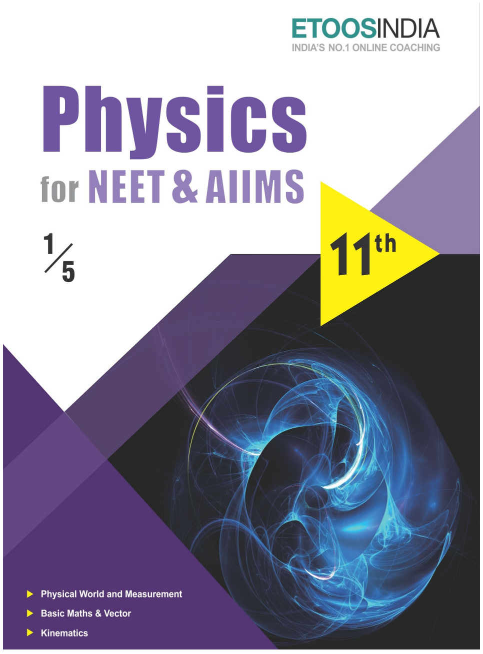
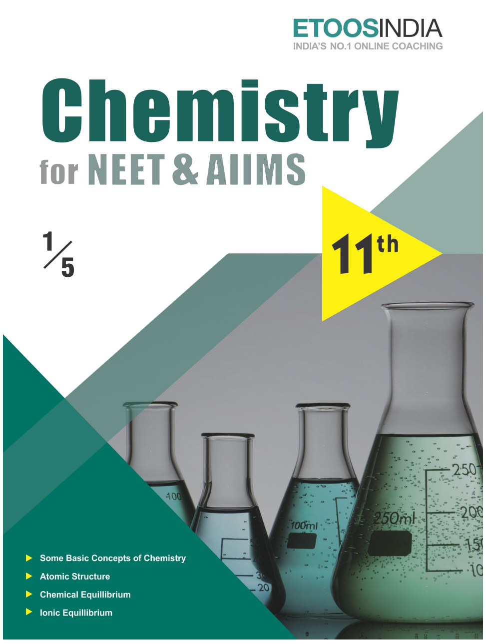
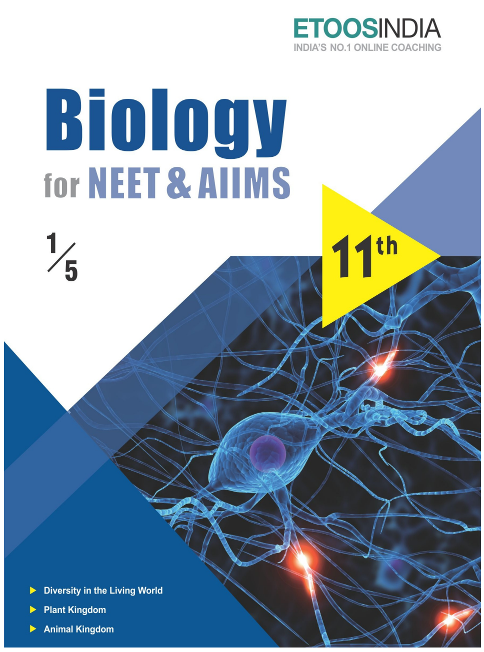
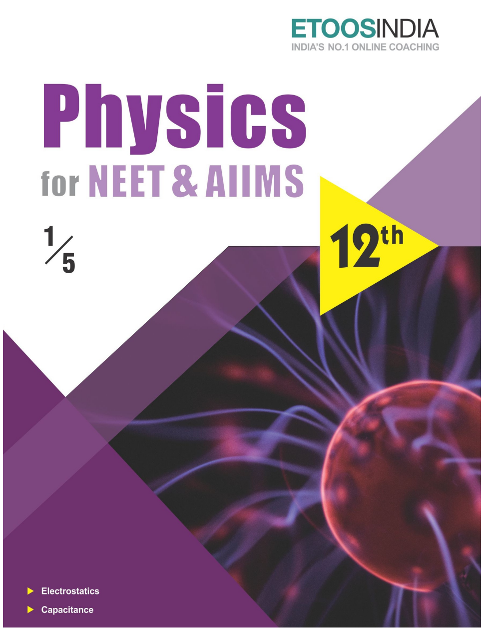
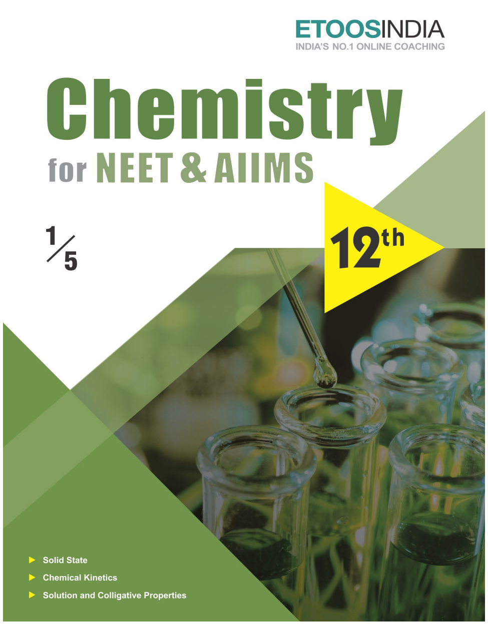
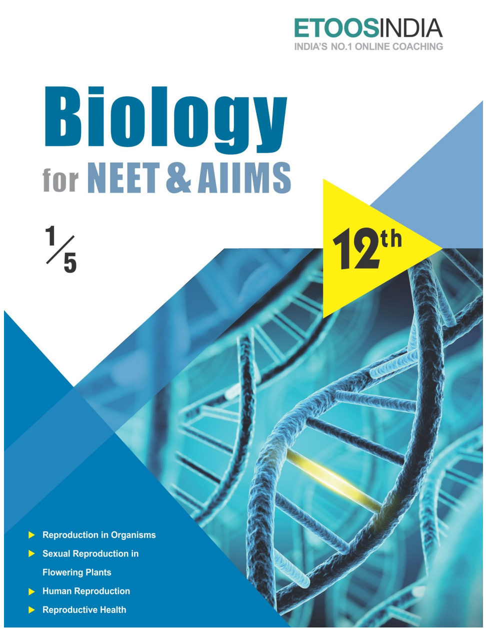












