Q. Sub code : 10EE666. Sem - 6th. June/July 2015.

Electrical Engineering Materials

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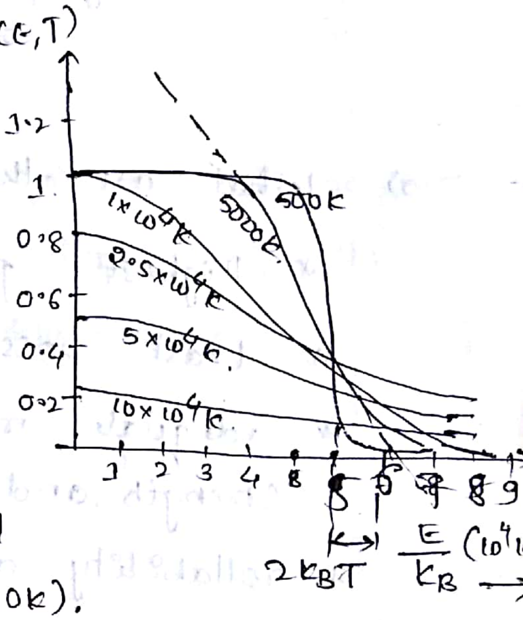
1)

a) Explain Fermi Dirac distribution by using sketches. [10 Marks]

At finite temperatures electrons (Fermions) occupy the density of states according to the fermi dirac distribution.

$$f(E,T) = \frac{1}{e^{E-\mu/k_BT}+1}$$



The chemical potential μ is determined the number N of valence electrons, which occupy the energy levels according to the Pauli principle.

* The Fermi level E_F is the topmost filled level at T=0K, defined by $E_F = \mu$ (T=0K).

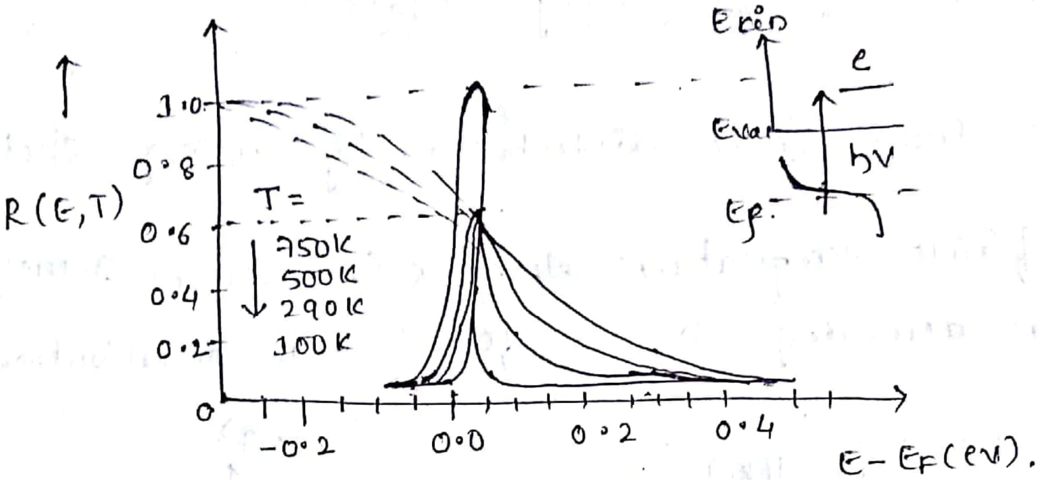
At finite T: $f(E_f) = 1/2$; for $k_BT << E_f$

classical Boltzmann limit for $E - E_f >> k_BT$:

$$f(E,T) = e^{(E-\mu k_BT)}$$

The width of the fermi dirac distribution at finite T is approximated by the tangent of (E,T) at E_f, which intersects at $E_f \mp 2k_BT$.

→ With increasing temperature only a small fraction of the electron distribution is excited.



[06 Marks]

b) What are the general properties of conducting materials

- Highest possible conductivity [least resistivity].
- Least possible temperature co-efficient of resistance.
- adequate mechanical strength. In particular, high tensile strength, and absence of brittleness.
- rollability and drawability is more
- Good weldability and solderability to ensure high reliability
- Adequate resistance to corrosion.

[04 Marks]

c) A copper wire and an aluminium wire, have same length and resistance. If same current passes through a copper and aluminium wire have same length and resistance, which wire will have higher temperature rise? Give Justification

→ Alumini
Cu wire
l = same
d = same

But we know that

$$R = \rho \frac{L}{a} = \rho \frac{L}{\frac{\pi}{4} d^2}$$

here L & d are same for conductors

$\therefore R = \rho$.

$\rho \rightarrow$ specific Resistance. $R \rightarrow$ Resistance.

$\rho_{Cu} \rightarrow 1.68 \times 10^{-8}$ Ωm. $\rho_{Al} \rightarrow 2.86 \times 10^{-8}$ Ωm

$\left[\rho = R\frac{A}{l} = \frac{\Omega m^2}{m}\right.$

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$P = I^2R.$

= Here Cu having less resistance as compare to Al.

