Inter (Part-II) 2019

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

SECTION-I

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

(i) State Gauss's law and write its mathematical relation.

Ans **Gauss's law:**

The flux through any closed surface is $\frac{1}{\varepsilon_o}$ times the total charge enclosed in it:

Mathematically:

$$\phi = \frac{1}{\varepsilon_o} \times Q$$

(ii) Define electron volt and show that 1 eV = 1.6×10^{-19} J.

Ans It is defined as "The energy gained or lost by an electron when it is accelerated through a potential difference of 1 volt.

$$1 \text{ eV} = \text{charge on electron} \times 1 \text{ volt}$$

$$= 1.6 \times 10^{-19} \text{ C} \times 1 \frac{\text{J}}{\text{C}}$$

$$= 1.6 \times 10^{-19} \text{ J}$$

(iii) Electric lines of force never cross. Why?

Ans Electric lines of force never cross each other. This is because $\vec{E}$ has only one direction at any given point. If the lines cross, $\vec{E}$ could have more than one direction which is physically not correct.

(iv) Do electrons tend to go to region of high potential or of low potential?

Ans Since, electrons are negatively charged, so they tend to go to region of high potential, towards positive charge.

(v) State Lorentz force and write its formula.

Ans The Lorentz force is the combination of electric and magnetic force on a point charge due to electromagnetic fields. Symbolically,

$$F = q\,[E + (v \times B)]$$

where,

q = particle of charge
v = velocity
E = Electric field
B = Magnetic field

(vi) Write two uses of cathode ray oscilloscope.

Ans Two uses are given below:

1. Its is used study the waveform of alternating potential difference.
2. It is used to measure peak potential difference.

(vii) How can you use a magnetic field to separate isotopes of chemical element?

Ans The ions of the isotopes of an element are projected in magnetic field of known strength 'B'. The ions more in circular path of radius 'r' and the e/m of the ion is given as:

$$\frac{e}{m} = \frac{v}{Br}$$

or $$r = \frac{v}{B} \times \frac{m}{e}$$

If v (velocity of ion), 'B' and 'e' are constants, then $r \propto m$.

So, ions of different masses will have different radii of curvature and hence, they can be separated in magnetic field.

(viii) Why the resistance of an ammeter should be very low?

Ans Since ammeter is connected in series to the circuit to measure the current, so its resistance should be very small that the resistance of circuit does not increase and current in the circuit remains the same.

(ix) **How the induced current can be increased?**

Ans The current can be increased by:

(i) Using strong magnetic field.

(ii) Moving the loop faster.

(iii) Replacing the loop by a coil of many turns.

(x) **What is motional emf and write its mathematical relation?**

Ans The emf induced by the motion of a conductor across a magnetic field is called motional emf.

$$\varepsilon = -vBL \sin\theta$$

(xi) **Does the induced emf in a circuit depend on the resistance of the circuit? Explain.**

Ans The emf induced by the motion of a conductor across a magnetic field is called motional emf.

The induced emf in a coil only depends upon the rate of change of magnetic flux and number of turns but does not depend upon the resistance of the coil or the circuit.

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

Yes the induced current in a circuit depends on the resistance of the circuit. Greater the resistance, the smaller will be induced current and vice versa.

(xii) **Show that ε and $\frac{\Delta\phi}{\Delta t}$ have the same units.**

Ans As we know that

$$\varepsilon = \frac{W}{q} = \frac{\text{Unit of work}}{\text{Unit of charge}} = \frac{J}{C}$$

$\therefore$ unit of ε = J/C = volt

Hence unit of $\boxed{\varepsilon = \text{volt}}$ (1)

$$\text{Unit of } \frac{\Delta\phi}{\Delta t} = \frac{B.\Delta A}{\Delta t} = \frac{NA^{-1}\,m^{-1}m^2}{s}$$

$$= \frac{NA^{-1}m}{s} = \frac{N \times m}{A \times s}$$

But $N \times m$ = Joule = J

$$A \times s = \text{coulomb} = C$$

$$\therefore \quad \text{unit of } \frac{\Delta\phi}{\Delta t} = \frac{J}{C} = \text{volt}$$

$$\therefore \quad \boxed{\text{unit of } \frac{\Delta\phi}{\Delta t} = \text{volt}} \qquad (2)$$

Hence, it is clear from eqs. (1) and (2), both ε and $\Delta\phi/\Delta t$ have the same units.

