CET - II PUC: PHYSICS: ATOMIC PHYSICS -1

INTRODUCTION TO ATOMIC PHYSICS, PHOTOELECTRIC EFFECT
DUAL NATURE OF MATTER, BOHR'S ATOM MODEL
SCATTERING OF LIGHT and LASERS
QUESTIONS and ANSWERS

1) Which of the following statements are correct?

   a) Electromagnetic waves can have wavelengths of several kilometres.

   b) High energy gamma rays travel at a higher speed than lower energy ones in free space.

   c) UV-rays are transverse waves.

   d) An electromagnetic wave can penetrate matter.

   1) (a), (b) and (c) 2)(b), (c) and (d) 3) (a), (c) and (d) 4)(a), (b) and (d)

   Answer: (3)

b) is**wrong** because speed of all the components of electromagnetic spectrum is same in free space.

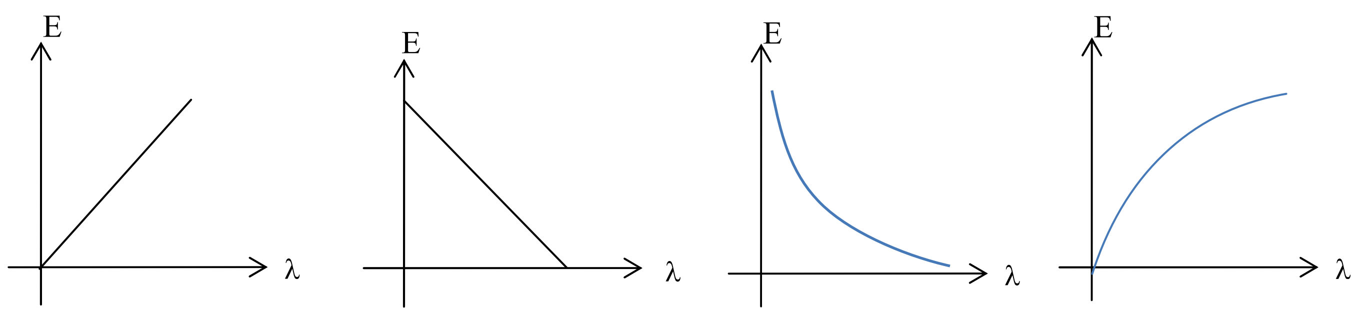
2) Given that the mass of neutron or proton is approximately 1840 times the mass of electron, then the ratio of specific charge of electron to that of α-particle is

   1) 1840 2)3680 3) $\frac{1}{1840}$ 4) $\frac{1}{3680}$

   Answer: (2)

$$\text{Required} = \frac{\text{Specific charge of electron}}{\text{Specific charge of } \alpha\text{-particle}} = \frac{e/m_e}{2e/m_\alpha} = \frac{m_\alpha}{2m_e} = \frac{4m_n}{2m_e} = \frac{2m_n}{m_e} = 2 \times 1840 = 3680$$

3) Of the following the graph which represents the variation of Energy (E) of the photon with the wavelength (λ) is



1) 2) 3) 4)

Answer: (3)

$$E = \frac{hc}{\lambda} \quad \text{or} \quad E \propto \frac{1}{\lambda}$$

$E\lambda$ = constant, is rectangular hyperbola with assymptotes as Co-ordinate axes

4) Match the following:

List – 1		List – 2	
a)	Burning candle	i)	Line absorption spectrum
b)	Sodium vapour lamp	ii)	Continuous emission spectrum
c)	Sun	iii)	Band emission spectrum
d)	Bunsen flame	iv)	Line emission spectrum

1) a – iii, b – i, c – iv, d – ii **2) a – iv, b – ii, c – i, d –iii**
3) a – ii, b – iii, c – i, d – iv **4) a – ii, b – iv, c – i, d – iii**
Answer: (4)

5) The kinetic energy of the photoelectron increases by 0.5 eV when the wavelength of incident light is changed from 500nm to another wavelength which is nearly
1) 400 nm 2) 700 nm 3)1000 nm 4) 1250 nm
Kinetic energy of photoelectrons increases when energy of incident light increases, i.e., when wavelength decreases. Here only one option has wavelength less than the given
Answer is (1)