2)

a) Draw the typical hysterisis loop for a ferromagnetic materials and explain. Show the residual magnetism and co-ercive force on a loop and define them. [10 Marks]

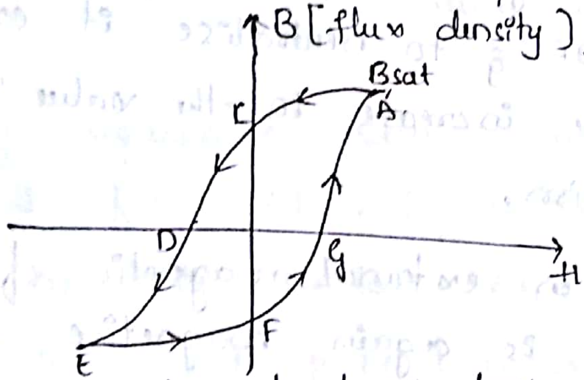

fig - hysteresis loop.

* In ferromagnetic material the flux density B increases, when external magnetic field applied to it is increased. when material reaches saturation state that increase in flux density B almost ceases even though external magnetic field H increases.

* At external magnetic field H=0, the magnetic material is still magnetised and the flux density has the value 'OC'. in the fig shown above. This is called as Remenent flux or 'residual magnetism'.

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24 * In order to demagnetize the material the magnetic field H must be reversed and when it reaches the value 'OD. The flux density becomes zero.

* The applied magnetising force (H) in the reverse direction which causes B to be zero is called as co-ercive force.

* Further increase in the external magnetic field in the reverse direction will increase flux density [B] in the reverse direction.

* The residual magnetism in reverse direction is represented by 'OF & to neutralise it external magnetic field H must be increase to the value 'OG in the +ve or original direction.

* Further increase in external magnetic field [H] in original direction is again magnetise the material in the original direction & the saturation occurs at point A.

* The loop ACDEFGA is called hysteresis loop.

* The energy required in taking a material through a complete cycle of magnetization is proportional to the area enclosed by the hysteresis loop. The shape & area of the loop depends on the details of internal structure of composition of ferromagnetic materials.

Defin

when zero the e

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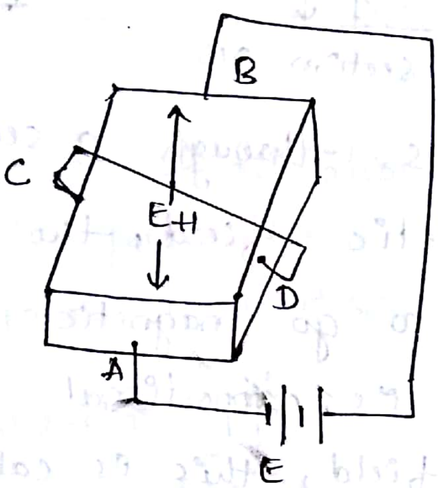
[10 Marks]

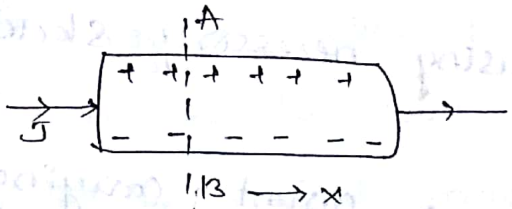
b) Define Hall effect and derive the expression for the Hall Voltage (V_H) by using necessary sketches.

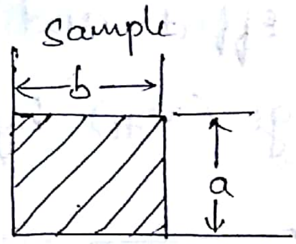


When a current carrying conductor is placed in a magnetic field and the direction of the magnetic field is perpendicular to current flow a transeverse electric potential gradient devolops in a conductor. This is called as "hall effect".

The fig represents semiconductor bar having contacts on of all four sides. If a voltage E_1 is applied across the two apposite contact A & B, a current will flow. If the bar is placed perpenducular to the magnetic field B and electric potential E_H, is generated between other two contact C & D. This voltage E_H is direct measure of the magnetic field strength and can be detected with a simple voltmeter.

Hall Effect generator may be used to measure magnetic field that has a strength 10^6, that of magnetic field of the earth.





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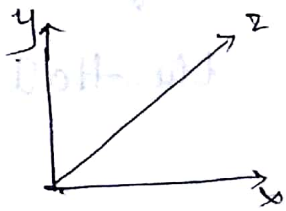

When a current flows through a semiconductor, bar placed in a magnetic field, the voltage is developed at right angle to go magnetic field and current flow. This voltage is proportional to current & intensity of the magnetic field, this is called Hall Effect.

The current density J resulting from applied electric field Ex in x direction.

The electrons drift with an average velocity V_x in x direction.

The electric field in y direction and is given by

$$E_y = B \cdot V_x \longrightarrow (1)$$

In the steady state a hall voltage, V_H is established in the y direction, given by.

$$V_H = E_y a = B \cdot V_x \cdot a \longrightarrow (2)$$

The current density in the sample is given by

$$J_x = N_e V_x \longrightarrow (3)$$

Where N_e = No of conduction electrons per m^3.

$$J_x = \frac{I}{a \times b} = N_e V_x$$

$$I = N_e V_x \cdot a \cdot b$$

$$V_x = B V_x \cdot a$$

On simplification.

$$V_H = \frac{I \cdot B}{Ne\ b}$$

$$V_H = \frac{I}{Ne} \cdot \frac{B}{b}$$

3)

a) What is polarization? And explain the
i) Ionic polarisation.
ii) Dipolar polarisation. [10 Marks]

Polarization.