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

(i) Define conventional current and solar cell.

Ans **Conventional Current:**

The conventional current in a circuit is defined as that equivalent current which passes from a point at higher potential to a point at a lower potential as if it represented a movement of positive charges.

Solar cell:

It is a device which converts light into electrical energy.

(ii) Define electrolysis and basic principle of electroplating.

Ans **Electrolysis:**

Electrolysis is the chemical decomposition of a compound into its components by passing current through the solution of the compound or molten state of the compound.

Electroplating:

Electroplating is depositing of one metal over the other by means of electrolysis.

(iii) Why does the resistance of a conductor rise with temperature?

Ans When the temperature rises, the atoms of conductor start vibrating with great amplitude and hence, the chance of collision of free electron with them increases. As a result, the resistance of the conductor increases.

(iv) Define peak value and peak to peak value of voltage or current.

Ans The highest value attained by the voltage or current in one cycle is known as peak value.

The sum of the positive and negative peak values of voltage or current is known as peak to peak value of voltage or current.

(v) A sinusoidal current has rms of 10 A. What is the peak value?

Ans $I_{rms} = 10\text{ A}$

Using $I_{rms} = \dfrac{I_o}{\sqrt{2}}$

$$I_o = I_{rms} \times \sqrt{2}$$
$$= 10 \times \sqrt{2}$$
$$= 10 \times 1.414$$
$$= \boxed{14.14\text{ A}} \quad \text{Peak value.}$$

(vi) What are superconductors?

Ans There are some materials whose resistivity becomes zero below a certain temperature T_c called critical temperature this temperature, such materials are called superconductors. They offer no resistance to electric current and are, therefore, perfect conductors.

(vii) What is meant by para, diamagnetic substances?

Ans **Paramagnetic substance:**

The property of a substance by which it is feebly attracted by strong magnet is called paramagnetism.

Diamagnetic substance:

Diamagnetic substance in which there is no resultant field as the magnetic fields produced by both orbital and spin motions of the electrons cancel each other and there is permanent magnetic moment between the atoms.

(viii) **What is meant by strain energy?**

Ans The potential energy stored in a body by virtue of an elastic deformation, equal to the work that must be done to produce this deformation is known as strain energy.

(ix) **Draw the truth table of XNOR gate.**

Ans

A	B	Output
0	0	1
0	1	0
1	0	0
1	1	1

(x) **Why ordinary silicon diodes do not emit light?**

Ans Ordinary silicon diode does not emit light because of opaque nature of silicon. Wavelength of photon emitted by silicon diode is greater than wavelength of visible light (lies in infrared region) which is not visible.

(xi) **Why is the base current in a transistor very small?**

Ans The base current in a transistor is very small, because while passing through base, the emitter current and the collector current are in opposite direction and these try to cancel each other according to the relation.

$$I_B = I_E - I_C$$

(xii) **Define intrinsic and extrinsic semi-conductor.**

Ans

Intrinsic semi-conductors	Extrinsic semi-conductors
1. A semi-conductor in its extremely pure form is known as intrinsic semi-conductor.	1. The doped semi-conductor materials are called extrinsic semi-conductors.
2. Silicon and germanium are intrinsic semi-conductors.	2. P-type and N-type are extrinsic semi-conductors.

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

(i) **Will higher frequency light eject greater number of electrons than low frequency light?**

Ans No, the higher frequency light will not eject greater number of electrons than low frequency light. However, the higher frequency light ejects electrons of large K.E. as compared to low frequency light.

(ii) **Photon A has twice the energy of photon B. What is the ratio of momentum of A to that of B?**

Ans The momentum of Photon = $P = \frac{h}{\lambda} = \frac{hf}{c} = \frac{E}{c}$

Momentum of Photon "A" = $P_A = \frac{hf_a}{c}$

Momentum of Photon "B" = $P_B = \frac{hf_b}{c}$

As photon "A" has twice the energy of photon "B"

$\therefore \quad f_A = f_B$

i.e., (Energy of A) = 2 (Energy of B)

As $\quad f \propto$ Energy $\qquad (\because \quad E = hf)$

$$P_A = \frac{2 f_B}{c} = 2 P_B$$

$$\frac{P_A}{P_B} = \frac{1}{2}$$

$$P_A = P_B = 1 : 2$$

(iii) **What is the energy of photon in a beam of infrared radiation of wavelength 1240 nm?**

