Inter (Part-II) 2018

Physics	Group-II	PAPER: II
Time: 2.40 Hours	(SUBJECTIVE TYPE)	Marks: 68

SECTION-I

2. Write short answers to any EIGHT (8) questions: (16)

(i) What is meant by EEG and ERG?

Ans EEG:

In EEG (electroencephalography), the potential differences created by the electrical activity of the brain are used for diagnosing abnormal behaviour.

ERG:

The electrical activity of the retina of the eye generates the potential differences used in ERG (electro-retinography).

(ii) Write any two characteristics of electric field lines.

Ans Two characteristics of electric field lines are given below:

1. Electric field lines originate from positive charges and end on negative charges.
2. The lines are closer where the field is strong and the lines are farther apart where the field is weak.

(iii) The potential is constant throughout a given region of space. Is the electric field zero or non-zero in this region? Explain.

Ans The electric field intensity at a point can be defined as negative potential gradient at that point *i.e.,*

$$E = \frac{-\Delta V}{\Delta r}$$

In other words, this is the rate of change of potential with distance while negative sign shows the direction of E along the direction of decreasing potential. Since potential V is constant throughout the region, so,

$$\Delta V = 0$$

Hence, E = 0 $\quad (\because \quad E = \frac{-\Delta V}{\Delta r} = \frac{0}{\Delta r} = 0)$

(iv) Is it true that Gauss's law states that the total number of lines of force crossing any closed surface in the outward direction is proportional to the net positive charge enclosed within surface? Explain.

Ans Yes, because according to Gauss's law, we have

$$\phi = \frac{q}{\varepsilon_o}$$

Since ε_o = constant

So $\phi \propto q$

i.e., the electric flux or the total number of lines of forces crossing any closed surface in the outward direction is proportional to the net positive charge enclosed within surface.

(v) How can a current loop be used to determine the presence of magnetic field in a given region of space?

Ans When a current carrying loop is placed in uniform magnetic field at different orientations, a torque is produced in a loop. If the loop is deflected in that region, then we can say that magnetic field is present due to torque, otherwise not.

(vi) Why does the picture on a T.V. screen become distort, when a magnet is brought near the screen?

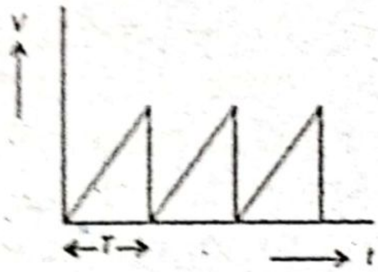
Ans The picture on TV screen is formed due to the motion of charged particles (electrons). When magnet is brought close to the TV screen, the path of the electrons is disturbed due to the magnetic force on them. So, the picture on the screen of TV is distorted.

(vii) Is it possible to obtain an isolated north pole? Give reasons.

Ans No, it is not possible. Modern theory of magnetism says that basically, magnetism is due to revolving charges. When an electron revolves in circular orbit, North Pole is formed on one side of loop. While on the other side, South Pole is formed. We cannot obtain isolated North Pole.

(viii) Draw saw tooth voltage waveform and explain it.

Ans



Saw tooth voltage waveform

The voltage applied across the x-plates of CRO is provided by a circuit. This is time base generator. Time is along x-axis while voltage is along y-axis.

(ix) Is it possible to change both the area of the loop and magnetic field passing through the loop and still not have an induced emf in the loop?

Ans Yes, it is possible. When area increases, the magnetic field decreases and when magnetic field increases, area decreases, but the magnetic flux passing through the loop does not change. In this situation, no emf is induced in the loop.

i.e., $\phi = \Delta B \cdot A = \text{constant}$

$\Rightarrow \quad \Delta\phi = 0$

$$\varepsilon = -N\frac{\Delta\phi}{\Delta t} = 0.$$

(x) When an electric motor such as an electric drill, is being used, does it also act as a generator? If so, what is the consequence of this?

Ans Yes, when an electric motor like electric drill is being used, it does also act as a generator.

When the motor rotates without load, it rotates quite fast, then the back emf induced is quite large, so the current flowing through the motor becomes very small. But if the motor drives some load, then depending upon the load, the speed of motor decreases and so emf induced also decreases. This makes the current flowing through the motor quite large. If the motor is overloaded beyond its limits, the induced back emf in the coil can produce high current that it may burn the motor out.