It is defined as a definite orientation of electric dipoles due to the influence of applied electric field.

i) Ionic polarization:

The ionic polarization takes place when some of the atoms in a molecule have a excess positive and negative charges.

When electric field is applied, this electric field will tend to shift positive ion related to negative ion.

so this ionic polarization measures the shift of ion related to each other.

ii) Dipolar polarization.

When an external field E is applied to a molecule carrying permenent dipole then the dipole moment will tend to align along the direction of external applied field. The orientation of the permenent dipole

22 to the polarization P is called the orientation or dipolar polarization.

* The orientational polarization may be written as,

$$\text{orientational polarization} = \frac{m^2}{3kT}.$$

where $m \rightarrow$ permenent dipole moment

$K \rightarrow$ Boltzmann's Constant.

$T \rightarrow$ absolute temperature

3) b) Discuss about Dipolar relaxation. [06 Marks]

The frequency dependence of the orientational polarization in liquids and glassy substances is much more important than that of electronic or ionic polarisation. This is because orientational polarization gives rise to dielectric losses in the frequency ranges between zero and many thousand megacycles. depending upon the substance.

In this case of rapidly varying fields there is no orientation polarisation. It is important to know which field oscillations should be considered rapid. When the relaxation time is much greator that the oscillation period, there is no orientational polarisation. When the field is switched off, the dipoles assume a random orientation. However this does no occur instantaneously and the polarisation diminishes in accordance with an exponential low. The rate of this decrease is described by the relaxation time (τ). The time for which the polarisation decreases to $1/e$ of its original value.

In the foll

orientation.

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In the simple case we may assume that the polarisation follows the exponential law $P = P_0 e^{-t/\tau}$.

where τ is the relaxation time.

P is only that part of the polarisation ~~follows the~~ which is associated with permanent dipoles.

If instead of switching off, the field is changed suddenly to a value for which the equilibrium polarisation is P_0. then the rate of change of polarisation is given by.

$$\frac{dp}{dt} = \frac{P_0 - P}{\tau} \longrightarrow (1)$$

or $$p + \tau \frac{dp}{dt} = P_0.$$

When alternating field is applied, we may write.

$$p + \tau \frac{dp}{dt} = P = \frac{Nm^2}{3KT} E_0 e^{j\omega t}$$

$$P = \frac{Nm^2}{3KT} \cdot \frac{E_0 e^{j\omega t}}{1 + j\omega\tau} \longrightarrow (2)$$

Thus when the external field is changed to a new value it takes a finite time before the free dipoles in a liquid or solid can take up their new equilibrium positions. As a consequence, the dipolar polarisability (α_d) is frequency dependent and from eq^n (2) may be shown that

$$\alpha_d = \frac{\alpha_{d0}}{1 + j\omega\tau} \longrightarrow (3)$$

Where α_{d0} → low frequency polarisability

τ → Time constant involved in the orientation process.

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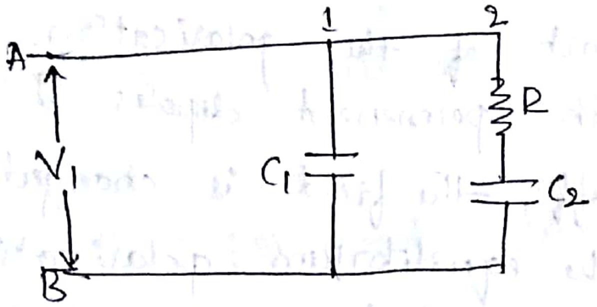
26 The following fig is used to explain the di... relaxation. The presence of R is one of the branc... this circuit accounts for viscous type of forces.



For steady voltage V_1, we have.

$q_1 = C_1 V_1$ = Electronic or Ionic polarisation.

$q_2 = C_2 V_1$ = Dipolar polarisation.

If terminals A & B are short-circuited the charg... disappear immediately. But the charge on C_2 decays accord... the relation.

$$q_2 = q_{2,0}\, e^{-t/RC_2}$$

where $q_{20} \rightarrow$ initial charge $= C_2 V_1$ and relaxation

$\tau = RC_2$ ∴ The admittance between the terminals A & B given by

$$\bar{Y}_{AB} = j\omega C_1 + \frac{j\omega C_2}{1+j\omega RC_2}$$

$$= j\omega C_1 + \frac{j\omega C_2}{1+j\omega\tau}$$

If the equivalent complex capacity of the combina... the circuit elements be represented by C^*.

where $C^* = \epsilon_r^* A/d$ then.

$$j\omega C = j\omega\left[C + \frac{C_2}{1+j\omega\tau}\right]$$

$$= j\omega \epsilon_r^* A/d$$

$$\epsilon_r^* = \frac{dC_2}{A} + \frac{dC_2/A}{1+j\omega\tau}$$

$\omega = 0$

$$\epsilon_r^* = (d/A)(C_1 + C_2)$$

$= \epsilon_s \rightarrow$ static value.

