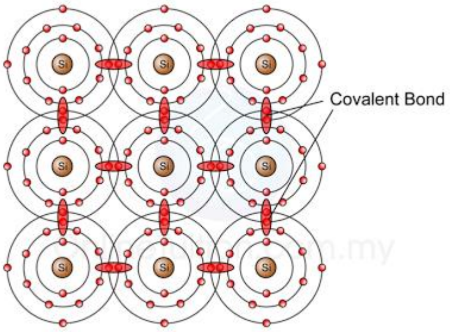
1) The screen is coated with a fluorescent salt, for e.g. zinc sulphide.
2) When electrons hit the screen, it will excite the salt ions to produce a flash of light.

Uses of Cathode Ray Oscilloscope

1) Measure potential difference
2) Measure short time interval
3) Display different types of wave form.

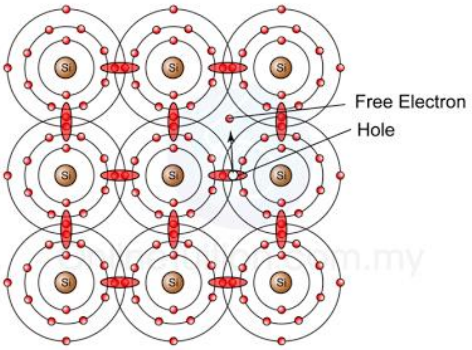
Semiconductor

Semiconductor is a class of crystalline solid with conductivity between a conductor and an insulator. Examples of semiconductors are silicon, germanium, boron, tellurium and selenium.

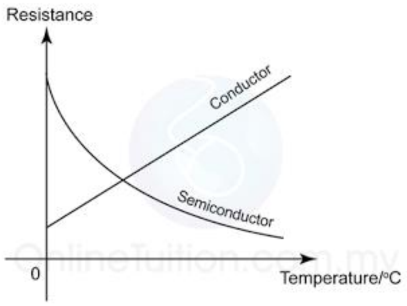


A silicon semiconductor has 4 valence electrons. Each of these 4 electrons are shared with another 4 silicon atoms to form 4 pairs of covalent bond. The bonded valence electrons are not free to move. Therefore it’s not a good conductor at room temperature. At room temperature, a silicone crystal acts approximately like an insulator because only a few free electrons and holes are presence.

Free electron and hole



If a bonded electron absorbs heat energy from the surrounding, it may be promoted to a higher energy level. These electrons are free to move when they are at a higher energy level. If an electron is promoted to a higher level, a vacancy is left in the valence shell, and it is called a hole. A hole has the tendency to pull electrons therefore it carries a positive charge. Both free electrons and holes can help to conduct electric current making the semiconductor conducive. As the temperature increases, more electrons get promoted thus creating more holes. Therefore, it can be said that conductivity increase as the temperature increases.

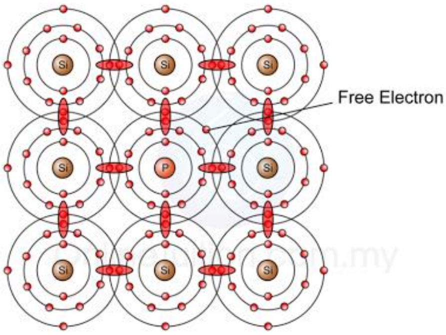


Since electrons carry a negative charge and holes carry a positive charge, when a potential difference is applied to the semiconductor, the electrons and holes will start to flow. The electrons will flow to the negative terminal while holes will flow to the positive terminal.

Doping a semiconductor

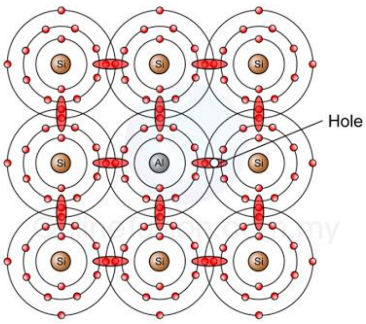
One way to increase the conductivity of a semiconductor is by doping. Doping is the a process of adding a small amount of impurities to a semiconductor called *dopants*. Semiconductors are named after the types of impurities doped