OR

$$\frac{hc}{\lambda_1} = W + E_{K1} \text{.......(1)} \quad \text{and} \quad \frac{hc}{\lambda_2} = W + E_{K2} \text{.......(2)}$$

$$(2) - (1) \Rightarrow \quad hc\left(\frac{1}{\lambda_2} - \frac{1}{\lambda_1}\right) = E_{K2} - E_{K1} = 0.5\,eV$$

$$\frac{1}{\lambda_2} - \frac{1}{\lambda_1} = \frac{E_{K2} - E_{K1}}{hc} \approx \frac{0.5 \times 1.6 \times 10^{-19}}{20 \times 10^{-26}} = \frac{0.8 \times 10^7}{20} = 0.04 \times 10^7$$

$$\frac{1}{\lambda_2} = 0.04 \times 10^7 + \frac{1}{5 \times 10^{-7}} = 0.04 \times 10^7 + 0.2 \times 10^7 = 0.24 \times 10^7$$

$$\lambda_2 = \frac{1}{0.24 \times 10^7} \approx 4 \times 10^{-7} \approx 400\,nm$$

6) Light photons of energies 1 eV and 2.5 eV are successively incident on a metal surface of work function 0.5 eV, then the ratio maximum velocities of the emitted electrons will be
1) 1 : 5 2)1 : 4 3)1 : 3 4) 1 : 2

Answer:

E_{K1}= 1eV– 0.5eV = 0.5 eV
E_{K2}= 2.5eV– 0.5eV = 2 eV
E_{K1}: E_{K2} = 1 : 4 WKT, Kinetic energy: $E_k \alpha\ v^2$
v_1: v_2 = 1 : 2
Answer is (4)

7) When UV light of wavelength 100 nm is incident on silver surface of work function 4.7eV, a negative potential of 7.7V is required to stop the photoelectrons from reaching the collector plate. The potential which is required to stop the photoelectrons when light of wavelength 200nm is incident on it will be
1) 1.5V 2) 3V 3)4.5V 4) 6V

Answer:

$E_{K1} = 7.7$ eV,

1^{st} case: Energy of photon: $E_1 = W + E_{K1} = 4.7 eV + 7.7 eV = 12.4 eV$

$$\frac{E_2}{E_1} = \frac{\lambda_1}{\lambda_2} = \frac{100 \text{ nm}}{200 \text{ nm}} = \frac{1}{2}$$

2^{nd} case: Energy of photon: $E_2 = 6.2$ eV

$E_{K2} = E_2 - W = 6.2 \text{ eV} - 4.7 \text{ eV} = 1.5 \text{ eV}$

Answer is (4)

8) When a monochromatic point source of light is at a distance of 1.50 m from a photoelectric cell, the cut-off voltage and the saturation current (i) are respectively 2V and 20 μA. If the same source is placed 75cm away from the photoelectric cell, then
   1) The stopping potential will be 2V and saturation current will be 80 μA
   2) The stopping potential will be 4V andsaturation current will be 80 μA
   3) The stopping potential will be 2V and saturation current will be 40 μA
   4) The stopping potential will be 4V andsaturation current will be 40 μA

Answer:

Intensity of incident light : $I \propto \frac{1}{d^2}$

$$\frac{I_2}{I_1} = \left(\frac{d_1}{d_2}\right)^2 = \left(\frac{1.5}{0.75}\right)^2 = 4$$

$I_2 = 4 I_1$

Number of electrons becomes 4 times the initial.

Hence the photoelectric current also becomes 4 times the initial.