$\omega \rightarrow \infty$

$$\epsilon_\infty = dC_1/A$$

$= \epsilon_\infty$

$$\epsilon_r^* = \epsilon_\infty + \frac{\epsilon_s - \epsilon_\infty}{1 + j\omega\tau}$$

$$= \epsilon_r' - j\epsilon_r''$$

Hence for alternating field, the dipolar part of the dielectric constant is a function of the satic value ϵ_s and of $\omega\tau$.

Also,

$$\epsilon_r' = \frac{\epsilon_\infty \omega^2 \tau^2 + \epsilon_s}{1 + \omega^2 \tau^2}$$

$$\epsilon_r'' = \frac{\omega\tau(\epsilon_s - \epsilon_\infty)}{1 + \omega^2 \tau^2}$$

$$\tan\delta = \frac{\omega\tau(\epsilon_s - \epsilon_\infty)}{\epsilon_\infty \omega^2 \tau^2 + \epsilon_s}$$

$$\epsilon_r^* = \epsilon_r' - j\epsilon_r''$$

$$= 1 + \frac{N \alpha_{do}}{\epsilon_0}$$

$$= 1 + \frac{N \alpha_{do}}{\epsilon_0 (1 + j\omega\tau)}$$

So that

$$\epsilon_r' = 1 + \frac{\mathcal{N} \alpha_{do}}{\epsilon_0 (1 + \omega^2 \tau^2)}$$

$$\epsilon_r'' = \frac{\alpha_{do}\, \omega\tau\, \mathcal{N}}{\epsilon_0 (1 + \omega^2 \tau^2)}$$

3) c) Give the reason. Why, hydrogen gas is more Coo[ling] than Nitrogen and Air?

→ Hydrogen having lighter weight than air and nitrogen. Hydrogen is "7" times lighter than air, so it can penetrate, all the internal parts of the machine and it can take the heat very easily from the Core part of the machine.

Therefore, hydrogen is the best coolant than air and nitrogen. That's why we are using hydrogen as coolant in big machines or turboalternators.

4) d) Classify and list the solid, liquid and gaseous insulating materials. Suggest were these insulators are used in electric field applications. [6 Marks]

* Solid insulating material.

1) Mica and Mica products
2) Abstostos and Asbestos products
3) glass
4) porcelren.

* Liquid insulating material

1) Mineral oil.
2) Transformer oil.
3) Vegitable oil.

Gas
1) Air
2) Nit[rogen]

Coolg

* Gaseous insulating materials.

1) Air
2) Nitrogen
3) SF6.

Uses.

* Solid Insulating materials

1) Mica is used in the commutator segments.
2) ~~glass~~ porcelein is used pin insulators in overhea
3) plastic is used in switches, Sockets, wirings cables etc.

* Liquid Insulating material

1) Used in Transformers, reactors, switches, circuit brea and rheostats.
2) It is used to improve the insulating property of solid insulating material by removing the gases an air.
3) It acts as good ~~dicat~~ dissipation media.
4) It is used ~~in~~ arc extinguishing in circuit breakers.

* Gaseous Insulating material

1) SF_6 → Used in circuit breaker.
2) Hydrogen → Used in large machines
3) Nitrogen → Used in machines.
4) Air → Used as Coolant & insulating material.

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4) b) Explain Dielectric loss with expression.

Consider a parallel plate condensor filled with a dielectric material characterized by ϵ_r'. Let the electrode area be A and the plate seperation be d. The admittance $\bar{Y}$ of the capacitor for any angular frequency ω is given by

$\bar{Y} = G + jB$.

Where G & B are conductance and susceptance respectively.

$\bar{Y} = G + j\omega C$.

Where $C \rightarrow$ Capacitance with may depend on frequency.

$C = \epsilon_r' A/d$,

The conductance G arises becouse of the conversion of part of the electrical energy into heat, but mainly becouse of the complex dielectric constant.

Thus $\bar{Y} = \frac{A}{d}(\sigma + j\omega\epsilon_r')$

$= \frac{A}{d} j\omega \epsilon_r^*$

Where ϵ_r^* is the complex permitivity such that

$j\omega\epsilon_r^* = \sigma + j\omega\epsilon_r'$

$\epsilon_r^* = \epsilon_r' - j\sigma/\omega = \epsilon_r' - j\epsilon_r''$

$= |\epsilon_r^*| \delta$

where $\epsilon_r^* = \frac{\sigma}{\omega}$.