1) *the n-type semiconductor*



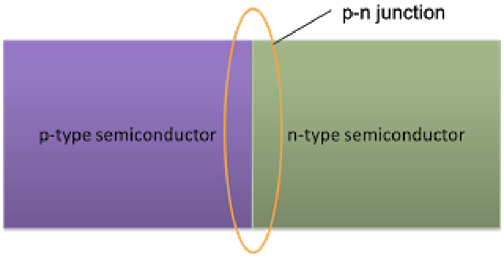
Produced by doping pentavalent atoms into a semiconductor. Form ________ covalent bonds with the silicon atoms around. Since pentavalence atom has 5 electrons, there is ______electron left over and it is a free electron. More pentavalance means greater conductivity for the semiconductor. Since negative charge carrier (the electrons) outnumber the positive charge carrier (the holes), the semiconductor is called an n-type semiconductor, where n stands for negative.

2) *the p-type semiconductor*



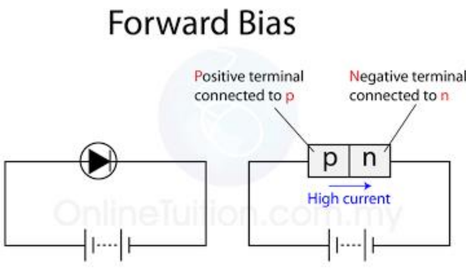
Produced by doping ____________ atoms into a semiconductor. Forms _______ covalent bonds with the silicon atoms around. Since the trivalent atom has only three valence electrons and each neighbour shares one electron, only seven electrons are in the valence orbit. This means a hole exists in the valence orbit of each trivalent atom. The more trivalent impurities that is added, the greater the conductivity of the semiconductor. Since the _____________ carrier outnumber the __________ carrier, the semiconductor is called a p-type of semiconductor, where the p stands for positive.

2.0 Semiconductor Diodes

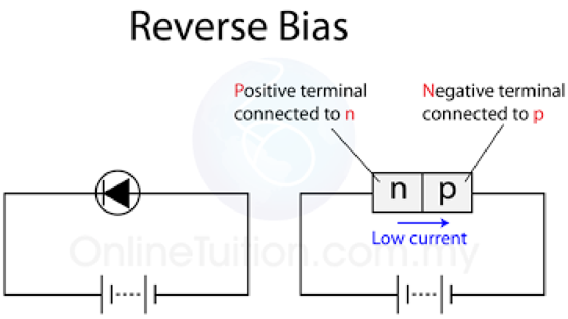


We can produce a single crystal with p-type semiconductor on one side and n-type on the other side. The border where both regions meet is called the p-n junction. At the junction, electrons from the n-type semiconductor will be attracted to the holes in the p-type semiconductor. As a result the holes and electrons at the junction disappear, forming a depletion layer. At the same time the p-type semiconductor becomes more negative and the n-type becomes more positive. This results in potential difference across the p-n junction. This potential difference is called the junction voltage. The junction voltage prevents the charge carrier from flowing across the depletion layer.

Forward bias

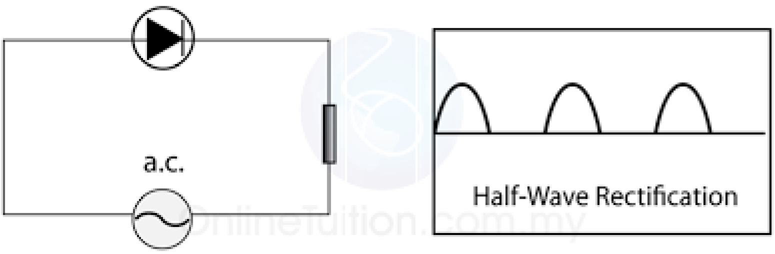


In a forward bias arrangement, the negative source is connected to the n-type material and vice versa. Current has no problem flowing in a forward-biased silicone diode.

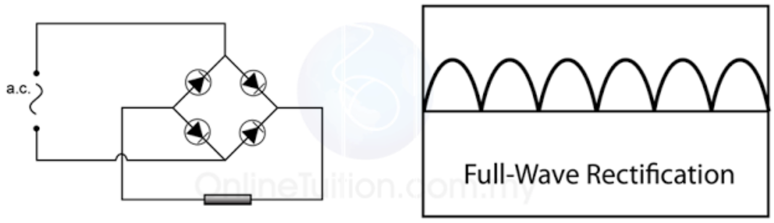


If you turn the dc source around, you will get reverse-bias arrangement………….. The negative battery terminal attracts the holes while the positive terminal attracts the electrons. Because of this the electrons and holes flow away from the junction widening the depletion layer.