Answer is (1)

9) If E is the energy, de-Broglie wavelength is proportional to
   1) E^{-1} for both photons and particles
   2) E^{-1} for photons and $E^{-1/2}$ particles
   3) $E^{-1/2}$ for both photons and particles
   4) $E^{-1/2}$ for photons and E^{-1} for particles

Answer:

For photon: $E = \frac{hc}{\lambda}$ or $\lambda \propto \frac{1}{E} \Rightarrow \lambda \propto E^{-1}$

For a particle: $\lambda = \frac{h}{\sqrt{2mE}} \Rightarrow \lambda \propto \frac{1}{\sqrt{E}} \Rightarrow \lambda \propto E^{-\frac{1}{2}}$

Answer is (2)

10) The resolving power of an electron microscope at 10 kV is R. The potential increased to 90 kV. The new resolving power will be

1) R 2) 3R 3) R/3 4) 9R

Answer: (2)

$$\text{Resolving power} \propto \frac{1}{\lambda} \quad \text{and} \quad \lambda \propto \frac{1}{\sqrt{V}}$$

$$\therefore \text{ Resolving power} \propto \sqrt{V}$$

$$\frac{R_2}{R_1} = \sqrt{\frac{V_2}{V_1}} \quad \Rightarrow \quad \frac{R_2}{R_1} = \sqrt{\frac{90kV}{10kV}} = 3$$

$$R_2 = 3R$$

11) For given kinetic energy which of the following has the smallest de-Broglie wavelength?

1) Electron 2)Proton 3)Neutron 4) alpha particle

Answer: (4)

$$\lambda = \frac{h}{\sqrt{2mE}} \quad \text{or} \quad \lambda \propto \frac{1}{\sqrt{m}},$$ When kinetic energy 'E' is same for all the particles

Heaviest particle will have smallest de - Broglie wavelength $(m_e < m_p < m_n < m_\alpha)$

12) The ionization energy of electron in the hydrogen in its ground state is 13.6 eV. The atoms are excited to higher energy levels to emit radiations of 6 wavelengths. Maximum wavelength of emitted radiation corresponds to the transition between

1) n = 2 to n =1 2)n = 3 to n = 1 3)n = 3 to n = 2 4) n = 4 to n =3

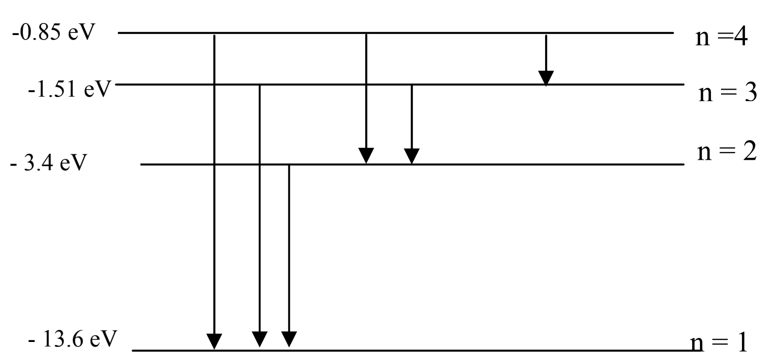
$$\text{Possible number of spectral lines} = \frac{n(n-1)}{2}$$

Given $\frac{n(n-1)}{2} = 6$ or $n(n-1) = 12$

$$\Rightarrow n = 4$$

Radiation of maximum wavelength is emitted when the energy difference between the two levels is least.

Answer is (4)



13) Hydrogen atom emits blue light when an electron jumps from n = 4 to n = 2 energy level. The colour of light emitted by the atom when the electron jumps from n = 15 to n = 2 energy level is

1) red 2) yellow 3) green 4) violet

More the energy difference between the two levels, lesser will be the wavelength of the emitted radiation.

Answer is (4)

14) Force acting on an electron in a Bohr orbit with principal quantum number n is proportional to

1) n 2) n^2 3) n^4 4) $1/n^4$

Force: $F = \frac{1}{4\pi\varepsilon_o} \times \frac{Z e^2}{r^2}$ and $r \propto n^2$

$\therefore F \propto \frac{1}{r^2} \propto \frac{1}{n^4}$

Answer is (4)

15) The kinetic energy of the orbiting electron in the hydrogen atom is E, then the potential energy and the total energy with proper sign are respectively

1) – E, 2E 2) – 2E, E 3) E, 2E 4) –2E, –E

Answer:

Potential energy: $E_p = -2E_k$ and total energy $= E_k + E_p = E + (-2E) = -E$

Answer: (4)