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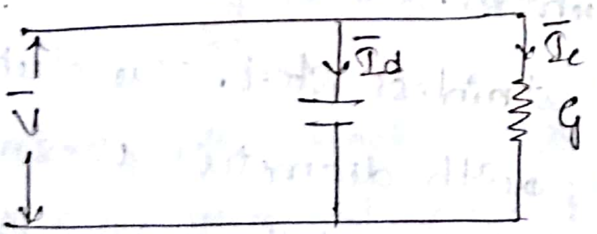
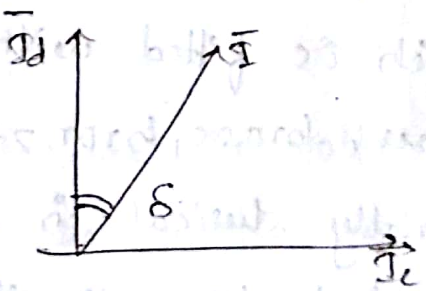
Thus the absorption of energy by the material in an alternating field is proportional to the imaginary part of the dielectric constant. The dielectric is said to have losses which are characterised by the loss tangent.

$$\tan\delta = \frac{\epsilon''}{\epsilon'} = \frac{\sigma}{\omega\epsilon'} = \frac{g}{B} = \frac{G}{\omega C} = \frac{1}{\omega CR}$$

We may represent the condensor containing the lossy dielectric by an equivalent circuit which consists of a pure capacitance and a parallel resistance, the latter being inversely proportional to $\epsilon'' \omega$. Such a circuit is shown in fig below.



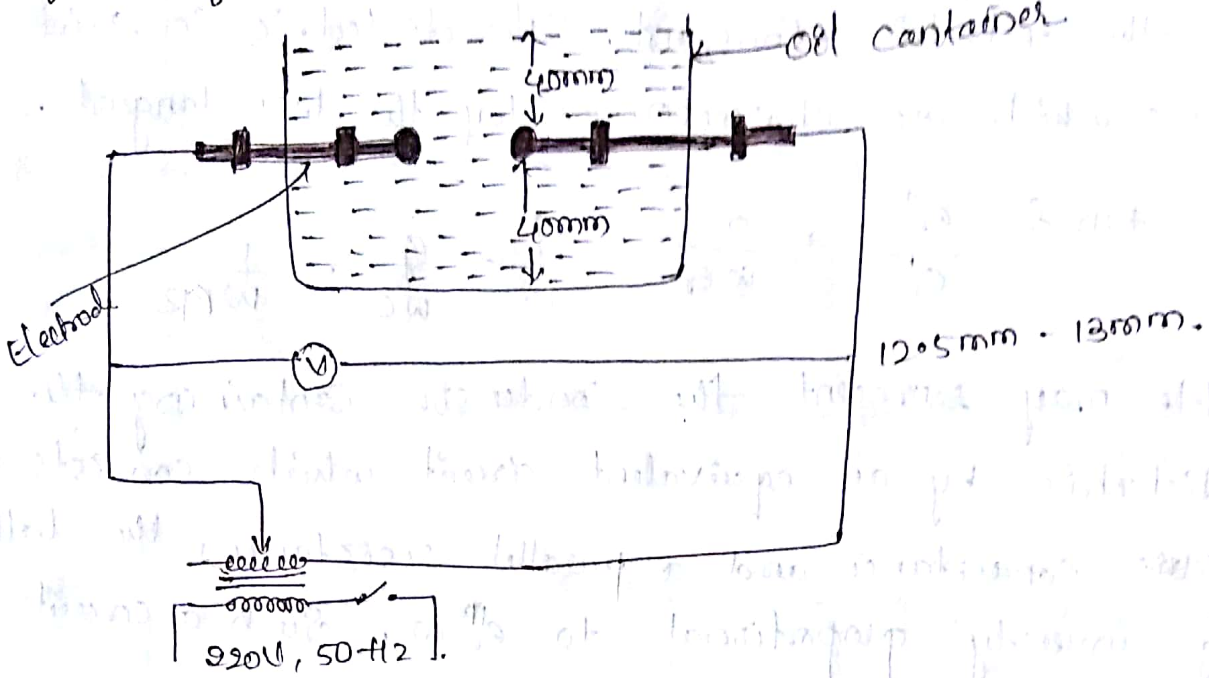


In this circuit $\bar{I}_c \rightarrow$ Conduction current. which is responsible for the dielectric losses and is in phase with the applied voltage.

$\bar{I}_d \rightarrow$ displacement current

$\bar{I} \rightarrow$ phasor sum of $\bar{I}_d$ & $\bar{I}_c$.

4)
c) Explain the procedure for testing the dielectric of transformer with neat Sketch.



The oil under test should be kept in a container which is filled with 2 electrodes. The electrodes are made up of Copper, brass, bronze and stainless steel. The electrodes are normally sherical in shape with diameter 12.5mm to 13mm. The electrodes are arranged horizontally and gap between them is [0.4mm to 0.02mm]

* The oil in a container should be 40mm above the electrodes and 40mm below the electrodes.
* After fixing up the gap properly between two electrode a high voltage is applied across the two electrodes through step up transformer, Increase the voltage from lower value to higher value still there is a spark in between two electrodes. Note this value of voltage carefully by voltmeter, because the needle will come to zero

position immidiately. after the sparks takes place. This voltage noted on the voltmeter, the spark occurs is the breakdown voltage is the dielectric strength of the oil or it is the maximum voltage the oil can withstand

According to standard specifications the oil should be able to stand 40KV for 1 minute; with a gap of 4mm to 0.02 mm between the electrode with diameter of electrodes as 13mm. The test should be conducted periodically and if oil fails to withstand 40KV for 1 minute it should be change.

PART - B

5)

a) Explain with block diagram of solar photovoltaic power generating system and give its V-I characteristics and equivalent circuit diagram.