Ans Given data

Wavelength = λ = 1240 nm

$= 1240 \times 10^{-9}$ m

Find, $\quad E = ?$

$E = hf \qquad \because \quad f = \frac{c}{\lambda}$

$$E = \frac{hc}{\lambda} \qquad \text{(i)}$$

h = Planck's constant = 6.63×10^{-34} Js

c = speed of light = 3×10^{8} ms^{-1}

Putting the value in eq. (i),

$$E = \frac{6.63 \times 10^{-34} \times 3 \times 10^{8}}{1240 \times 10^{-9}}$$

$$= \frac{6.63 \times 3 \times 10^{-26}}{1240 \times 10^{-9}}$$

$$= \frac{19.89 \times 10^{-26}}{1240 \times 10^{-19}}$$

$$= 1.6 \times 10^{-19}\ J$$

$$E = 1.0\ eV \qquad (\because\ 1.6 \times 10^{-19}\ J = 1.0\ eV)$$

(iv) What are the advantages of LASER over ordinary light?

Ans: The laser light is intense and coherent, so it does not spread while passing through a medium, its energy can be focused at a point to get enough energy for welding, cutting and surgical tool which ordinary light cannot do.

(v) Can the electron in ground state of hydrogen absorb a photon of energy 13.6 eV and greater than 13.6 eV?

Ans: Yes, it can absorb a photon of energy 13.6 eV or greater than 13.6 eV. In this case, when the electron will break from the nucleus, the surplus energy of photon is taken away by electron as kinetic energy.

(vi) Define the isotopes of an element. Write down the isotopes of hydrogen.

Ans: The nuclei of an element that have the same charge number but different mass number are called isotopes of the element.

Hydrogen has three isotopes:

1. Protium: It has only one proton in the nucleus ($^{1}_{1}H$).
2. Deuterium: It has one proton and one neutron in its nucleus ($^{2}_{1}H$).
3. Tritium: It has one proton and two neutrons in its nucleus ($^{3}_{1}H$).

(vii) What is radioactive decay? Give an example.

Ans Whenever a radioactive element emits α or β-particles, this element changes into a new element. This phenomenon is called radioactive decay.

Example:

Radium changes to radon gas.

$$^{226}_{88}R \longrightarrow ^{222}_{86}Rn + ^{4}_{2}He$$

(viii) What factor does make a fusion reaction difficult to achieve?

Ans The fusion reaction requires large energy and temperature up to million °C and it is very difficult to achieve such requirements (*i.e.*, high temperature and energy).

(ix) How can radioactivity help in the treatment of cancer?

Ans Radiotherapy with γ rays from cobalt-60 is often used in treatment of cancer. The γ rays are carefully focussed on the malignant tissue.

SECTION-II

NOTE: Attempt any THREE (3) questions.

Q.5.(a) State Gauss's law and apply it to find electric field intensity due to an infinite sheet of charge. (5)

Ans Gauss's law states that "The flux through any closed surface is $\frac{1}{\varepsilon_o}$ times the total charge enclosed in it."

Suppose point charges $q_1, q_2, q_3, \ldots, q_n$ are arbitrarily distributed in an arbitrarily shaped closed surface. The electric flux passing through the closed surface is:

$$\phi_e = \frac{q_1}{\varepsilon_o} + \frac{q_2}{\varepsilon_o} + \frac{q_3}{\varepsilon_o} + \ldots + \frac{q_n}{\varepsilon_o}$$

$$\phi_e = \frac{1}{\varepsilon_o}(q_1 + q_2 + q_3, \ldots, q_n)$$

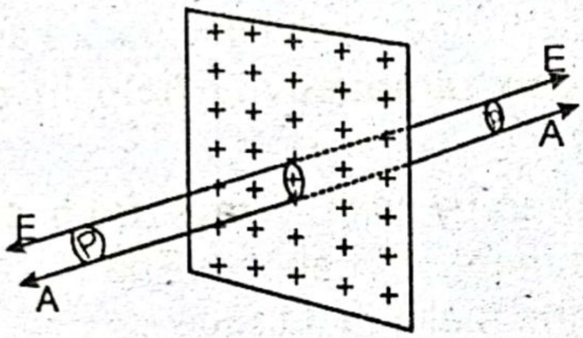
$$\phi_e = \frac{1}{\varepsilon_o} \text{(total charge enclosed by closed surface)}$$

$$\phi_e = \frac{1}{\varepsilon_o} \times Q$$

where $Q = q_1 + q_2 + q_3 + \ldots + q_n$ is the total charge enclosed by closed surface.