ETOOS Comprehensive Study Material For NEET & AIIMS

CHAPTER 09

MODERN PHYSICS

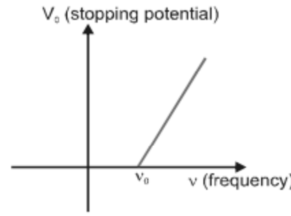
In its efforts to learn as much as possible about nature, modern physics has found that certain things can never be "known" with certainty. Much of our knowledge must always remain uncertain. The most we can know is in terms of probabilities.

"RICHARD FEYNMAN"

INTRODUCTION

Structure of matter always been an interesting area of research for physicists. Till 20^{th} century it was assumed that matter consists of indivisible small tiny particles called "atoms". But with the study and research it was found that the atom is divisible and made of other small partiicles called electron, proton and Neutron. So may physicists tried to explain the structure of atom but finally it was Neils Bohr whose explanation about the structure was well accepted. For simplicity they have taken hydrogen atom and then it can be extended to other H-like atoms too. Some of the historical modles are also explained and them drawbacks.

(iv) Effect of frequency



(a) Stopping potential is found to vary with frequency of incident light linearly. Greater the frequency of incident light, greater the stopping potential.

(b) There exists a certain minimum frequency ν_0 below which no stopping potential is required as no emission of electrons takes place. This frequency is called threshold frequency. For photoelectric emission to take place, $\nu > \nu_0$.

ETOOS KEY POINTS

(i) Photo electric effect is an instantaneous process, as soon as light is incident on the metal, photo electrons are emitted.

(ii) Stopping potential does not depend on the distance between cathode and anode.

(iii) The work function represented the energy needed to remove the least tightly bounded electrons from the surface. It depends only on nature of the metal and independent of any other factors.

1. Failure of wave theory of light

(i) According to wave theory when light incident on a surface, energy is distributed continuously over the surface. So that electron has to wait to gain sufficient energy to come out. But in experiment there is no time lag. Emission of electrons takes place in less than 10^{-9} s. This means, electron does not absorb energy. They get all the energy once.

(ii) When intensity is increased, more energetic electrons should be emitted. So that stopping potential should be intensity dependent. But it is not observed.

(iii) According to wave theory, if intensity is sufficient then, at each frequency, electron emission is possible. It means there should not be existence of threshold frequency.

2. Einstein's Explanation of Photoelectric Effect

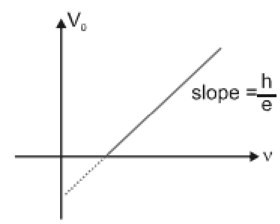
Einstein explained photoelectric effect on the basis of photon–electron interaction. The energy transfer takes place due to collisions between an electrons and a photon. The electrons within the target material are held there by electric force. The electron needs a certain minimum energy to escape from this pull. This minimum energy is the property of target material and it is called the work function. When a photon of energy E=hν collides with and transfers its energy to an electron, and this energy is greater than the work function, the electron can escape through the surface.

3. Einstein's Photoelectric Equation $h\nu = \phi + KE_{max}$

Here hν is the energy transferred to the electron. Out of this, ϕ is the energy needed to escape.

The remaining energy appears as kinetic energy of the electron.

