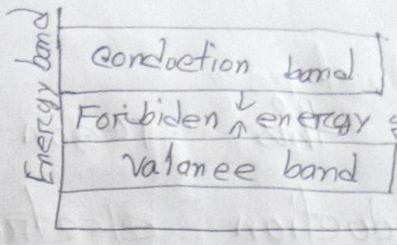
⊞ Valanee band :



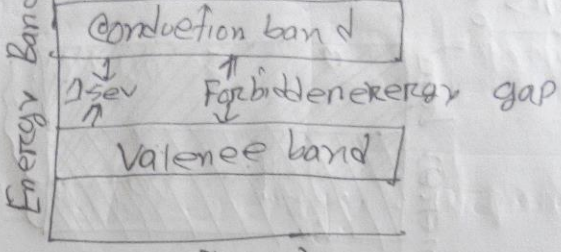
⇒ The range of energy prossessed by Valanee eletrons is known as valenee band the electrons in the outrmost orbit of an atom are known as valenee electrons. In a normal atom valenee band has the electron of highest energy this band may be completely or partially filled.

Condoetion band : In certain materials the valenee electrons are lossely attaeted to the nueleus even at ordinary temperature some of the Valenee electron may get detaehed to beeames free electrons. In faet it is these free electrons which are responsible for the condoetion of current in a conduetor.

For this reson they are called conduction electron, the range of energies possessed by conduction band electrons is known as conduction band.

Forbiden energy gap : The separation between conduction band and Valence band on the energy level diagram is know as forbidden energy gap.

Insolators:



Fig(1)

⇒ Insulators (e.g. wood, glass, etc) are those substene which do not allow the Passage of electric current through them. In terms of energy band the Valenee band is full while the conduction band is empty. Further the energy gap between valenee band and conduction band is very large ($\simeq$ 15 ev) and shown is fig(1).

Conductors:

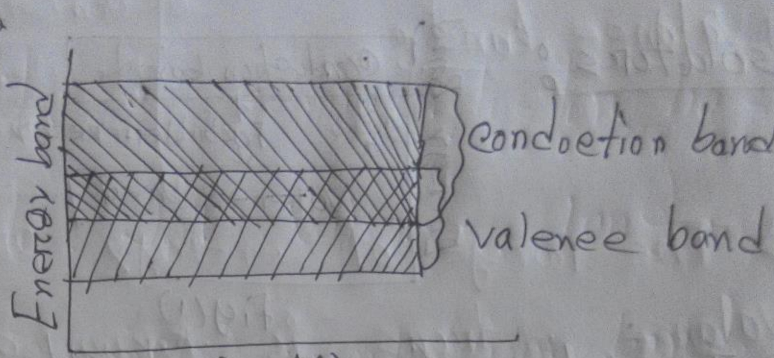


Fig (ii)

⇒ Conductors (e.g copper, aluminium) are those substance which easily allow the passage of electric current through them. It is because there are a large number of free electrons available in a conductor. In terms of energy band the valence band and conduction's band overlap each other, as shown is fig (ii) semiconductors

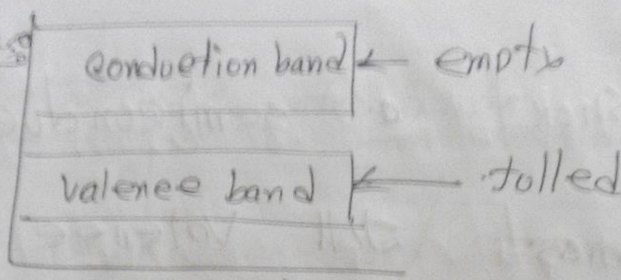


Fig (iii)

⇒ semiconductors (e.g germainum, silicon, etc) are those substance whose electrical conductivity lies is between conductors and insulators in terms of energy band of the valence band is almost filled and conduction band is almost empty. Further the energy gap between valence band and conduction band is very small. as shown in fig(iii)

Therefore comparatively smaller electric field is required to push the electrons from the valence band to the conduction band.