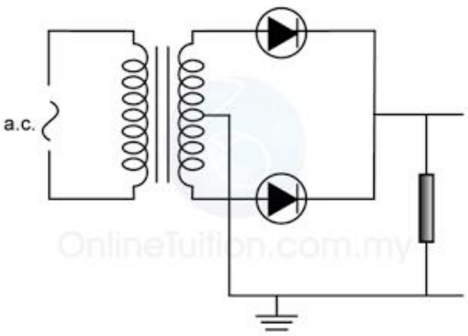
So you might at this point think why do we need this……… We need this for something called half-wave rectification. Diodes are known commonly as rectifiers. They can be used to change a.c. to d.c. The image below shows how a diode allows only the positive half of the original a.c. current to pass through.



You might be asking at this point if there is a half-wave rectification is there a full-wave rectification? As it turns out, there is…..



This can be done using a bridge rectifier or using a transformer and two diodes shown below

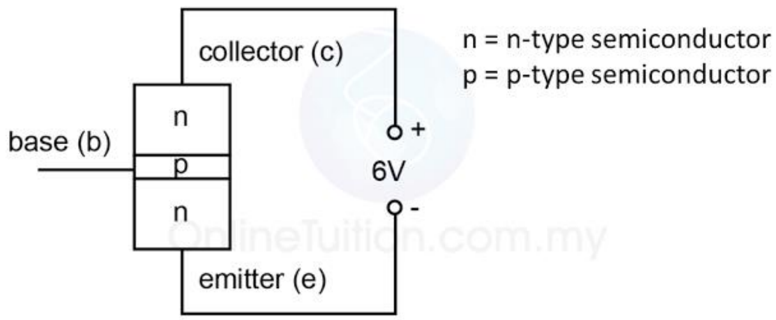


After which we can smoothen the peaks using a capacitor. A capacitor charges up when current flows from the diode, then discharges through the load when the current from the diode is zero. Now the current is finally useful.

3.0 Transistors

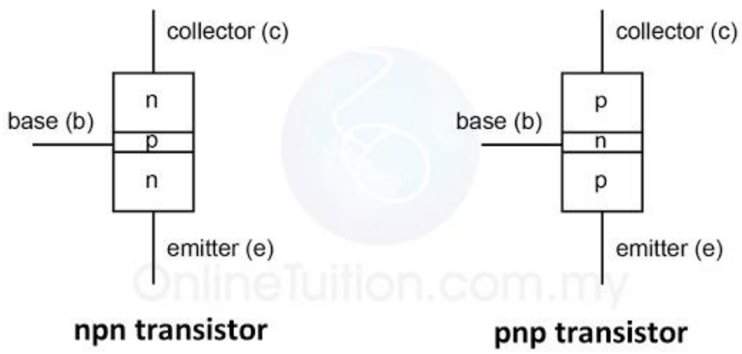
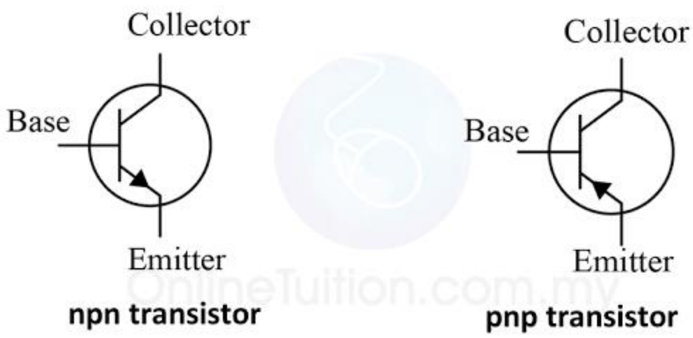
Another application of semiconductors are transistors. A transistor consists of