Now $KE_{max} = eV_0$ (where V_0 is stopping potential)



$$\therefore\ h\nu = \phi + eV_0 \Rightarrow\ V_0 = \left(\frac{h}{e}\right)\nu - \frac{\phi}{e}$$

Thus, the stopping potential varies linearly with the frequency of incident radiation.

Slope of the graph obtained is $\frac{h}{e}$. This graph helps in determination of Planck's constant.

ETOOS KEY POINTS

(i) Einstein's Photo Electric equation is based on conservation of energy.

(ii) Einstein explained P.E.E. on the basis of quantum theory, for which he was awarded noble prize.

(iii) According to Einstein one photon can eject one e^- only. But here the energy of incident photon should greater or equal to work function.

(iv) In photoelectric effect all photoelectrons do not have same kinetic energy. Their KE range from zero to E_{max} which depends on frequency of incident radiation and nature of cathode.

(v) The photo electric effect takes place only when photons strike bound electrons because for free electrons energy and momentum conservations do not hold together.

Ex. In an experiment on photo electric emission, following observations were made;

(i) Wavelength of the incident light = 1.98×10^{-7} m;

(ii) Stopping potential = 2.5 volt.

Find : (a) Kinetic energy of photoelectrons with maximum speed.

(b) Work function and

(c) Threshold frequency;

Sol. (a) Since $v_s = 2.5$ V, $K_{max} = eV_s$ So, $K_{max} = 2.5$ eV

(b) Energy of incident photon

$$E = \frac{12400}{1980} eV = 6.26 \text{ eV} \qquad W = E - K_{max} = 3.76 \text{ eV}$$

(c) $h\nu_{th} = W = 3.76 \times 1.6 \times 10^{-19}$ J $\therefore$ $\nu_{th} = \dfrac{3.76 \times 1.6 \times 10^{-19}}{6.6 \times 10^{-34}} \approx 9.1 \times 10^{14}$ Hz

Ex. A beam of light consists of four wavelength 4000 Å, 4800 Å, 6000 Å and 7000 Å, each of intensity 1.5×10^{-3} Wm^{-2}. The beam falls normally on an area 10^{-4} m^2 of a clean metallic surface of work function 1.9 eV. Assuming no loss of light energy (i.e. each capable photon emits one electron) calculate the number of photoelectrons liberated per second.

Sol. $E_1 = \dfrac{12400}{4000} = 3.1$ eV, $E_2 = \dfrac{12400}{4800} = 2.58$ eV $E_3 = \dfrac{12400}{6000} = 2.06$ eV

and $E_4 = \dfrac{12400}{7000} = 1.77$ eV

Therefore, light of wavelengths 4000 Å, 4800 Å and 6000 Å can only emit photoelectrons.

$\therefore$ Number of photoelectrons emitted per second = No. of photons incident per second)

$$= \frac{I_1A_1}{E_1} + \frac{I_2A_2}{E_2} + \frac{I_3A_3}{E_3} = IA\left(\frac{1}{E_1} + \frac{1}{E_2} + \frac{1}{E_3}\right)$$

$$= \frac{(1.5 \times 10^{-3})(10^{-4})}{1.6 \times 10^{-19}} \left(\frac{1}{3.1} + \frac{1}{2.58} + \frac{1}{2.06}\right)$$

Etoos Tips & Formulas

1. Atomic Models :

(a) Thomson model : (Plum pudding model)

(1) Most of the mass and all the positive charge of an atom is uniformly distributed over the full size of atom (10^{-10} m).

(2) Electrons are studded in this uniform distribution.

(3) Failed to explain the large angle scattering α-particle scattered by thin foils of matter.

(b) Rutherford model : (Nuclear Model)

(1) The most of the mass and all the positive charge is concentrated within a size of 10-14 m inside the atom. This concentrated is called the atomic nucleus.

(2) The electron revolves around the nucleus under electric interaction between them in circular orbits.

(3) An accelerating charge radiates the nucleus spiralling inward and finally fall into the nucleus, which does not happen in an atom. This could not be explained by this model.

(c) Bohr atomic model : Bohr adopted Rutherford model of the atom & added some arbitrary conditions. These conditions are known as his postulates

(1) The electron in a stable orbit does not radiate energy.

(2) A stable orbit is that in which the angular momentum of the electron about nucleus is an integral (n) multiple of $\frac{h}{2\pi}$ i.e., $mvr = n\frac{h}{2\pi}$; n = 1, 2, 3, ..(n $\neq$ 0).

(3) The electron can absorb or radiate energy only if the electron jumps from a lower to a higher orbit or falls from a higher to lower orbit.

(4) The energy emitted or absorbed is a light photon of frequency ν and of energy. $E = h\nu$

For hydrogen atom : (z = atomic number = 1)

L_n = angular momentum in the n^{th} orbit = $n\frac{h}{2\pi}$

r_n = radius of n^{th} circular orbit = $(0.529\ \overset{o}{A})\,n^2 \Rightarrow r_n \propto n^2$

E_n = Energy of the electron in the n^{th} orbit = $\frac{-13.6\,eV}{n^2} \Rightarrow E_n \propto \frac{1}{n^2}$

Note : Total energy of the electron in an atom is negative, indicating that it is bound.