In short a semiconductor has

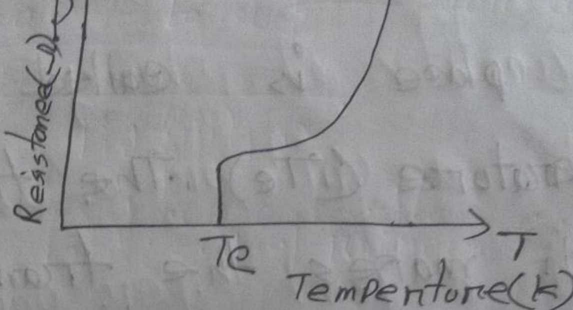
① almost full valence band.

② almost empty conduction band.

③ small energy gap ($\simeq 1eV$) between and conduction band.

17 -10

Super conductivity : (অতিপরিবাহিতা)



Super conductivity was first observed In 1911 Dutch physicist kamerlingh omes. omes in the course of his experiment on the electrical conductivies of metal at low temperatures he observed that as purified mercury is called its resistivity. vanished obruplly at 4.2 K fig(1) above this temperature the resistivity is small but finite, while the resistivity below this point is so small that it is essentially zero.

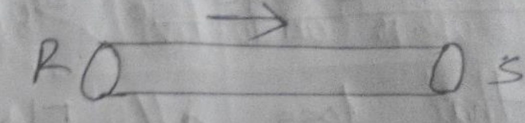
The temperature at which the transition takes place is called the critical temperature (Te). The temperature (Te) which makes the transition of a normal conductor to the suppercondoc tivity. State is defined at the transition tempercator above the critrical temperature (Te) the substone in the familier normal state bot loe low (Te) centers on entirely ditterent super condoctivity. state the Phenomenon is called supercondoctivity.

Super condoct : super conductor matarial that loss all Electrical resistonce at low temparature, recent reseach math discovered matarials are super condoctivity surpering high temparcture.

19-10-17

Electric corrent: The amount of charge flowing per second in a particular direction along the normal to the cross-sectrinal area of a conductor is called current. current is denoted by I.

Current density:



The quantity of charge that flows through a unit area of cross-section around a point per unit time is called current density. It is denoted by J. Current density is a vector density.

Let RS is a conductor having uniform cross-section its cross-sectional area is A the flow of current along the cross sectional area of the conductor

$\propto I$ where,

J = current density

I = current

A = Area of cross-sectional.

unit of the current density $J = \frac{I}{A}$

$= \frac{A}{m^2}$

In vector form,

$$i = \int \vec{J} \cdot \vec{ds} = J \int \bar{ds} = \bar{J} \cdot \bar{A}$$

where $\int \bar{dJ} = \bar{A}$

unit of the current density $J = \frac{I}{A}$

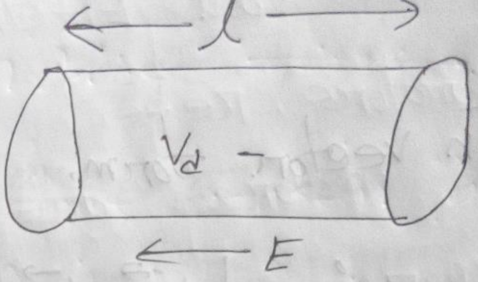
$$= \frac{A}{m^2}$$

In vector form,

$$i = \int \vec{J} \cdot d\vec{s} = J \int d\bar{s} = \bar{J} \cdot \bar{A}$$

where $\int d\bar{s} = \bar{A}$

Drift velocity :



A potential difference between the two ends of the conductor is esstalished the free electrons drift towards E that is oppside to the Electric field inside the unductor with and average speed this avarage speed is known as drift velocity. It denoted by V_d.

Find an equation for drify veloeity when an electric field is applied on the conductor. Relation between current density and drift veloeity.

⇒ let us consider a conductor of lenght l and cross-sectional area A. The electrons moves with wish avarage veloeity v_0 toward $-E$ if n it the number of electron per unit volume of the conductor then the to number of electron inside volume Ai is given by $v = nAl$ —— ①

To charge flowing inside the condoetor

$q = ive$ —— (ii) [Here e charge of electron.