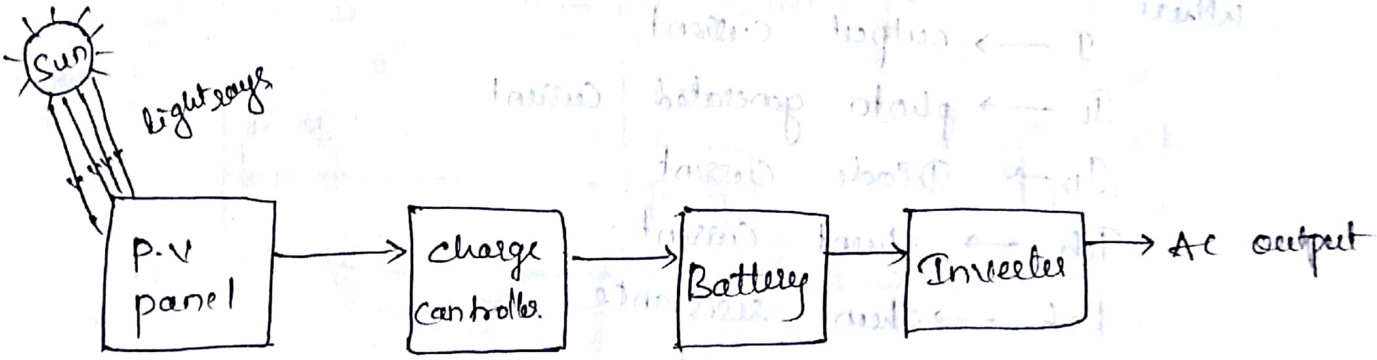


fig. a) Block diagram of solar Cell.

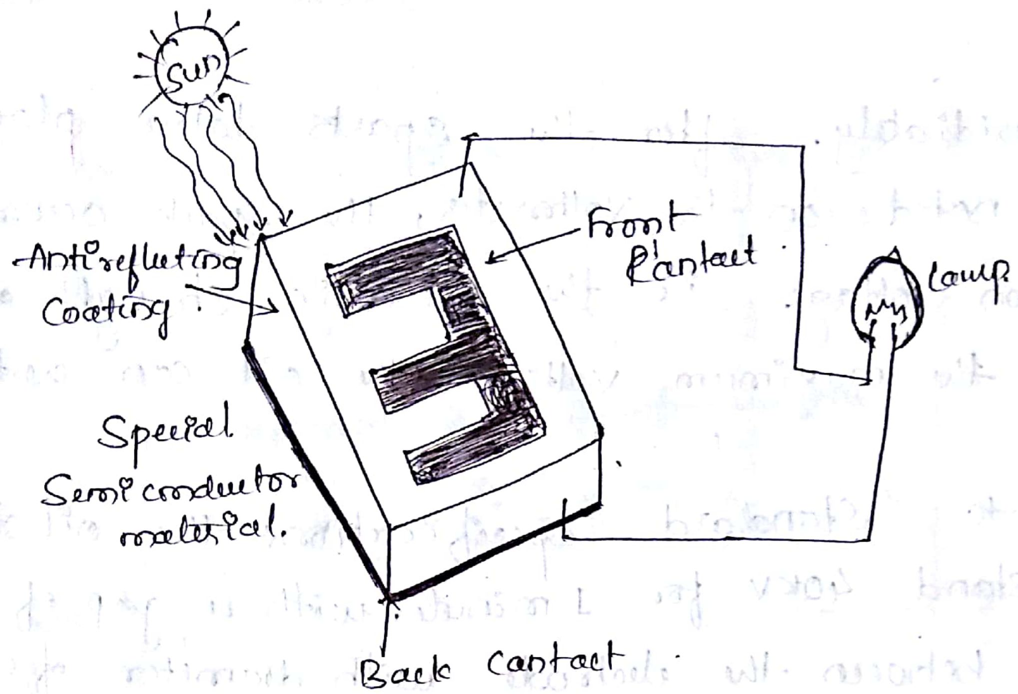
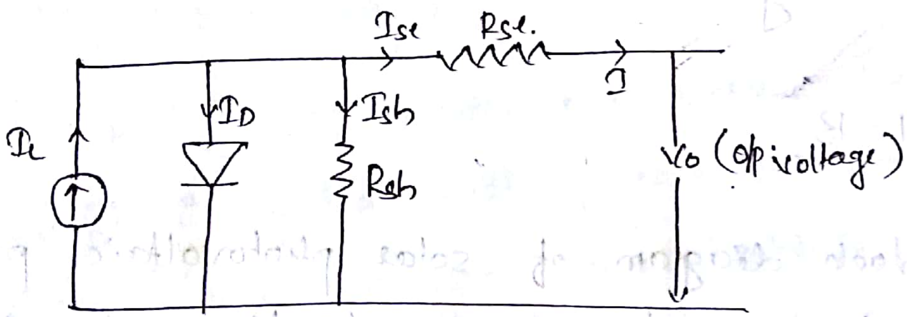


fig (b) Solar cell.