Electric intensity due to an infinite sheet of charge:

Suppose, we have a plane sheet of infinity extent on which positive charges are uniformly distributed. The uniform surface charge density is say σ. A finite part of this sheet is shown below:



To calculate the electric intensity E at a point P, close to the sheet, imagine a closed Gaussian surface in the form of a cylinder passing through the sheet, whose one flat face contains point P. From symmetry, we can conclude that $\vec{E}$ points at right angle to the end faces and away from the plane. Since, $\vec{E}$ is parallel to the curved surface of the cylinder, so, there is no contribution to flux from the curved wall of the cylinder.

At one end face:

$$\phi_e = \vec{E}.\vec{A}$$
$$= EA \cos\theta$$
$$= EA \cos 0^o$$
$$= EA$$

At other end face:

$$\phi_e = \vec{E}.\vec{A}$$

$$= EA \cos 0$$
$$= EA \cos 0^\circ$$
$$= EA$$
$$\phi = \phi_e + \phi_e$$
$$= EA + EA$$
$$= 2\,EA$$

According to Gauss's Law:

$$\phi = \frac{1}{\epsilon_o} \times q$$

$$2EA = \frac{1}{\epsilon_o} \times q \qquad (1)$$

$$\sigma = \frac{q}{A}$$

$$q = \sigma A \qquad \text{Put in (1)}$$

$$2EA = \frac{1}{\epsilon_o} \times \sigma A$$

$$E = \frac{1}{2\epsilon_o A} \times \sigma A$$

$$E = \frac{1}{2\epsilon_o} \times \sigma$$

In vector form:

$$\vec{E} = \frac{1}{2\epsilon_o} \sigma \,.\, \hat{r}$$

where $\hat{r}$ is a unit vector normal to the directed away from it.

(b) A platinum wire has resistance of 10 Ω at 0°C and 20 Ω at 273°C. Find the value of temperature coefficient of resistance. (3)

Ans Resistance at 0°C = R_o = 10 Ω

// // // 273°C = R_t = 20 Ω

Initial temperature = t_1 = 0 + 273 = 273 °K

Final temperature = t_2 = 273 + 273 = 546 °K

Temperature difference = $t = t_2 - t_1 = 546 - 273 = 273\ ^oK$

Temperature coefficient = $\propto$ = ?

$$\propto = \frac{R_t - R_o}{R_{ot}}$$

$$\propto = \frac{20-10}{10 \times 273} = \frac{\cancel{10}}{\cancel{10} \times 273} = \frac{1}{273}$$

$$= 3.66 \times 10^{-3}\ K^{-1}$$

Q.6.(a) Define galvanometer. How it is converted into an ammeter and voltmeter? (5)

Ans A galvanometer is an electrical instrument used to detect the passage of circuit.

Conversion of Galvanometer into Ammeter:

In order to convert the galvanometer into an ammeter, which can measure a maximum current-I, a low resistance R_s called shunt is connected in parallel with the galvanometer. The value of the shunt R_s is so adjusted that the current I_g passes through. The galvanometer and the remaining current $(I - I_g)$ should pass through the shunt R_s.

Since, the shunt is connected in parallel with the galvanometer, so the potential difference across them must be the same.

$$V_s = V_g$$

$$(I - I_g) = I_g R_g$$

$$R_s = \frac{I_g R_g}{I - I_g}$$

This equation gives the value of shunt R_s to convert the given galvanometer into an ammeter of range I.

Conversion of Galvanometer into Voltmeter:

In order to convert the galvanometer into a voltmeter, which can measure a maximum voltage V, a high resistance "R_h" is connected in series with the galvanometer.

The value of the resistance R_h should be such that full deflection will be obtained, when it is connected across V-volt.