From eqv (ii) and (i)

$$q = nAle \quad \text{—— (iii)}$$

The avarage time taken by the electrons to travel through the Condoetor is

$$t = \frac{l}{v_d}$$

we know

$$i = \frac{q}{t}$$

$$\text{or} = \frac{nAle}{l/v_d} = \frac{nAlev_d}{l}$$

$$i = nAev_d$$

again we know current.

$$J = \frac{i}{A}$$

$$J = \frac{nAev_d}{A}$$

$$J = nev_d$$

$$v_d = \frac{J}{ne}$$

29-10

Resistance :

The poperty of a substance due to which opposes the flow of electricity through it is called resistence. It is denoted by R. It can be measured by the ohm's low.

According to ohm's low

$$I = \frac{V}{R}$$

$$\therefore R = \frac{V}{I}$$

where $R \rightarrow$ Resistance, $V \rightarrow$ Potential difference, I = current

The unit of the resistance is ohm (Ω)

Resistivity / specific resistance :

The electrical resistance of a conductor is directly proportional to the length of the conductor and inversely propotional to the cross-sectional area of the conductor. This relation expressed by

$$R \propto \frac{l}{A}$$

$$\text{or } R = \frac{\rho l}{A}$$

where : ρ (Row) is called the resistivity of the material.

$$\rho = \frac{RA}{l}$$

where $l \rightarrow$ is length of the conductor
$A \rightarrow$ Aare of the conductor $R \rightarrow$ Resistance

Conductivity : Conductivity is the Proporty of a conductor by means of which it allowed the current of flow through the conductor when a potential difference is applied across the conductor it is the reciprocal of resistivity and its represented by σ.

$$\sigma = \frac{1}{\rho}$$

The unit of the conductivity is $ohm^{-1} . meter^{-1}$.

Ohm's low of condoctivity :

Soln : It is experimentally that in a metallic conductor at constant temperature the current density J is a linearly proportional to the eletric field $\vec{E}$ thus

$$\vec{J} = 6\vec{E} \quad \text{—— ①}$$

The equation $\vec{J} = 6\vec{E}$ is general vector statement of Ohm's low. Here 6 is a constant it's called the condoctvity of the conductor. The reciprocal of the condoctivity is called the resistivity ρ.

Interms of ρ equation ① can be write

$$\vec{E} = \rho \vec{J} \qquad \text{—— (ii)}$$

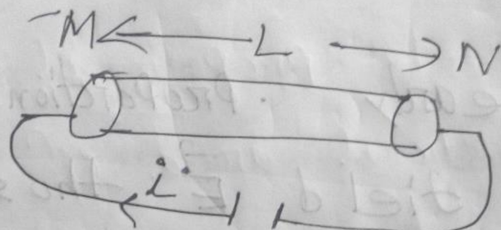


Fig: (1)

in fig (1) the electric field along the rod is in the direction mn and its value is $E = \frac{V}{L}$ every where here V is total potential drop from M to N then,

$$J = 6\left(\frac{V}{L}\right)$$

The total current $i = JA = \frac{\sigma VA}{L}$

Here A is the cross-sectional area of the rod. this leads to

$$\frac{V}{i} = \frac{L}{\sigma A} = \frac{\rho L}{A} \quad \text{——— (iii)}$$

The ratio $\frac{V}{i}$ is called the resistence R.

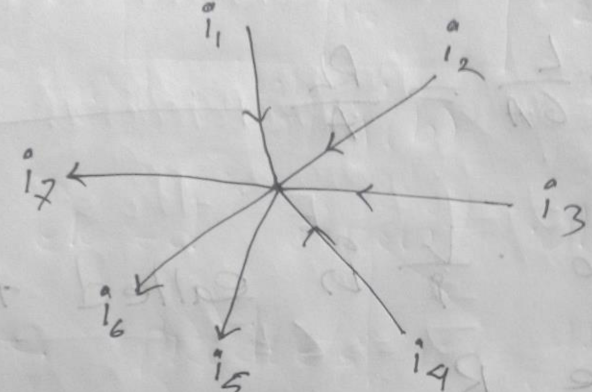
$$R = \frac{\rho L}{A}$$

From equation (iii)

$$V = iR$$

* state and explain Kirchhoff's low in a network.