(xi) What is back motor effect in generators? Explain.

Ans When an AC generator coil rotates in a magnetic field, it causes a current to be produced in it. This current in turn causes the coil to experience a torque, the direction of which is opposite to the direction of torque rotating the coil in the first place. This is called motor effect because it is the characteristic of a motor coil to experience a torque because of the current it carries. The word 'back' is added to show that the torque is opposing the generators motions. Hence, it is back motor effects in generators.

(xii) Why transformers are used in A.C. supply network?

Ans Transformers are used in A.C. supply network, because it can step-up and step-down the A.C. voltage to the require value. For example,

1. In a television, a step-up transformer increases the voltage for working of a picture tube.
2. Inside a house, a step-down transformer decreases the voltage up to 9-volts for ringing a doorbell or operating a transistor radio.

3. Write short answers to any EIGHT (8) questions: (16)

(i) What is meant by tolerance? Find the resistance of a resistor with red, green, orange and gold respective bands.

Ans **Tolerance:**

The variation from the marked value of the resistor is called tolerance.

1st band is red = 2
2^{nd} band is green = 5
3^{rd} band is orange = 3 = No. of zeros = 000
4^{th} band is gold which shows tolerance = ± 5%
So, the actual of resistance = 25000 ± 5%
The given colour band have the resistance 25000 ± 5%.

(ii) **What are the difficulties in testing whether the filament of a lighted bulb obeys Ohm's law?**

Ans According to Ohm's law, current is directly proportional to the potential difference where physical state of conductor must remain constant. Therefore, when current passes through the filament of bulb, initially temperature of filament is low and its resistance remains constant. Hence, filament obeys Ohm's law but with the passage of time, its temperature increases. So, resistance of filament also increases. Therefore, Ohm's law is not valid due to increase in temperature.

(iii) **Distinguish between resistivity and conductivity.**

Ans **Resistivity:**

The resistance of a wire of 1 m length and 1 m^2 area of the cross-section is called the resistivity of wire. SI unit of resistivity is ohm-m.

Conductivity:

The reciprocal of resistivity is called conductivity. SI unit of conductivity is mho–m^{-1}.

(iv) **How does doubling the frequency affect the reactance of an inductor?**

Ans The reactance of inductor is given by

$$X_L = 2\pi fL \Rightarrow X_L \propto f$$

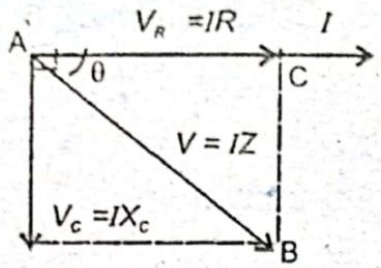
This result shows that if the frequency of A.C is doubled, then the reactance of an inductor also becomes doubled.

(v) **In R-C series circuit, will the current lag or lead the voltage. Illustrate your answer by a vector diagram.**

Ans In R-C series circuit, the current leads the applied voltage by an angle θ which is given by

$$\theta = \tan^{-1}\left(\frac{1}{2\pi fCR}\right)$$

Vector Diagram:



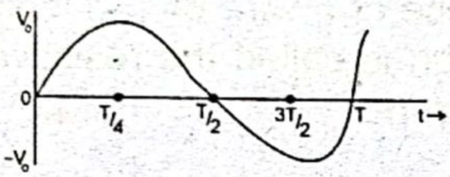
(vi) **Name the device that will permit the flow of direct current but oppose the flow of alternating current.**

Ans Inductor is a device that will permit the flow of direct current but oppose the flow of alternating current.

(vii) **Define A.C. current. Make its waveform.**

Ans The current which reverses its direction in the circuit many times in one second is called A.C current.

Waveform:



(viii) **Distinguish between p-type semiconductor and n-type semiconductor.**

Ans **n-type semiconductors:**

The materials formed with doping of pentavalent impurity such as antimony, arsenic or phosphorous are called n-type materials.

When silicon crystal is doped with a pentavalent element, *e.g.,* arsenic etc., four valence electrons of impurity atom form covalent bond with the four neighbouring Si-atoms, while the fifth valence electron is left free and it behaves as a free electron in the crystal.

p-type semiconductors:

The material formed with doping of trivalent impurities such as boron, Al or Ga are called p-type materials.