Binding Energy $(BE)_n = E_n = \frac{13.6\,eV}{n^2}$

(5) $E_{n2} - E_{n1}$ = Energy emitted when an electron jumps from n_2^{th} orbit to n_1^{th} orbit ($n_2 > n_1$)

$$\Delta E = (13.6\,eV)\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$$

$\Delta E = h\nu$; ν = frequency of spectral line emitted.

$\frac{1}{\lambda}$ = wave no, [no. of waves in unit length (1m)] $= R\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$

where R = Rydberg's constant, for hydrogen = $1.097 \times 10^7\ m^{-1}$

SOLVED EXAMPLE

Ex. 1. Find the momentum of a 12.0 MeV photon.

Sol. $p = \frac{E}{c} = 12$ MeV/c.

Ex. 2. Monochromatic light of wavelength 3000 Å is incident nornally on a surface of area 4 cm². If the intensity of the light is 15×10^{-2} W/m², determine the rate at which photons strike the surface.

Sol. Rate at which photons strike the surface

$$= \frac{IA}{hc/\lambda} = \frac{6\times10^{-5}\ J/s}{6.63\times10^{-19}\ J/photon} = 9.05 \times 10^{13}$$

photon/s.

Ex. 3. The kinetic energies of photoelectrons range from zero to 4.0×10^{-19} J when light of wavelength 3000 Å falls on a surface. What is the stopping potential for this light ?

Sol. $K_{max} = 4.0\times 10^{-19}\ J \times \frac{1eV}{1.6\times10^{-19}\ J} = 2.5$ eV.

Then, from $eV_s = K_{max}$, $V_s = 2.5$ V.

Ex. 4. What is the threshold wavelength for the material in above Ex. ?

Sol. $$2.5\ eV = \frac{12.4\times10^3\ eV.Å}{3000\ Å} - \frac{12.4\times10^3\ eV.Å}{\lambda_{th}}$$

Solving, $\lambda_{th} = 7590$ Å.

Ex. 5. Find the de Broglie wavelength of a 0.01 kg pellet having a velocity of 10 m/s.

Sol. $\lambda = h/p = \frac{6.63\times10^{-34}\ J.s}{0.01\ kg\times10\ m/s} = 6.63 \times 10^{-23}$ Å.

Ex. 6. Determine the accelerating potential necessary to give an electron a de Broglie wavelength of 1 Å, which is the size of the interatomic spacing of atoms in a crystal.

Sol. $V = \frac{h^2}{2m_0e\lambda^2} = 151$ V.

Ex. 7. Determine the wavelength of the second line of the Paschen series for hydrogen.

Sol. $\frac{1}{\lambda} = (1.097 \times 10^{-3}\ Å^{-1}) \left(\frac{1}{3^2} - \frac{1}{5^2}\right)$ or

$\lambda = 12{,}820$ Å.

Ex. 8. How many different photons can be emitted by hydrogen atoms that undergo transitions to the ground state from the n = 5 state ?

Sol. No of possible transition from n = 5 are $^5C_2 = 10$

Ans. 10 photons.

Ex. 9. An electron rotates in a circle around a nucleus with positive charge Ze. How is the electrons' velocity releated to the radius of its orbit ?

Sol. The force on the electron due to the nuclear provides the required centripetal force

$$\frac{1}{4\pi\varepsilon_0}\frac{Ze.e}{r^2} = \frac{mv^2}{r}$$

$\Rightarrow v = \sqrt{\frac{Ze^2}{4\pi\varepsilon_0.rm}}$ **Ans.** $v = \sqrt{\frac{Ze^2}{4\pi\varepsilon_0.rm}}$.

Ex. 10. **(i)** Calculate the first three energy levels for positronium.

(ii) Find the wavelength of the H_a line (3 → 2 transition) of positronium.

Sol. In positronium electron and positron revolve around their centre of mass

$$\frac{1}{4p\varepsilon_0}\frac{e^2}{r^2} = \frac{mv^2}{r/2} \quad \text{.............(1)}$$

$$\frac{nh}{2\pi} = 2 \times mv_{k/2} \quad \text{.............(2)}$$

From **(1)** & **(2)**

$$V = \frac{1}{2}.\frac{1}{4\pi\varepsilon_0}.\frac{e^2}{nh}\times 2p = \frac{e^2}{4\varepsilon_0 nh}$$

$$TE = -\frac{1}{2}mv^2 \times 2 = -m.\frac{e^4}{16\varepsilon_0{}^2n^2h^2}$$

$$= -6.8\frac{1}{n^2}\ eV$$

(i) $E_1 = -6.8$ ev

$E_2 = -6.8 \times \frac{1}{2^2}$ eV $= -1.70$ eV

$E_3 = -6.8 \times \frac{1}{3^2}$ eV $= -0.76$ eV

Exercise # 1 SINGLE OBJECTIVE NEET LEVEL

1. If in nature there may not be an element for which the principal quantum number $n > 4$, then the total possible number of elements will be
(A) 60 (B) 32
(C) 4 (D) 64