Since "R_g" and "R_h" are in series, therefore, the combined resistance is $R_g + R_h$. As I_g current is passing through the circuit, so, according to Ohm's law, we have

$$V = I_g (R_g + R_h)$$

$$\frac{V}{I_g} = R_g + R_h$$

$$R_h = \frac{V}{I_g} - R_g$$

This equation gives the value of high resistance "R_h" which is to be used to convert the given galvanometer into voltmeter of range 0 – V volts.

(b) A pair of adjacent coils has a mutual inductance of 0.75 H. If the current in the primary changes from 0 to 10 A in 0.025 s, what is the average induced emf in the secondary? What is the change in flux in it, if the secondary has 500 turns? (3)

Ans Given data:

Mutual inductance: $M = 0.75$ H

Change in Current in P. coil $= \Delta I_p = 10 - 0 = 10$ A

Time internal $= \Delta t = 0.025$ sec

No. of turns on S. Coil $= N_s = 500$

To find

(i) Average induced emf in S. Coil $= \varepsilon_s = ?$

(ii) Change in flux through S. Coil $= \Delta\phi_s = ?$

(i) For average induced emf

$$\varepsilon_s = M \frac{\Delta I_p}{\Delta t}$$

$$\varepsilon_s = 0.75 \times \frac{10}{0.025}$$

$$\varepsilon_s = 300\text{ V}$$

(ii) For change in flux through S. Coil

$$\varepsilon_s = N_s \frac{\Delta\phi_s}{\Delta t}$$

$$\Delta\phi_s = \frac{\varepsilon_s \times \Delta t}{N_s} = \frac{300 \times 0.025}{500}$$

$$= 1.5 \times 10^{-2}\text{ Wb}$$

Q.7.(a) Discuss the behaviour of an inductor in an A.C. circuit and write an expression for the inductive reactance. (5)

Ans Consider an inductor is connected with an alternating voltage source.

Suppose that the inductor is made from a thick wire so that it has a large self-inductance "L" and a negligible resistance.

At any instant "t", the current flowing through the inductor is given by

$$I = I_o \sin \omega t \qquad \text{(i)}$$

The changing current produces the back emf in the coil which is given by

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

To maintain the current, the applied voltage V must be equal and opposite to back emf. Thus

$$V = -\varepsilon_L$$

$$V = L\frac{\Delta I}{\Delta t} \qquad \text{(ii)}$$

Since L is constant, So V is proportional to $\frac{\Delta I}{\Delta t}$. As $\frac{\Delta I}{\Delta t}$ is the slope of I – t curve, so the value of V is given by the slope of I – t curve at different instant of time.

Inductive Reactance:

It is the measure of opposition offered by an inductor to alternating current passing through it. It is denoted by X_L and is given by

$$X_L = \frac{V_{rms}}{I_{rms}} = w_L = 2\pi fL$$

This equation shows that reactance of coil depends upon the frequency of the A.C and inductance L. Thus X_L is directly proportional to both f and L.

The unit of X_L is ohm.

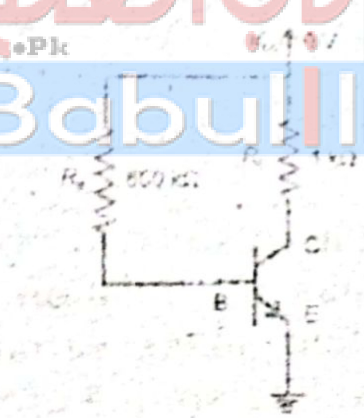
$$X_L = \frac{V_{rms}}{I_{rms}} = \frac{\text{volt}}{\text{Ampere}} = \text{ohm.}$$

(b) In circuit, as shown in fig., there is negligible potential drop between B and E. If β is 100, calculate: (3)

(i) base current (ii) collector current

(iii) potential drop across R_c

(iv) V_{CE}



Ans To determine,

(i) Base current = I_B = ?

(ii) Collector current = I_C = ?

(iii) Potential drop $R_C = V_C$ = ?

(iv) V_{CE} = ?