The impurity atom when doped with pure Si or Ge occupies the central position. Its three valence electrons form covalent bond with three valence electrons of intrinsic semiconductor.

(ix) **What are hard and soft magnetic materials? Give example of each.**

Ans **Hard Magnetic Materials:**

Such ferromagnetic materials which can neither be easily magnetized, nor be demagnetized are called hard magnetic materials.

Example:

Steel is a hard magnetic material because its domain are not oriented to order but once oriented retains its alignment. Thus, steel makes a good permanent magnet.

Soft Magnetic Materials:

Such ferromagnetic materials which can be easily magnetized and demagnetized are called soft magnetic materials.

Example:

Iron is a soft magnetic material because its domains are easily oriented in the direction of applied external magnetic field and readily returns to random positions when field is removed.

(x) **What is the net charge on a n-type and a p-type substance?**

Ans p-type and n-type substances are neutral. Since, they are made as result of combination of atoms of intrinsic semi-conductor and atoms of impurity. Atom as whole is neutral. Therefore, there is no net charge on p-type or n-type substance.

(xi) **How the current flows in forward and reverse biased diode?**

Ans In forward biased, p-type of diode is connected to the positive terminal of battery and n-type is connected to the negative terminal of battery. When applied voltage is greater than potential barriers, maximum current (mA) flows. In this case, current is due to majority charge carriers.

In reverse biased, p-type and n-types are connected in reverse order. Minimum current (μA) flows in this case due to minority charges.

(xii) **The input of a gate are 1 and 0. Identify the gate if its output is: (a) 0, (b) 1.**

Ans

(a) If the inputs of a gate are 1 and 0 and its output is 0, the gate may be AND-gate or NOR-gate or XNOR-gate.

(b) If the input of a gate are 1 and 0 and its output is 1, then the gate may be OR-gate, NAND-gate or XOR-gate.

4. Write short answers to any SIX (6) questions: (12)

(i) If the speed of light were infinite, what would the equations of special theory of relativity reduce to?

Ans When speed of light approaches to infinity then $c = \infty$

$$t = \frac{t_0}{\sqrt{1 - \frac{V^2}{c^2}}}$$

$$t = \frac{t_0}{\sqrt{1 - \frac{V^2}{\infty^2}}}$$

$$t = \frac{t_0}{\sqrt{\sqrt{1 - 0}}}$$

$$t = t_0$$

Similarly,

$$l = l_0$$

$$m = m_0$$

$$E = m(\infty)$$

(ii) State Heisenberg uncertainty principle. Give its two mathematical forms.

Ans This principle states that "It is impossible to measure the position and momentum of an electron (particle) at the same time with perfect accuracy.

Mathematical Form:

1st mathematical form is:

$$\Delta p . \Delta x \approx h$$

2nd mathematical form is:

$$\Delta E . \Delta t \approx h$$

(iii) **Which photon red, or blue carries the most**

(a) Energy (b) Momentum

Ans (a) Energy:

According to the relation $E = hf$, the photons of blue light having larger frequency must have the largest value of energy as compared with photons of red colour light.

(b) **Momentum**

Since $p = \frac{h}{\lambda}\left(\begin{array}{c}\text{Momentum is inversely}\\\text{proportional to wavelength}\end{array}\right)$

and $\lambda = \frac{1}{f}\left(\begin{array}{c}\text{Wavelength is inversely}\\\text{proportional to frequency}\end{array}\right)$

These relations show that if frequency is small, λ is large and hence 'p' is small. This proves that red light photons have smaller value of momentum than blue light.

(iv) **Is energy conserved when an atom emits a photon of light? Explain.**

Ans The law of conservation of energy holds when a photon of light emits from the excited atom, because the energy absorbed by the atom during its excitation is exactly balanced by the energy emitted during its de-excitation.

(v) **What is population inversion?**

Ans In laser action, when more atoms are in metastable state than ground state, this condition is known as population inversion.

(vi) **What is radioactive tracer? Describe one application each in medicine and agriculture.**

Ans A radioactive isotope acts as an indicator or tracer that makes it possible to follow the course of a chemical or biological process.

Application:

(i) In medicine:

Tracers are used in medicine to detect malignant tumors.

(ii) In agriculture:

Tracers are used in agriculture to study the uptake of a fertilizer by a plant.