2. In the Bohr's hydrogen atom model, the radius of the stationary orbit is directly proportional to (n = principle quantum number)
(A) n^{-1} (B) n
(C) n^{-2} (D) n^2

3. In the n^{th} orbit, the energy of an electron $E_n = -\frac{13.6}{n^2} eV$ for hydrogen atom. The energy required to take the electron from first orbit to second orbit will be
(A) $10.2\ eV$ (B) $12.1\ eV$
(C) $13.6\ eV$ (D) $3.4\ eV$

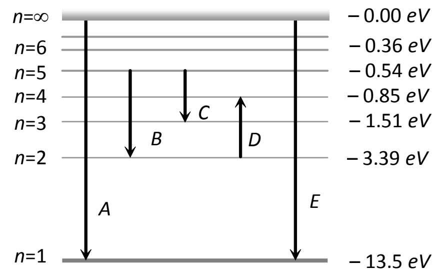
4. In the following atoms and moleculates for the transition from $n = 2$ to $n = 1$, the spectral line of minimum wavelength will be produced by
(A) Hydrogen atom (B) Deuterium atom
(C) Uni-ionized helium (D) di-ionized lithium

5. The Lyman series of hydrogen spectrum lies in the region
(A) Infrared (B) Visible
(C) Ultraviolet (D) Of x – rays

6. The size of an atom is of the order of
(A) $10^{-8} m$ (B) $10^{-10} m$
(C) $10^{-12} m$ (D) $10^{-14} m$

7. Which one of the series of hydrogen spectrum is in the visible region
(A) Lyman series (B) Balmer series
(C) Paschen series (D) Bracket series

8. The energy levels of the hydrogen spectrum is shown in figure. There are some transitions A, B, C, D and E. Transition A, B and C respectively represent



(A) First member of Lyman series, third spectral line of Balmer series and the second spectral line of Paschen series
(B) Ionization potential of hydrogen, second spectral line of Balmer series and third spectral line of Paschen series
(C) Series limit of Lyman series, third spectral line of Balmer series and second spectral line of Paschen series
(D) Series limit of Lyman series, second spectral line of Balmer series and third spectral line of Paschen series

9. In the above figure D and E respectively represent
(A) Absorption line of Balmer series and the ionization potential of hydrogen
(B) Absorption line of Balmer series and the wavelength lesser than lowest of the Lyman series
(C) Spectral line of Balmer series and the maximum wavelength of Lyman series
(D) Spectral line of Lyman series and the absorption of greater wavelength of limiting value of Paschen series

10. The Rutherford α-particle experiment shows that most of the α-particles pass through almost unscattered while some are scattered through large angles. What information does it give about the structure of the atom
(A) Atom is hollow
(B) The whole mass of the atom is concentrated in a small centre called nucleus
(C) Nucleus is positively charged
(D) All the above

Exercise # 2 SINGLE OBJECTIVE AIIMS LEVEL

1. If the frequency of light in a photoelectric experiment is doubled then maximum kinetic energy of photoelectron

(A) be doubled

(B) be halved

(C) become more than double

(D) become less than double

2. In a photoelectric experiment, if stopping potential is applied, then photocurrent becomes zero. This means that :

(A) the emission of photoelectrons is stopped

(B) the photoelectrons are emitted but are reabsorbed by the emitter metal

(C) the photoelectrons are accumulated near the collector plate

(D) the photoelectrons are dispersed from the sides of the apparatus.

3. Two separate monochromatic light beams A and B of the same intensity (energy per unit area per unit time) are falling normally on a unit area of a metallic surface. Their wavelength are λ_A and λ_B respectively. Assuming that all the incident light is used in ejecting the photoelectrons, the ratio of the number of photoelectrons from beam A to that from B is

(A) $\left(\frac{\lambda_A}{\lambda_B}\right)$ (B) $\left(\frac{\lambda_B}{\lambda_A}\right)$