16) The orbital radius of the electron in the hydrogen atom changes from r to 4r, then the energy of the orbital electron change from E to

1) E/4 2) E/2 3) 2E 4) 4E

Answer:

Given: $r_1 = r$, $r_2 = 4r$, $E_1 = E$, $E_2 = ?$

$$r \propto n^2 \Rightarrow \frac{r_1}{r_2} = \left(\frac{n_1}{n_2}\right)^2$$

$$E_n \propto \frac{1}{n^2} \Rightarrow \frac{E_2}{E_1} = \left(\frac{n_1}{n_2}\right)^2 = \frac{r_1}{r_2} = \frac{1}{4}$$

$$\therefore E_2 = \frac{1}{4}E$$

Answer is (1)

17) When hydrogen atom is excited state, emits a photon of energy 12.1eV when it makes a transition to a ground state, its orbital angular momentum changes by

1) 1.05×10^{-34}Js 2) 2.11×10^{-34}Js 3) 3.16×10^{-34}Js 4) 4.22×10^{-34}Js

Answer:

$\because$ 12.1 eV = −1.5 eV − (−13.6 eV)

Transition is from 3rd orbit to 1st orbit.

Angular momentum in n^{th} orbit $= \frac{n h}{2\pi}$

Change in angular momentum $= \frac{3h}{2\pi} - \frac{h}{2\pi} = \frac{2h}{2\pi} = \frac{h}{\pi} = \frac{6.625\times10^{-34}}{3.14} = 2.11\times10^{-34}$ Js

Answer is (2)

18) How many times does the electron go around the first Bohr orbit in one second?

1) $\frac{4\pi^2 mr^2}{h}$ 2) $\frac{h}{4\pi^2 mr^2}$ 3) $\frac{h}{2\pi mr}$ 4) $\frac{2\pi mr}{h}$

Answer:

Required to find the frequency of orbiting electron in the first orbit of Hydrogen atom

Time period : $T = \frac{2\pi r}{v}$ and $m v r = \frac{n h}{2\pi} \Rightarrow v = \frac{h}{2\pi m r}$ (n = 1)

$$T = \frac{2\pi r}{\frac{h}{2\pi m r}} = \frac{4\pi^2 r^2 m}{h} \qquad \therefore f = \frac{h}{4\pi^2 r^2 m}$$

Answer: (2)

19) Angular momentum of an electron in an orbit of H atom is proportional to

1) r 2) $\frac{1}{r}$ 3) $\sqrt{r}$ 4) $\frac{1}{\sqrt{r}}$

Answer: (3)

Angular momentum = $\frac{n h}{2\pi} \propto n$, But $r \propto n^2$

$\therefore$ Angular momentum $\propto \sqrt{r}$

20) Energy levels A, B, C of a certain atom correspond to increasing values of energy i.e.,$E_A < E_B < E_C$. If λ_1, λ_2, λ_3 are the wavelengths of radiations corresponding to the transitions C to B, B to A and C to A respectively, which of the following statements is correct?

1) $\lambda_3 = \lambda_1 + \lambda_2$ 2) $\lambda_3 = \frac{\lambda_1 \lambda_2}{\lambda_1 + \lambda_2}$ 3) $\lambda_1 + \lambda_2 + \lambda_3 = 0$ 4) $\lambda_3^2 = \lambda_1^2 + \lambda_2^2$

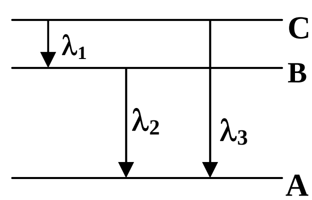
Answer: (2)

$$E_{CB} + E_{BA} = E_{CA}$$

$$(E_C - E_B) + (E_B - E_A) = (E_C - E_A)$$

$$\frac{hc}{\lambda_1} + \frac{hc}{\lambda_2} = \frac{hc}{\lambda_3} \Rightarrow \frac{1}{\lambda_1} + \frac{1}{\lambda_2} = \frac{1}{\lambda_3}$$

$$\Rightarrow \frac{\lambda_2 + \lambda_1}{\lambda_1 \lambda_2} = \frac{1}{\lambda_3} \Rightarrow \lambda_3 = \frac{\lambda_1 \lambda_2}{\lambda_1 + \lambda_2}$$