(vii) **Which radiation dose would deposit more energy to your body:**

(a) 10 mGy to hand or

(b) 1 mGy to your entire body

Ans Since, absorbed dose is defined as the energy absorbed per unit mass.

$$i.e., \text{Absorbed dose} = D = \frac{\text{Energy absorbed}}{\text{Mass}}$$

Since, the mass of the whole body is very large as compared to the mass of hand. Therefore, the entire body absorbs greater energy than the hand. It means that 1 mGy dose given to entire body deposits more energy than 10 mGy given to hand.

(viii) **Write the name of basic forces of nature.**

Ans Basic forces of nature are as follows:

1. Gravitational force
2. Magnetic force
3. Electric force
4. Weak nuclear force
5. The strong nuclear force

(ix) **What is the function of control rods in nuclear reactor?**

Ans In order to control the chain reaction in the core, the cadmium or boron rods are used because they are good neutron absorbers. These rods are called control rods. These rods can be moved in and out of the core to control the number of neutrons that can initiate further fission reaction.

SECTION-II

NOTE: Attempt any THREE (3) questions.

Q.5.(a) State Ohm's law and derive its expression. Discuss why filament of a lighted bulb is non-ohmic by graph. Also give any two examples of non-ohmic devices. (5)

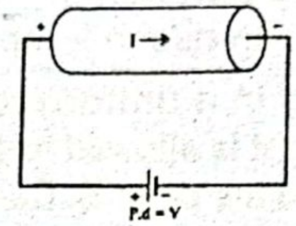
Ans **Ohm's Law:**

Statement:

This law states that "The current flowing through a conductor is directly proportional to the potential difference across its ends provided the physical state (temp., shape, density) of the conductor remains constant."

Mathematical Form:

Let I be the current flowing through a conductor, when a potential difference V is applied across its ends, then according to Ohm's law,



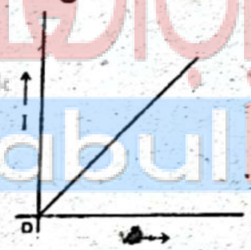
$$I \propto V$$

$$\Rightarrow \quad V = RI$$

where R is the constant of proportionality and is called the resistance of the conductor. The value of resistance depends upon the nature, dimension and the physical state of the conductor.

Ohmic:

The devices or materials which strictly obey Ohm's law are called ohmic. For such materials, the graph between V and I is a straight line as shown in fig.

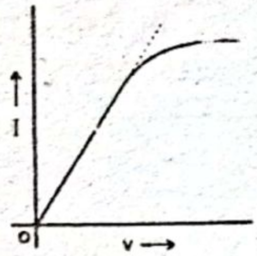


For ohmic devices, $\frac{V}{I} = R = \text{Constant}$

Non-Ohmic:

The devices which do not obey Ohm's law are called non ohmic. *e.g.,* Filament bulbs and semi-conductor diodes.

For such devices, the graph between V and I is not a straight line as shown in fig.



Note:

The deviation of graph from the straight line is due to change of resistance with rise in temperature.

(b) A proton placed in a uniform electric field of 5000 N/C directed to right is allowed to go to a distance of 10.0 cm from point A to the point B. Calculate: (1½, 1½)

(i) Work done by the field.

(ii) Its velocity.

Ans **Given:**

Electric field intensity = E = 5000 NC^{-1}
Distance moved = d = 10 cm = 0.1 m
Mass of proton = m = 1.67×10^{-27} kg
Charge on proton = q = 1.6×10^{-19} C
Work done on charge = $W_{A\to B}$ = ?
Velocity of proton = V = ?

Work done on charge:

Using formula,

$$W_{A\to B} = \vec{F}\cdot\vec{d}$$

$$W_{A\to B} = q\vec{E}\cdot\vec{d} \qquad \text{since } \vec{F} = q\vec{E}$$

$$= qEd \qquad (\therefore \theta = 0^\circ)$$

Putting values,

$$W_{A\to B} = 1.6 \times 10^{-19} \times 5000 \times 0.1$$

$$= 1.6 \times 10^{-19} \times 500 \text{ J} \qquad \because 1\text{J} = \frac{1}{1.6 \times 10^{-19}}\text{ eV}$$

$$= \frac{1.6 \times 10^{-19} \times 500}{1.6 \times 10^{-19}}\text{ eV}$$

$$\boxed{W_{A\to B} = 500\ eV}$$

For velocity of Proton:

Using formula,

$$K.E. = \frac{1}{2}mv^2$$

$$\Rightarrow \quad v = \sqrt{\frac{2 \times K.E}{m}}$$

Putting values,

$$v = \sqrt{\frac{2 \times 500 \times 1.6 \times 10^{-19}}{1.67 \times 10^{-27}}}$$

$$= \sqrt{\frac{1.6 \times 10^{-16}}{1.67 \times 10^{-27}}}$$

$$= \sqrt{9.5 \times 10^{10}}$$

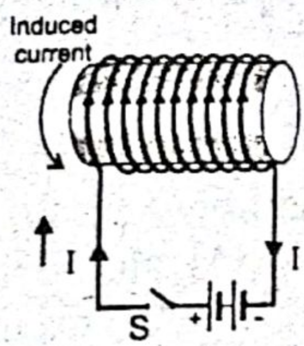
$$\boxed{v = 3.09 \times 10^5\ m/sec}$$

Q.6.(a) What is inductor? Also derive a formula for energy stored in an inductor. (1,4)

Ans The phenomenon in which changing current in coil produces an emf in itself is called inductance and coil is called inductor.

Energy Stored in an Inductor:

Consider a coil is connected to a battery. When the switch is turned on, voltage is supplied across the ends of the coil and current starts passing through it which rises from zero to its maximum value. Due to change of current, an emf is induced, which is opposite to that of battery. Therefore, work is done by the battery to move charges against the induced emf.



Work done by the battery in moving a small charge Δq is given by

$$W = \Delta q \varepsilon_L \qquad (1)$$

where 'ε_L' is the magnitude of induced emf which is given as

$$\varepsilon_L = L\frac{\Delta I}{\Delta t}$$

Substituting this value of ε_L in (1), we get

$$W = \Delta q \, . \, L\frac{\Delta I}{\Delta t} = \frac{\Delta q}{\Delta t} \, . \, L\Delta I \qquad (2)$$

As, the current increases from zero to a maximum value 'I', it means more and more energy is stored in the inductor. Therefore, total work done by the battery is found by inserting for the change in current, $\Delta I = I$, and the average current, $\frac{\Delta q}{\Delta t} = \frac{1}{2}$ in Eq. (2).

$$\text{Total work} = W = \left(\frac{1}{2}I\right) LI$$

$$W = \frac{1}{2}LI^2 \qquad (3)$$

This work is stored as potential energy in the inductor. Thus, the energy stored in an inductor is given as

$$U_m = \frac{1}{2}LI^2 \qquad (4)$$

This equation shows that energy stored in the inductor at any instant depends on the current in the inductor at that instant. Notice that this expression has the same form as the equation for the electrostatic energy stored by a capacitor 'C' with a voltage 'V' across its plates *i.e.,* $U_C = \frac{1}{2}CV^2$.

(b) We know that in case of a capacitor, energy is stored in the electric field between the plates and likewise in an inductor energy is stored in the magnetic field. Therefore, eq. (4) can be expressed in terms of the magnetic field $\vec{B}$, for the special case of a long, thin solenoid. Let 'n' are the number of turns per unit length of the coil of the solenoid and area of cross-section 'A'.

The magnetic field strength inside the solenoid = $B = \mu_o nI$.

Since,

Flux through the coil = $\phi = BA$

or $\qquad \phi = \mu_o nIA \qquad (5)$

$(\because \; B = \mu_o nI)$

Substituting the value of ϕ, we have

$$N\phi = LI \qquad \text{or} \qquad L = \frac{N\phi}{I}$$

or $\qquad L = N\dfrac{\mu_o nIA}{I} \qquad (\because \; \phi = \mu_o nIA)$

or $\qquad L = N\mu_o nA$

If 'l' is the length of the solenoid, then putting $N = n\,l$ in the above equation, we have the self-inductance of the solenoid as

$$L = (n\,l)\,\mu_o nA$$

or $\qquad L = \mu_o n^2 A\,l$

Now, substituting the value of 'L' in eq. (4), we have

$$U_m = \frac{1}{2}(\mu_o n^2 A l)\, I^2 \qquad (6)$$

Since magnetic field for solenoid is given by

$$B = \mu_o nI$$

or $\qquad I = \dfrac{B}{\mu_o n}$

Substituting the value of 'I' in Eq. (6), we have

$$U_m = \frac{1}{2}(\mu_o n^2 A l)\left(\frac{B}{\mu_o n}\right)$$

or $\qquad U_m = \dfrac{1}{2}\mu_o n^2 A l \times \dfrac{B}{\mu_o^2 n^2}$

$$U_m = \frac{1}{2}\frac{B^2}{\mu_o}(Al) \quad (7)$$

Energy Density

"The energy stored per unit volume inside the solenoid is called energy density".