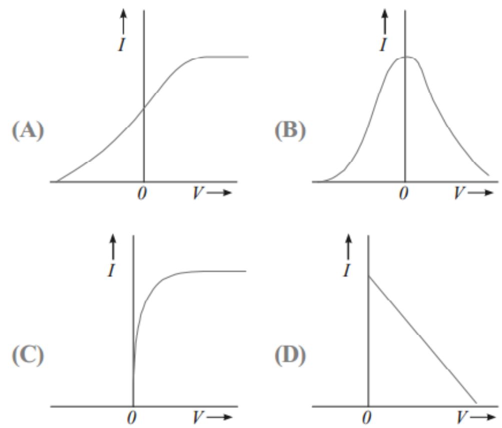
(C) $\left(\frac{\lambda_A}{\lambda_B}\right)^2$ (D) $\left(\frac{\lambda_B}{\lambda_A}\right)^2$

4. When a centimetre thick surface is illuminated with light of wavelength λ, the stopping potential is V. When the same surface is illuminated by light of wavelength 2λ, the stopping potential is $V/3$. The threshold wavelength for the surface is :

(A) $\frac{4\lambda}{3}$ (B) 4λ

(C) 6λ (D) $\frac{8\lambda}{3}$

5. Which one of the following graphs in figure shows the variation of photoelectric current (I) with voltage (V) between the electrodes in a photoelectric cell ?



6. A photon of light enters a block of glass after travelling through vacuum. The energy of the photon on entering the glass block

(A) increases because its associated wavelength decreases

(B) Decreases because the speed of the radiation decreases

(C) Stays the same because the speed of the radiation and the associated wavelength do not change

(D) Stays the same because the frequency of the radiation does not change

7. The maximum kinetic energy of photoelectrons emitted from a surface when photons of energy 6 eV fall on it is 4 eV. The stopping potential is :

(A) 2V (B) 4V

(C) 6V (D) 10V

8. The anode plate in an experiment on photoelectric effect is kept vertically above the cathode plate. Light source is put on and a saturation photocurrent is recorded. An electric field is switched on which has vertically downward direction

(A) The photocurrent will increase

(B) The kinetic energy of the electrons will increase

(C) The stopping potential will decrease

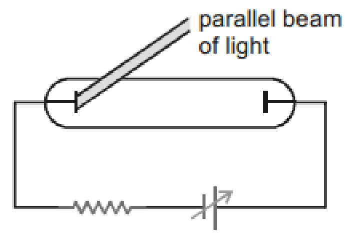
(D) The threshold wavelength will increase

Exercise # 3 PART - 1 MATRIX MATCH COLUMN

1. The energy, the magnitude of linear momentum, magnitude of angular momentum and orbital radius of an electron in a hydrogen atom corresponding to the quantum number n are E, p, L and r respectively. Then according to Bohr's theory of hydrogen atom, match the expressions in column-I with statement in column-II.

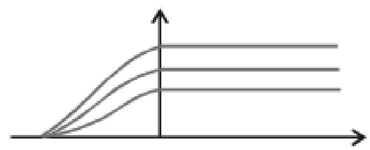
Column-I	Column-II
(A) Epr	(P) is independent of n.
(B) $\frac{p}{E}$	(Q) is directly proportional to n
(C) Er	(R) is inversely proportional to n.
(D) pr	(S) is directly proportional to L.

2. In the shown experimental setup to study photoelectric effect, two conducting electrodes are enclosed in an evacuated glass-tube as shown. A parallel beam of monochromatic radiation, falls on photosensitive electrode. Assume that for each photons incident, a photoelectron is ejected if its energy is greater than work function of electrode. Match the statements in column I with corresponding graphs in column II.

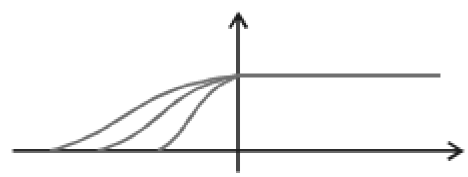


Column-I | **Column-II**

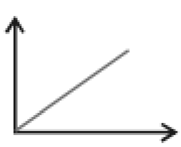
(A) Saturation photocurrent (for same metal) versus intensity of radiation is represented by

(P) 

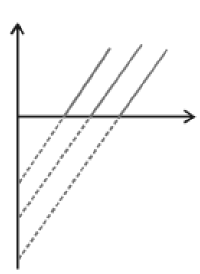
(B) Maximum kinetic energy of ejected photoelectrons versus frequency for electrodes of different work function is represented by

(Q) 

(C) Photo current versus applied voltage for different intensity of radiation (for same metal) is represented by

(R) 

(D) Photo current versus applied voltage at constant intensity of radiation for electrodes of different work function.