1st low or current low :



In any electrical network the algebric sum of current meating at a Junction is always zero.

$$i.e \cdot \sum i = 0$$

Explain: let us consider a Jonction that i_1, i_2, i_3, i_4, i_5, i_6, i_7 and i_λ current are ditfereeen between fig(1) and meeting at a point taking the current following away from the Jonction as negative the currents following towards the Jonction we get-

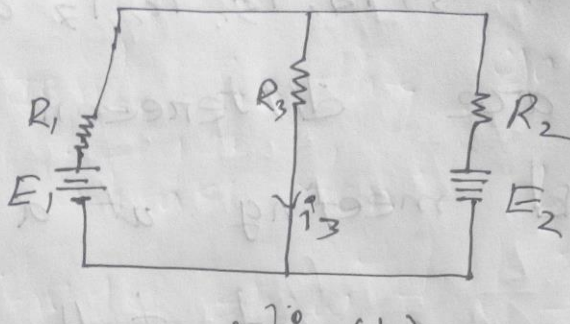
$$i_1 + i_2 + i_3 + i_4 = -I_5 - I_6 - i_7 = 0$$

$$i_1 + i_2 + i_3 + i_4 = I_5 + I_6 + I_7$$

i.e incoming currents = out going currents

Total current intering any Jonetio not a circuit equals the total current learing that Jonetion.

2nd low or voltage low :



Fig(b)

In a closed circuit algebric sum of the products of the current and resistance of the each part of the circuit is equal to the total emfs acting in the circuit.

$$\text{i.e,} \quad \sum iR = \sum E$$

Explain: In the fig (b) we see that closed circuit formed by E_1, E_2 R_1, R_2 and E_1 we have according to second law.

$$E_1 - E_2 = i_1 R_1 - i_2 R_2$$

and also for the closed circuit formed by E_1, R_1 R_3 and E_1 we have

$$E_1 = I_1 R_1 + I_3 R_3$$

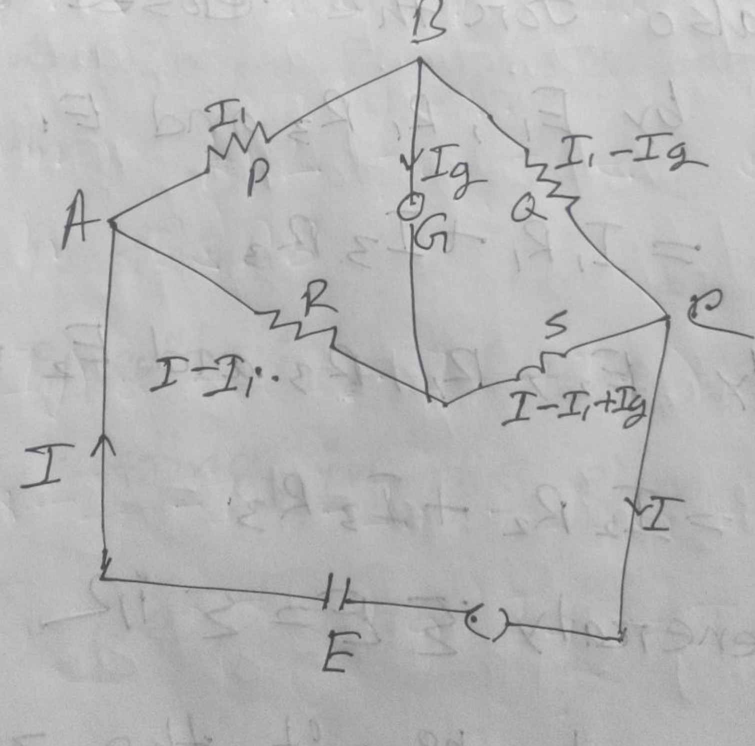
Similarly E_2, R_1, R_3 and E_2 we have

$$E_2 = I_2 R_2 + I_3 R_3$$

In generaly $\Sigma E = \Sigma iR$

In a closed circuit the 2nd law is also called loop theorem.