(i) Applying input loop equation

$$V_{CC} = I_B R_B + V_{BE}$$

$$9V = I_B \times 800\ k\Omega + 0.7\ V$$

$$I_B = \frac{9V - 0.7\ V}{800 \times 10^3\ \Omega}$$

$$= 1.0375 \times 10^{-5}\ A \qquad (\because\ V\Omega^{-1} = A)$$

$$= 10.375 \times 10^{-6}\ A$$

$$I_B = 10.37\ \mu A$$

(ii) $I_C = \beta\, I_B$

$$= 100 \times 10.37\ \mu A$$

$$= 1037\ \mu A$$

$$= 1.04\ m\ A$$

(iii) Now $V_C = V_{CC} - V_{CE}$

$$= 9V - 7.96\ V$$

$$= 1.04\ V$$

(iv) Applying output drop eq.

$$V_{CC} = I_C R_C + V_{CE}$$

$$9V = 1.04\ m\ A \times 1\ k\Omega + V_{CE}$$

$$= 1.04 \times 10^{-3}\ A \times 1000\ \Omega + V_{CE}$$

$$9V = 1.04 + V_{CE}$$

$$V_{CE} = 9V - 1.04\ V \qquad (\because\ A\Omega = V)$$

$$= 7.96\ V$$

Q.8.(a) Write down the postulates of special theory of relativity. Discuss the relation of time dilation, length contraction, mass variation and energy-mass relation with reference of this theory. (4)

Ans **Special Theory of Relativity:**

The theory of relativity is concerned with the way in which observers who are in a state of relative motion describe physical phenomena. The special theory of relativity treats problems involving inertial or non-accelerating frames of reference. There is another theory called general theory of relativity which treats problems involving frames of reference accelerating with respect to one another. The special theory of relativity is based upon two postulates, which can be stated as follows:

1. The laws of physics are the same in all inertial frames.
2. The speed of light in free space has the same value for all observers, regardless of their state of motion.

Time Delation:

According to special theory of relativity, time is not absolute quantity. It depends upon the motion of the frame of reference.

Suppose an observer is stationary in an interval frame. He measures the time interval between two events happening successively in this frame. Let this time interval be "t_o". This is known as proper time. If the observer is moving with respect to frame of events with velocity "v" or the frame of events is moving with respect to observer with a uniform velocity "v", the time measured by the observer would not be "t_o" but it would be "t" such that $t = \frac{t_o}{\sqrt{1 - \frac{v^2}{c^2}}}$.

where c is the velocity of light and it is very greater than "V". Therefore, the term $\frac{v^2}{c^2}$ is very small.

Length of Contraction:

If you are in motion relative to two points that are fixed distance apart, the distance between the two points appears shorter than if you were at rest relative to them. This effect is known as length contraction. The length contraction happens only along the direction of motion.

The length of an object or distance between two points measured by an observer who is relatively at rest is called proper length "l_o". If an object and an observer are in relative motion with speed v, then the contracted length "l" is given by $l = l_o\sqrt{1 - \frac{v^2}{c^2}}$.

Mass Variation:

According to this theory, mass of an object is varying quantity and depends upon the speed of the object. An object whose mass when measured at rest is m_o will have, an increased mass m when observed to be moving at speed V. They are related by

$$m = \frac{m_o}{\sqrt{1 - \frac{v^2}{c^2}}}$$

Energy-mass relation:

According to special theory of relativity, mass and energy are different entities but are inter-convertible. The total energy E and mass m of an object are related by the expression

$$E = mc^2$$

where m depends on the speed of the object. At rest, the energy equivalent of an object's mass m_o is called rest mass energy E_o.

$$E_o = m_oc^2$$

(b) A 1.0 m long copper wire is subjected to stretching force and its length is increased by 20 cm. Calculate the percentage elongation which the wire undergoes. (3)

Ans **Data:**

Length of copper wire = l = 1.0 m

Change in length = Δl = 20 cm = 0.20 m

To find:

Percentage elongation = ?

For percentage elongation

$$\text{Percentage elongation} = \frac{\text{Change in length}}{\text{Original length}} \times 100\%$$

$$= \frac{0.2}{1.0} \times 100\%$$

$$= 20\%$$

Percentage elongation = 20%

Q.9.(a) What are inner shell transitions? Describe the production of X-rays and their uses. (5)

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

(b) How much energy is absorbed by a man of mass 80 kg who receives a lethal whole body equivalent dose of 400 rem in the form of low energy neutrons for which RBE factor is 10? (3)

Ans RBE factor = 10 D = ?

De = 400 rem = 400 × 0.01 Sv = 4 Sv

Using eq. to find D,

$$D = \frac{De}{RBE} = \frac{4\ Sv}{10} = 0.4\ Gy$$