(S) 

Exercise # 4

PART - 1

PREVIOUS YEAR (NEET/AIPMT)

ELECTRONS AND PHOTONS

1. Einsteins' work on photoelectric effect gives support to [CBSE AIPMT 2000]

(A) $E = mc^2$ (B) $E = hv$

(C) $hv = \frac{1}{2}mv^2$ (D) $E = \frac{h}{\lambda}$

2. The energy of a photon of light is 3 eV. Then the wavelength of photon must be [CBSE AIPMT 2000]

(A) 4125 nm (B) 412.5 nm

(C) 41250 nm (D) 4 nm

3. A light source is at a distance d from a photoelectric cell, then the number of photoelectrons emitted from the cell is n. If the distance of light source and cell is reduced to half, then the number of photoelectrons emitted will become [CBSE AIPMT 2001]

(A) $\frac{n}{2}$ (B) 2 n

(C) 4 n (D) n

4. The following particels are moving with the same velocity, then maximum de-Broglie wavelength will be for [CBSE AIPMT 2002]

(A) proton (B) α-particle

(C) neutron (D) β-particle

5. Which of the following rays are incident on metal plate, the photoelectric effect does not occur. It occurs by incidence of [CBSE AIPMT 2002]

(A) It produces heating effect

(B) It does not deflect in electric field

(C) Its casts shadow

(D) It produces fluorescence

6. When ultraviolet rays are incident on metal plate, the photoelectric effect does not occur. It occurs by incidence of [CBSE AIPMT 2002]

(A) infrared rays (B) X-rays

(C) radiowaves (D) light waves

7. A photoelectric cell is illuminated by a point source of light 1 m away. When the source is shifted to 2 m, then [CBSE AIPMT 2003]

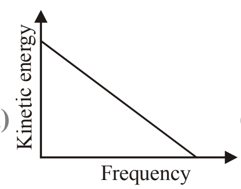
(A) each emitted electron carries half the initial energy

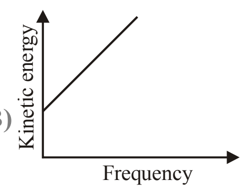
(B) number of electrons emitted is a quarter of the initial number

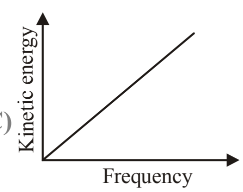
(C) each emitted electron carries one quarter of the initial energy

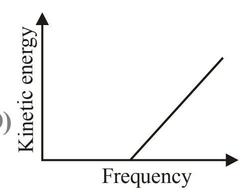
(D) number of electrons emitted is half the initial number

8. According to Einsteins' photoelectric equation, the graph between the kinetic energy of photoelectrons ejected and the frequency of incident radiation is [CBSE AIPMT 2004]

(A)


(B)


(C)


(D)


9. The work functions for metals A, B and C are respectively.1.92 eV, 2.0 eV and 5 eV. According to Einsteins' equation, the metals which will emit photoelectrons for a radiation of wavelength 4100 Å is/are [CBSE AIPMT 2005]

(A) None of these (B) A only

(C) A and B only (D) All the three metals

10. A photosensitive metallic surface has work function, $h v_0$. If photons of energy $2 hv_0$ fall on this surface, the electrons come out with a maximum velocity of 4×10^6 m/s. When the photon energy is increased to $5 hv_0$, then maximum velocity of photoelectrons will be [CBSE AIPMT 2005]

(A) 2×10^6 m/s (B) 2×10^7 m/s

(C) 8×10^5 m/s (D) 8×10^6 m/s

MOCK TEST

STRAIGHT OBJECTIVE TYPE

1. In an α-decay the Kinetic energy of α particle is 48 MeV and Q-value of the reaction is 50 MeV. The mass number of the mother nucleus is:- (Assume that daughter nucleus is in ground state)

(A) 96 (B) 100 (C) 104 (D) none of these

2. The angular momentum of an electron in first orbit of Li^{++} ion is :

(A) $\frac{3h}{2\pi}$ (B) $\frac{9h}{2\pi}$ (C) $\frac{h}{2\pi}$ (D) $\frac{h}{6\pi}$

3. If first excitation potential of a hydrogen like atom is V electron volt, then the ionization energy of this atom will be:

(A) V electron volt (B) $\frac{3V}{4}$ electron volt

(C) $\frac{4V}{3}$ electron volt (D) cannot be calculated by given information.

4. All electrons ejected from a surface by incident light of wavelength 200 nm can be stopped before travelling 1 m in the direction of uniform electric field of 4 N/C. The work function of the surface is:

(A) 4 eV (B) 6.2 eV (C) 2 eV (D) 2.2 eV

5. An electron of mass 'm', when accelerated through a potential V has de–Broglie wavelength λ. The de–Broglie wavelength associated with a proton of mass M accelerated through the same potential difference will be:

(A) $\lambda\sqrt{\frac{M}{m}}$ (B) $\lambda\sqrt{\frac{m}{M}}$ (C) $\lambda\left(\frac{M}{m}\right)$ (D) $\lambda\left(\frac{m}{M}\right)$

6. Two hydrogen atoms are in excited state with electrons residing in n = 2. First one is moving towards left and emits a photon of energy E_1 towards right. Second one is moving towards right with same speed and emits a photon of energy E_2 towards right. Taking recoil of nucleus into account during emission process