☐ Wheas tones Network for balance condition or Find the expression for current in the galvanometers in a wheas ton's brige network and hence show that $\frac{P}{Q} = \frac{R}{S}$



fig(1)

Sol^n: Four resistance P, Q, S and R from closed network ABCD fig(1). A cell of emf E is connected between A and C, A galvanometer of resistance G is connected between B and D. let I be the ω along E, A, I along AB and I_g along BD.

By kirchhoffs first low the current along the various branches will be as shown. we can obtain an expression for the current through The galvanometer I_g by applying kirchhoffs voltage low (KVL)

Applying KVL to the closed mesh A, B, D, A

$$I_1 P + I_g G - (I - I_1) R = 0$$

$$I_1 P + I_g G - IR + I_1 R = 0$$

$$(P+R) I_1 + G I_g = IR \quad \text{—— (1)}$$

Applying KVL to the closed mesh BCDB

$$(I_1 - I_g) Q - (I - I_1 + I_g) S - I_g G =$$

$$I_1 Q - I_g Q - IS - I_1 S - I_g S - I_g G = 0$$

$$(Q+S) I_1 - (Q+S+G) I_g = IS \quad \text{—— (2)}$$

Multiply eqn (i) by $(Q+S)$

$$(P+R)(Q+S)I_1 + G(Q+S)I_g = R(Q+S)I \quad \text{—— (iii)}$$

Multiplying eqn (ii) by $(P+R)$

$$(P+R)(R+S)I_1 - (P+R)(Q+S+G)I_g = I(P+R)S \quad \text{—— (iv)}$$

Subtracting eqn (iv) from eqn (iii)

$$[G(Q+S)+(P+R)(Q+S+G)]\,I_g = [R(Q+S) - S(P+R)]\,I$$

$$I_g = \frac{(QR-PS)I}{G(P+Q+R+S)+(P+R)(Q+S)} \quad \text{——}$$

Condition for balance is $I_g = 0$

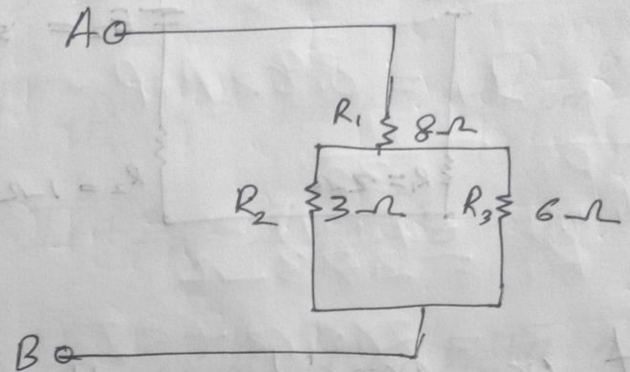
i.e $(QR - PS) = 0$

Since I has a finite value

$$QR - PS = 0$$

Thus the condition for the balance of the bridge.

* What is the resistance between A and B in figure below –



Soln: For the two resistors in parallel

$$\frac{1}{R_s} = \frac{1}{R_1} + \frac{1}{R_3}$$

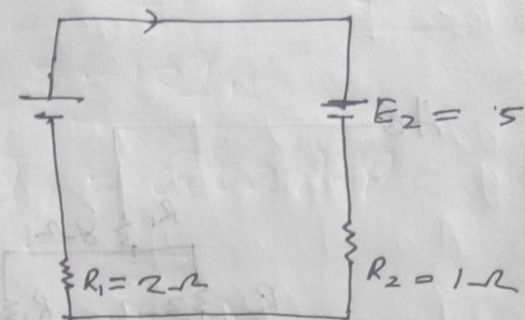
$$= \frac{1}{3} + \frac{1}{6}$$

$$= \frac{2+1}{6} = \frac{3}{6} = \frac{1}{2}$$

and $R_{AB} = R_1 + R_P$

$$= 8 + 2$$

$$= 10\Omega$$



Sol^n: let us consider the closed circuit $R_1 R_3 R_1 E_1$ from kirchoffs 2nd law

$$R_1 = I_1 R_1 + I_2 R_3$$

$$3 = 2I_1 + 3I_3 \quad \text{——— (i)}$$

Again from the closed circuit $E_1 E_2$, R_2, R_1,

we have

$E_1 - E_2 = I_1 R_1 - I_2 R_2$

or $3 - 1.5 = 2I_1 - I_2$

or $1.5 = 2I_1 - I_2$ ——— (ii)