We get energy density;

$$U_m = \frac{1}{2}\frac{B^2}{\mu_o}(Al) \times \frac{1}{Al}$$

$$U_m = \frac{1}{2}\left(\frac{B^2}{\mu_o}\right) \quad (8)$$

Note: The expression for magnetic energy density in a magnetic field in similar to the expression for electric energy density in an electric field (*i.e.*, $U_e = \frac{1}{2}\varepsilon_o E^2$).

(b) A solenoid 15.0 cm long has 300 turns of wire. A current of 5.0 A flows through it. What is the magnitude of magnetic field inside the solenoid? (3)

Ans Length of the solenoid = L = 15.0 cm = 0.15 m

Total number of turns = N = 300

Current = I = 5.0 A

Permeability of free space = $\mu_o = 4\pi \times 10^{-7}\ WbA^{-1}m^{-1}$

Number of turns per unit length = $n = \frac{N}{l} = \frac{300}{0.15\ m}$

$= 2000$ turns/m

Magnetic field = $B = \mu_o nI$

$= 4 \times 10^{-7}\ WbA^{-1}m^{-1} \times 2000\ m^{-1} \times 5.0\ A$

$B = 1.3 \times 10^{-2}\ Wbm^{-2}$

Q.7.(a) Define impedance. Derive an expression for impedance and phase angle in R-C and R-L series circuit excited by A.C. voltage. (1,2,2)

Ans **Impedance:**

Combined effect of resistances and reactance in an A.C. circuit is called impedance.

Calculation of Impedance by R – C Circuit:

The value of applied voltage 'V' is obtained by the resultant of the vectors $I_{rms} R$ and $\frac{I_{rms}}{\omega C}$ *i.e.*,

$$V_{rms} = \sqrt{(I_{rms} R)^2 + \left(\frac{I_{rms}}{\omega C}\right)^2}$$

or $$V_{rms} = I_{rms}\sqrt{R^2 + \left(\frac{1}{\omega C}\right)^2}$$

or $$\frac{V_{rms}}{I_{rms}} = \sqrt{R^2 + \left(\frac{1}{\omega C}\right)^2}$$

we know that

$$\text{Impedance} = Z = \frac{V_{rms}}{I_{rms}}$$

Substituting the value of $\frac{V_{rms}}{I_{rms}}$, we have

$$Z = \sqrt{R^2 + \left(\frac{1}{\omega C}\right)^2} \qquad (1)$$

Equation (1) suggests that we can find the impedance of a series A.C. circuit by vector addition. The resistance 'R' is represented by a horizontal line in the direction of current which is taken as reference. The reactance X_C is shown by a line lagging the R – line by 90°. The impedance 'Z' of the circuit is obtained by the vector summation of resistance and reactance.

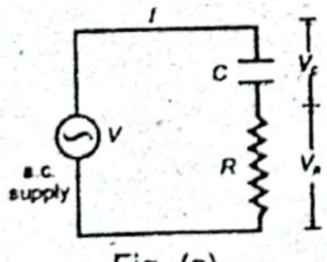


Fig. (a)

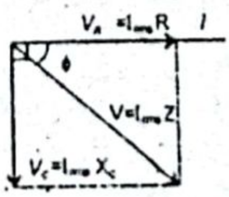


Fig. (b)

Phase angle for R.C circuit:

Figure (a) shows that the current and the applied voltage are not in phase. As the voltage lags that current by 90°, therefore, the current leads the applied voltage by an angle θ such that

$$\theta = \tan^{-1}\left(\frac{X_C}{R}\right) = \tan^{-1}\left[\frac{1}{\omega CR}\right]$$

The angle which the line representing the impedance 'Z' makes with R-line gives the phase difference between the voltage and current. In Fig. (c), the current is leading the voltage applied by an angle

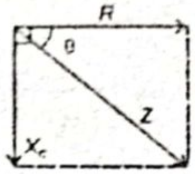
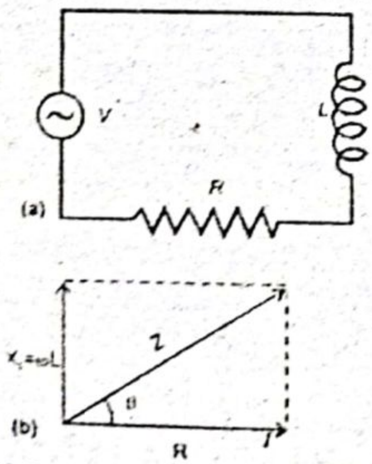


Fig. (c)

R-L Series Circuit

Such a circuit in which resistance 'R' and inductance 'L' are connected in series is called R-L series circuit.