(A) $E_1 > E_2$ (B) $E_1 < E_2$ (C) $E_1 = E_2$ (D) information insufficient

7. In a hydrogen atom following the Bohr's postulates the product of linear momentum and angular momentum is proportional to $(n)^x$ where 'n' is the orbit number. Then 'x' is :

(A) 0 (B) 2 (C) –2 (D) 1

8. The voltage applied to an X-ray tube is 18 kV. The maximum mass of photon emitted by the X-ray tube will be:

(A) 2×10^{-13} kg (B) 3.2×10^{-36} kg (C) 3.2×10^{-32} kg (D) 9.1×10^{-31} kg

9. The wavelengths of K_α x-rays of two metals 'A' and 'B' are $\frac{4}{1875\ R}$ and $\frac{1}{675\ R}$ respectively, where 'R' is Rydberg's constant. The number of elements lying between 'A' and 'B' according to their atomic numbers is

(A) 3 (B) 6 (C) 5 (D) 4

11th Class Modules Chapter Details

Physics
5
Modules

Chemistry
5
Modules

Mathematics
5
Modules

PHYSICS

Module-1

1. Physical World & Measurements
2. Basic Maths & Vector
3. Kinematics

Module-2

1. Law of Motion & Friction
2. Work, Energy & Power

Module-3

1. Motion of system of particles & Rigid Body
2. Gravitation

Module-4

1. Mechanical Properties of Matter
2. Thermal Properties of Matter

Module-5

1. Oscillations
2. Waves

CHEMISTRY

Module-1(PC)

1. Some Basic Conceps of Chemistry
2. Atomic Structure
3. Chemical Equilibrium
4. Ionic Equilibrium

Module-2(PC)

1. Thermodynamics & Thermochemistry
2. Redox Reaction
3. States Of Matter (Gaseous & Liquid)

Module-3(IC)

1. Periodic Table
2. Chemical Bonding
3. Hydrogen & Its Compounds
4. S-Block

Module-4(OC)

1. Nomenclature of Organic Compounds
2. Isomerism
3. General Organic Chemistry

Module-5(OC)

1. Reaction Mechanism
2. Hydrocarbon
3. Aromatic Hydrocarbon
4. Environmental Chemistry & Analysis Of Organic Compounds

BIOLOGY

Module-1

1. Diversity in the Living World
2. Plant Kingdom
3. Animal Kingdom

Module-2

1. Morphology in Flowering Plants
2. Anatomy of Flowering Plants
3. Structural Organization in Animals

Module-3

1. Cell: The Unit of Life
2. Biomolecules
3. Cell Cycle & Cell Division
4. Transport in Plants
5. Mineral Nutrition

Module-4

1. Photosynthesis in Higher Plants
2. Respiration in Plants
3. Plant Growth and Development
4. Digestion & Absorption
5. Breathing & Exchange of Gases

Module-5

1. Body Fluids & Its Circulation
2. Excretory Products & Their Elimination
3. Locomotion & Its Movement
4. Neural Control & Coordination
5. Chemical Coordination and Integration

12th Class Modules Chapter Details

Physics
5
Modules

Chemistry
5
Modules

Mathematics
5
Modules

PHYSICS

Module-1

1. Electrostatics
2. Capacitance

Module-2

1. Current Electricity
2. Magnetic Effect of Current and Magnetism

Module-3

1. Electromagnetic Induction
2. Alternating Current

Module-4

1. Geometrical Optics
2. Wave Optics

Module-5

1. Modern Physics
2. Nuclear Physics
3. Solids & Semiconductor Devices
4. Electromagnetic Waves

CHEMISTRY

Module-1(PC)

1. Solid State
2. Chemical Kinetics
3. Solutions and Colligative Properties

Module-2(PC)

1. Electrochemistry
2. Surface Chemistry

Module-3(IC)

1. P-Block Elements
2. Transition Elements (d & f block)
3. Co-ordination Compound
4. Metallurgy

Module-4(OC)

1. HaloAlkanes & HaloArenes
2. Alcohol, Phenol & Ether
3. Aldehyde, Ketone & Carboxylic Acid

Module-5(OC)

1. Nitrogen & Its Derivatives
2. Biomolecules & Polymers
3. Chemistry in Everyday Life

BIOLOGY

Module-1

1. Reproduction in Organisms
2. Sexual Reproduction in Flowering Plants
3. Human Reproduction
4. Reproductive Health

Module-2

1. Principles of Inheritance and Variation
2. Molecular Basis of Inheritance
3. Evolution

Module-3

1. Human Health and Disease
2. Strategies for Enhancement in Food Production
3. Microbes in Human Welfare

Module-4

1. Biotechnology: Principles and Processes
2. Biotechnology and Its Applications
3. Organisms and Populations

Module-5

1. Ecosystem
2. Biodiversity and Conservation
3. Environmental Issues