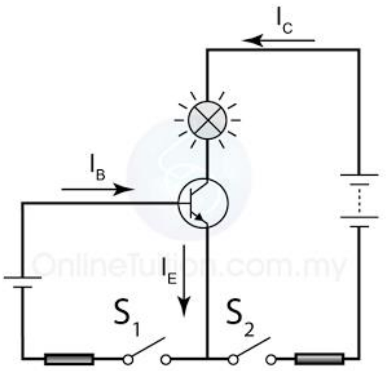
a) the emitter (e),
b) the base (b)
c) the collector (c)



In a transistor, the emitter emits charge carriers (free electrons or holes). The charge carriers move towards the base. The charge carriers will then pass through the thin base layer and to be collected by the collector. There are 2 types of transistors:

a) npn transistor
b) pnp transistor

npn transistor	pnp transistor
	
	



From the figure above you can see two circuits; the base and collector circuit.

S1	S2	B1	B2
Open	Open	Does not light up	Does not light up
Close	Open	Light up	Does not light up
Open	Close	Does not light up	Does not light up
Close	Close	Light up	Light up

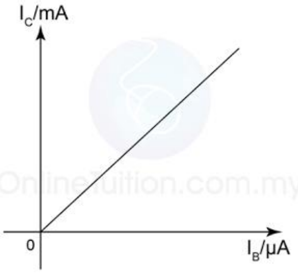
Basically what the above table is showing is that the collector circuit is controlled by the base circuit. Current will flow in the collector circuit when there is current going through the base. However, when base current, I_B is zero the collector current, I_C is automatically zero as well. In general,

$$I_E = I_B + I_C$$

where I_E is the emitter current. Another thing is that

$$I_E > I_C > I_B$$

The most important role of a transistor is current amplification. A transistor can be used to amplify current changes because a small change in the base current, I_B produces a large change in collector current, I_C. The following graph shows the relationship between the base current and collector current:



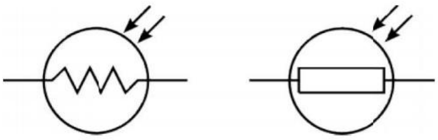
The ratio of I_B/I_C is called the amplification factor.

$$Amplifcation\ Factor = \frac{I_C}{I_B}$$

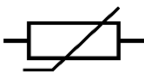
Applications of transistor:

1) Sound amplifier
2) Automatic switch

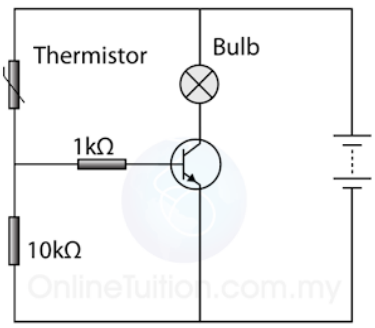
A **light-dependent resistor (LDR)** is a type of resistor whose **resistance changes** with **intensity of light**. Its resistance will increase if the intensity of light is low and vice versa. Shown below is the symbol for LDR

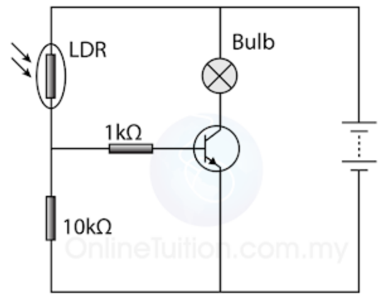


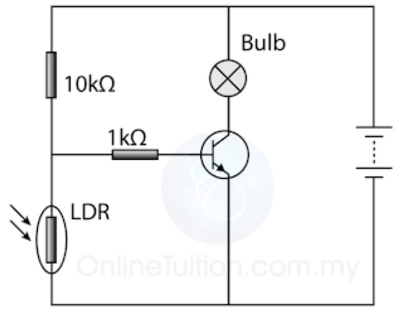
A **thermistor** is a resistor which **resistance changes** with its **surrounding temperature**. The resistance of a thermistor is high in surroundings of a low temperature, and low in surroundings of high temperature.



From the circuit below, when the surrounding temperature increases, the resistance of the thermistor will decrease. This will cause the base voltage (voltage across the 1kΩ resistor) to increase and exceed the minimum voltage, switching on the transistor. Current the flows through the bulb to light it up.







In which circuit above will the light bulb switch on when it is dark?