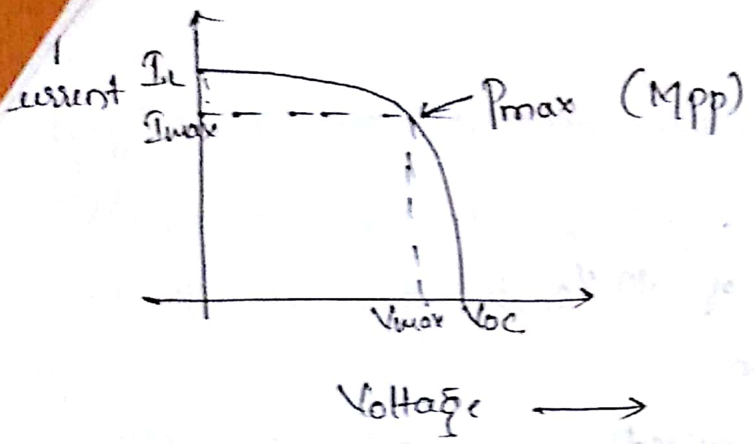
VI characteristics of Solar cell



$I = I_L - I_D - I_{sh}$

where

- $I \longrightarrow$ output current
- $I_L \longrightarrow$ photo generated current
- $I_D \longrightarrow$ Diode current
- $I_{sh} \longrightarrow$ Shunt current.
- $R_{sh} \longrightarrow$ shunt resistance
- $R_{se} \longrightarrow$ series resistance
- $V_o \longrightarrow$ output voltage



Fill factor - ?

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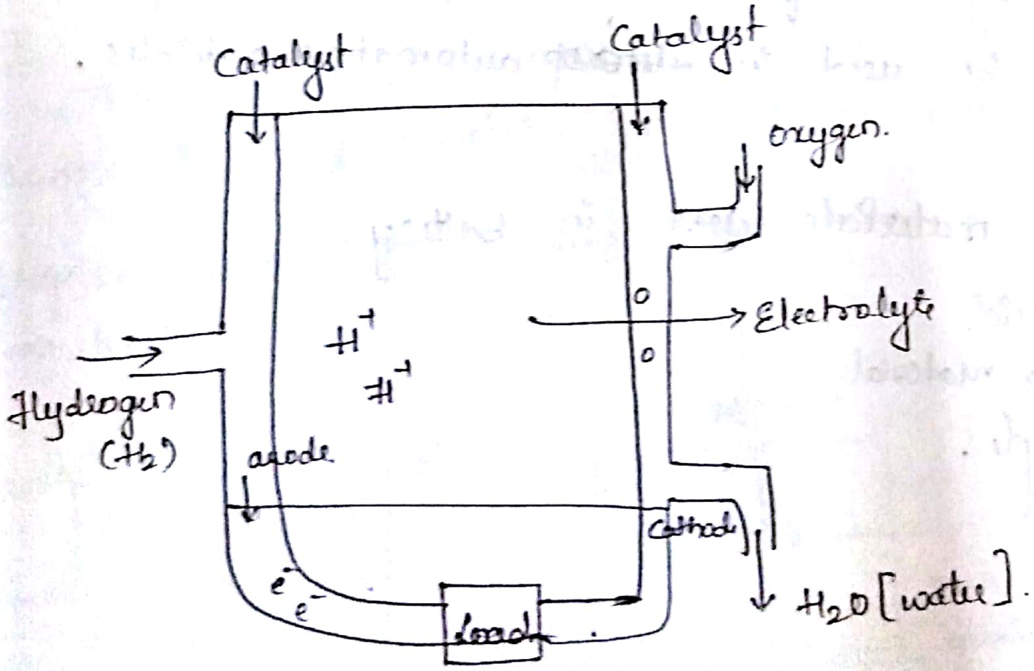
η = ?

Where Mpp → maximum power point.

5) b) Write a note on fuel cell.

A fuel cell is an eletrochemical energy conversion device which produces electricity, water and heat. i.e. it produces an electric current from chemical reaction.



It has two, electrodes seperated by an electrolyte.

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Advantages

* High conversion efficiency of 70 %.
* Less atmospheric pollution.
* Less cooling water is required.
* Space required is less.

Disadvantages.

* High initial cost
* Less service life.

Application

* It can be used for electric lamps, small pumps & motors
* Can also be used in ~~[illegible]~~ automotive vehicles.

5)
c) List the materials used in battery.

* Lead - acid
* Insulating material
* Electrolyte.
* Catalysts.
*

Define magnetostriction explain with graphs. 33

defⁿ → The change of lengths of a ferromagnetic material, when it is magnetised is known as magnetostriction.

Or

When a ferromagnetic substance is magnetised there are small changes in its dimension, this phenomenon is called as magnetostriction.

The magnetostriction co-efficient (λ).

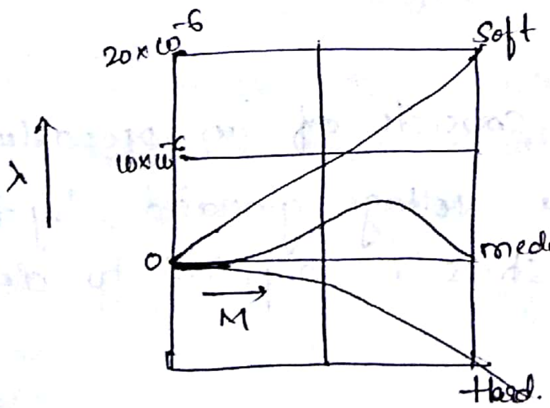
defⁿ → The increase in length per unit length of the crystal in the direction of magnetization.

i.e. $\delta l / l$.