Fig. (d) shows an R-L series circuit excited by an A.C. source. The current is taken as reference, so, it is represented by a horizontal line. Resistance 'R' is drawn along this line because the potential drop $I_{rms} R$ is in phase with current. As the potential across the inductance *i.e.,* $V_L = I_{rms} X_L = I_{rms} (\omega L)$ leads the current by 90°, so the vector line of reactance $X_L = \omega L$ is drawn at right angle to R-line as shown in Fig. (e).



Calculation of Impedance:

The impedance 'Z' of the R-L series circuit is obtained by the vector sum of 'R' and ωL lines. Thus,

$$Z = \sqrt{R^2 + X_L^2}$$

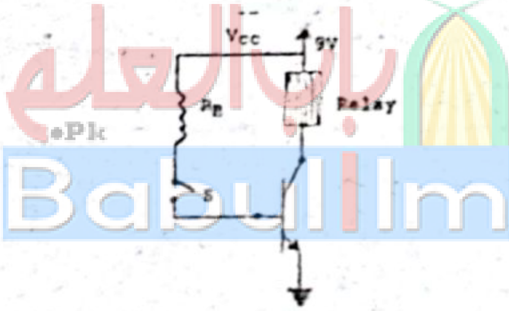
The phase difference between voltage and current is given by θ.

$$Z = \sqrt{R^2 + (\omega L)^2}$$

$$\theta = \tan^{-1}\left(\frac{\omega L}{R}\right)$$

The angle 'θ' which 'Z' makes with R-line gives the phase difference between the voltage and current. In this case, the voltage applied leads the current by an angle 'θ'. By comparing the impedance diagrams of R-C and R-L circuits, it can be seen that the vector lines of reactances X_C and X_L are directed opposite to each other with 'R' as reference.

(b) Fig. shows a transistor which operates a relay as the switch *s* is closed. The relay is energized by a current of 10 mA. Calculate the value R_B which will just make the relay operate. The current gain β of the transistor is 200. When the transistor conducts, its V_{BE} can be assumed to be 0.6 V. (3)



Ans Given:

Collector current = I_C = 10 mA = 10×10^{-3} A

Current gain = β = 200

P.d. between E & B = V_{BE} = 0.6 V

Power supply = V_{CC} = 9 V

By the above given diagram:

R_B = ?

Using the relation,

$$\beta = \frac{I_C}{I_B}$$

$$\Rightarrow \quad I_B = \frac{I_C}{\beta}$$

Putting values,

$$I_B = \frac{10 \times 10^{-3}}{200}$$

$$\Rightarrow \quad I_B = 0.05 \text{ mA}$$

Now applying Kirchhoff's 2nd rule to base circuit, we have

$$V_{CC} - I_B R_B - V_{BE} = 0$$

$$\Rightarrow \quad R_B = \frac{V_{CC} - V_{BE}}{I_B}$$

Putting values,

$$R_B = \frac{9 - 0.6}{0.05 \times 10^{-3}}$$

$$= 168 \times 10^3 \ \Omega$$

$$\boxed{R_B = 168 \text{ k}\Omega}$$

Q.8.(a) What is photoelectric effect? How its different results were successfully explained on the basis of Quantum Theory? (1,4)

Ans The emission of electrons from a metal surface when exposed to light of suitable frequency is called the photoelectric effect. The emitted electrons are known as photoelectrons.