At point P we have from first low

$I_1 + I_2 - I_3 = 0$ ——— (iii)

Eliminating I_3 with the help of eq^n (iii)

eq^n (1) becomes

$3 = 2I_1 + 5(I_1 + I_2)$

$= 2I_1 + 5I_1 + 5I_2$

$3 = 7I_1 + 55I_2$ ——— (iv)

From eq^n (11) and (iv) we get

eh^n (11) $\times 5$ and adding eq^n (iv)

$$7.5 = 10I_1 - 5I_2$$
$$3 = 2I_1 + 5I_2$$
$$10.5 = 17I_1$$
$$I_1 = 0.62\ Amp$$

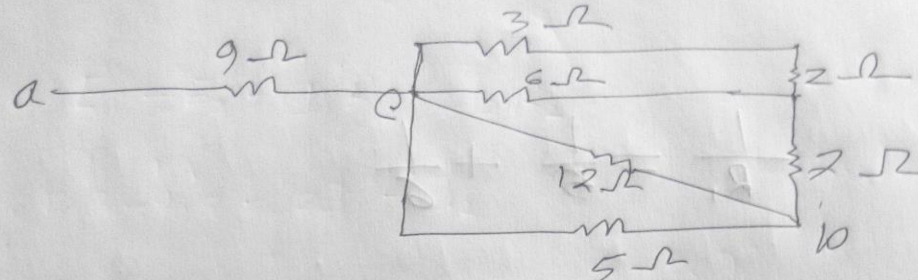
Somsistiting $ea^n(4)$

$$3 = 2 \times 0.62 + 5I$$
$$\Rightarrow 5I_2 = 3 - 4.43$$
$$\Rightarrow I_2 = \frac{-1.434}{5}$$
$$\Rightarrow I_2 = 0.286\ Amp$$

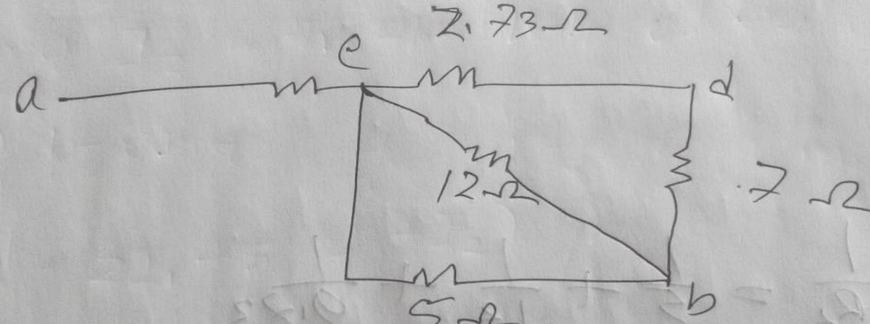
From ea^n (iii) $I_1 = 0.62$ and $I_2 = -0.286$

$$I_3 = 0.62 - 0.286$$
$$= 0.334\ Amp.$$

⊞



Find the equivalent resistance between points a, and b, for the combination show in figure below



Sol^n: The 3 Ω and 2 Ω resistors are and their equivalent resistance is 5 Ω. The 5 Ω resistance is in parallel with 6 Ω resistance their equivalent resistance R_1 is given by

$$\frac{1}{R_1} = \frac{1}{5} + \frac{1}{6}$$

$$= \frac{6+5}{30}$$

$$\frac{1}{R_1} = \frac{11}{30}$$

$$R_1 = 2.73\,\Omega$$

$$\frac{1}{R_2} = \frac{1}{5} + \frac{1}{12} + \frac{1}{2.73}$$

$$\frac{1}{R_2} = 0.368\,\Omega$$

$$R_2 = 2.6\,\Omega$$