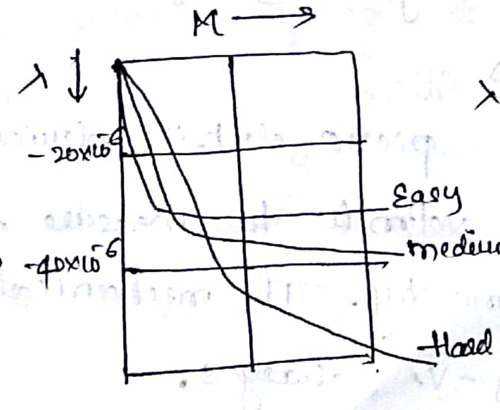
OR

The fractional change in length, $\delta l / l$ associated with the change in magnetisation from '0' to saturation.

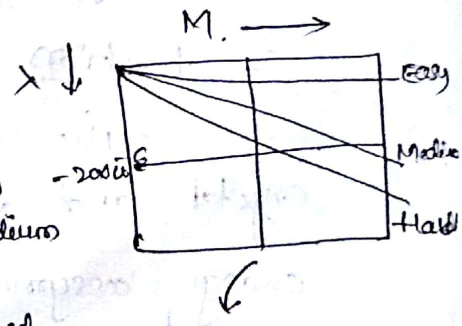
* Negative values of 'λ' shows contraction in the direction of magnetization.



a) Iron



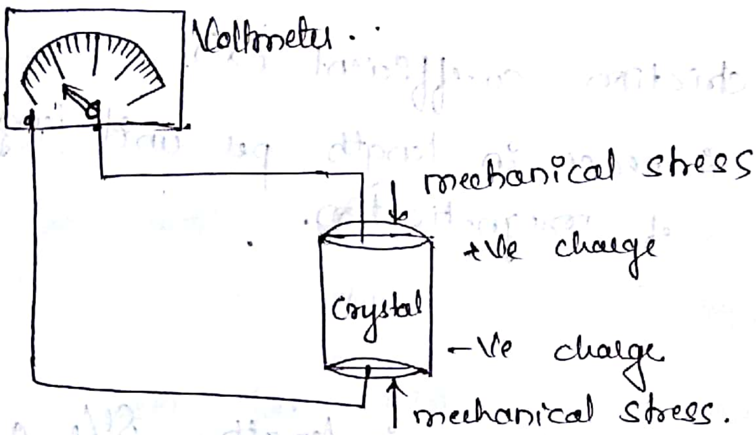
b) Nickel.



c) Cobalt

b) Q1 What is piezo-electricity? Explain the construction & working of piezo-electric device.

→ piezo electricity means it is the ability of the some materials to generate an electrical charge in response to applied mechanical stress. The fig below shows the piezo electric crystal.



The -Ve & +Ve electric charges are seperated, but symmetrically distributed so that the crystal overall is electricity neutral. When stress is applied, this symmetry is distributed and the charge asymmetry generates a voltage.

Construction

The piezo electric device consists of an piezo electric crystal and voltmeter to measure the voltage generated by the charge assymmetry. The mechanical stress is required to seperate the +Ve & -Ve charges.

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Write a note on Smart hydrogels [4 marks] 33

→ Smart hydrogels are defined as the polymer network able to respond to external stimuli through abrupt in the physical nature of the network.

* The types of stimulie that affects the smart hydrogel are physical factors and chemical factors.

i) physical factors.

a) Temperature

b) Light

c) Elektric forces

d) magnetic forces

e) mechanical forces.

2) chemical stimuli.

a) pH value

b) Solvent ex change.

The reaction of Smart hydrogel is always an expansion or contraction within millisecond, upon the stimulation. Essentially when a gel swells, it absorbs an additional fluid, into it. When it defleats, it expells these fluid out of its membrane.

8) a) explain the thermoplastic and thermosetting materi
34
give examples for each. [6 marks].

→

Thermoplastic materials

Thermoplastic materials are the synthetic material these materials are soften when an application of heat with or without pressure. But they require cooling set them to required shape.

* When thermoplastic materiale heated at low temperat 140°c then they can be moduate required shape witho any change in chemical Structure.

* They can be reused after Scrap.
* They are produced from organic substances like oil, and Coal products.
* By adding the fillers like root, mica, wood, glass, fi textile are added to get required shape.
* They are widely used for floor tiles, walls, plugs, so switches, holders, cabinet of radio's, decorative articles, Insulation for wires, Cables, pvc films, tapes, pvc sheets in the batteries, wirings.

examples → i) pvc
ii) cellulose acetate
iii) polysterone
iv) polyhydro carbons.

35;3

6) What are the general properties of ceramics and how it is applicable to capacitor?

→ general properties of ceramics.

* It is hard, strong & dense.
* Stronger in compression than in tension.
* Not affected by chemical action except with strong acids and alkalies.
* Completely stable at high temperatures.
* Excellent dielectric properties.
* Weak in impact strength.

Application of ceramics to capacitor.