Explanation on the Basis of Quantum Theory:

Einstein extended the idea of quantization of energy proposed by Max Planck that light is emitted or absorbed in quanta, known as photons. The energy of each photon of frequency f as given by quantum theory is

$$E = hf$$

A photon could be absorbed by a single electron in the metal surface. The electron needs a certain minimum energy called the work function 'Φ' to escape from the metal surface. If the energy of incident photon is sufficient, the electron is ejected instantaneously from the metal surface. A part of the photon energy (work function) is used by the electron to break away from the metal and the rest appears as the kinetic energy of the electron. That is,

Incident photon energy – Work function = Max. K.E. of photoelectron

or $$hf - \Phi = \frac{1}{2} mv_{max}^{2} \quad (1)$$

This is known as Einstein's photoelectric equation.

When $K.E_{max}$ of the photoelectron is zero, the frequency f is equal to threshold frequency f_o. Hence the Eq. (1) becomes

$$hf_o - \Phi = 0 \quad \text{or} \quad \Phi = hf_o \quad (2)$$

Hence, we can also write Einstein's photoelectric equation as

$$K.E_{max} = hf - hf_o$$

It is to be noted that all the emitted electrons do not possess the maximum kinetic energy, some electrons come straight out of the metal surface and some lose energy in atomic collisions before coming out. The equation 19.14 holds good only for those electrons which come out with full surplus energy.

Albert Einstein was awarded Nobel Prize in physics in 1921 for his explanation of photoelectric effect.

Note that the phenomenon of photoelectric effect cannot be explained if we assume that light consists of waves and energy is uniformly distributed over its wavefront. It can only be explained by assuming light consists of corpuscles of energy known as photons. Thus it shows the corpuscular nature of light.

(b) The length of a steel bar is 1.0 m and its cross-sectional area is 0.03 × 10^{-4} m^2. Calculate the work done in stretching the wire when a force of 100 N is applied within the elastic region. Young's modulus of steel is 3.0 × 10^{11} Nm^{-2}. (3)

Ans **Given data**

Length of steel wire = l = 1.0 m

Area of cross-section = A = 0.03 × 10^{-4} m^2

Force applied = F = 100 N

Young's modulus of steel = Y = 3.0 × 10^{11} Nm^{-2}

To determine

Work done = W = ?

Calculations

Using the relation

$$Y = \frac{F}{A} \div \frac{\Delta l}{l}$$

or $$Y = \frac{Fl}{A\Delta l}$$

or $$\Delta l = \frac{Fl}{YA}$$

Substituting the values, we have

$$\Delta l = \frac{100\ \text{N} \times 1.0\ \text{m}}{3.0 \times 10^{11}\ \text{Nm}^{-2} \times 0.03 \times 10^{-4}\ \text{m}^2}$$

$$= \frac{100\ \text{m}}{0.09 \times 10^{7}}$$

$$\Delta l = 1.1 \times 10^{-4}\ \text{m}$$

Work done = Average force × Δl

$$W = \left(\frac{0 + F}{2}\right) \times \Delta l$$

$$W = \frac{F\Delta l}{2}$$

Substituting the values, we have

$$W = \frac{100\ \text{N} \times 1.1 \times 10^{-4}\ \text{m}}{2}$$

$$= 5.5 \times 10^{-3}\ \text{Nm} \qquad (\because \text{Nm} = \text{J})$$

$$\therefore \quad W = 5.5 \times 10^{-3}\ \text{J}$$

Q.9.(a) What is inner shell transitions? Explain the production of X-rays. **(1,4)**

Ans For Answer see Paper 2018 (Group-I), Q.9.(a).

(b) Find the mass defect and binding energy for tritium, if the atomic mass of tritium is 3.016049u. **(3)**

Ans **Given data:**

Mass of tritium = m = 3.016949 u

To determine:

Mass defect = Δm = ?

Binding energy = B.E. = ?

Calculations:

To calculate mass defect, we use the following formula

$$\Delta m = Z \times m_p + (A - Z)\, m_n - m_{nucleus}$$

where,

m_p = mass of proton = 1.007276 u

m_n = mass of neutron = 1.008665 u

and m = atomic mass of tritium (mass of nucleus)

Substituting the values in the above formula, we have

$\Delta m = 1 \times 1.007276\ u \times (3 - 1)\ 1.008665\ u - 3.016049\ u$

$= 1.007276\ u + 2.01733\ u - 3.016047\ u$

$= 8.559 \times 10^{-3}\ u$

$\Delta m = 0.00856\ u$

To calculate binding energy, use the following formula:

1u = 931 MeV

So, $\Delta E = \Delta m \times 931$

$= 0.00856 \times 931$

$= 7.97$ MeV