21) If λ_1, λ and λ_2 are the wavelengths of stokes lines, incident light and anti-stokes lines respectively then

1) $\lambda_1 = \lambda = \lambda_2$ 2) $\lambda_1 < \lambda < \lambda_2$ 3) $\lambda_1 > \lambda > \lambda_2$ 4) $\lambda_1 < \lambda_2 < \lambda$

Answer: (3)

22) Check the incorrect statements on scattering of light.

1) Blue colour of sky is due to Rayleigh scattering
2) In Rayleigh scattering intensity of scattered light is proportional to $1/\lambda^4$
3) Clouds having droplets of water, which scatter all the wavelengths almost equal, so they are generally white.
4) The sun looks reddish at sunset and sunrise due to Tyndall scattering.

Answer: (4) The sun looks reddish at sunset and sunrise due to ***Rayleigh scattering***

23) A composite beam of light containing wavelengths 440nm and 550nm is passed through a gas, in a given direction , the ratio of the intensity of scattered light of those wavelengths will be

1) 16 : 25 2) 25 : 16 3)256 : 625 4) 625 : 256

Answer: (4)

Intensity of scattered light : $I \propto \frac{1}{\lambda^4}$

$$\frac{I_1}{I_2} = \left(\frac{\lambda_2}{\lambda_1}\right)^4 = \left(\frac{550}{440}\right)^4 = \left(\frac{5}{4}\right)^4 = \frac{625}{256}$$

24) Consider the statements. A laser beam (a) is highly monochromatic (b) has angular divergence (c) is an electromagnetic wave (d) cannot be used in optical communication.

1) (a) (b) and (c) are correct 2)(a) (c) and (d) are correct

3) (a) and (c) are incorrect 4) (b) and (d) are incorrect

Answer: (4)

25) Which of the following statement is WRONG with respect to Ruby laser?

1)It is developed by T. Maiman.

2)The wavelength of light emitted by it is 694.3nm.

3) It is a continuous laser.

4) It is a three level laser.

Answer: (3)Ruby laser is a **pulsed laser**.

26) The technique to measure large distances using lasers is known as

1) LIDAR 2) RADAR 3) SONAR 4) both (2) and (3)

Answer is (1)

LIDAR: LIght Detection And Ranging, LASER is used in this techique.

RADAR: RAdio Detection And Ranging, Radio waves and microwaves are used in this.

SONAR: SOund Navigation And Ranging, Sound waves are used in this.

27) Light of wavelength 300nm is incident on a surface of area 4 cm^2. If intensity of light is 150 mW/m^2, then rate at which photons strike the target (per second) is

1) 7×10^5 2)9×10^{13} 3)3×10^{10} 4) 6×10^{19}

Answer: (2)

$$E = \frac{hc}{\lambda} = \frac{6.6\times10^{-34}\times3\times10^8}{3\times10^{-7}} = 6.6\times10^{-19}\,J$$

Intensity: $I = \frac{nE}{At}$ $(A=4\times10^{-4}m^2, t=1s)$

$$\Rightarrow n = \frac{IAt}{E} = \frac{150\times10^{-3}\times4\times10^{-4}\times1}{6.6\times10^{-19}}$$

$$= \frac{600\times10^{-7+19}}{6.6} \approx 90\times10^{12}$$

$$= 9\times10^{13}$$

Answer is (2)

28) An X–ray photon has a wavelength of 0.02 Å. Its momentum is

1) 3.3×10^{-22} kg m/s 2) 6.6×10^{-21} kg m/s

3) 6.6×10^{-24} kg m/s 4) 1.65×10^{22} kg m/s

Answer (1):

$$\text{Momentum}: p = \frac{h}{\lambda} = \frac{6.6\times10^{-34}}{0.02\times10^{-10}} = \frac{6.6\times10^{-34}}{2\times10^{-12}} = 3.3\times10^{-22}$$

29) Which one is the correct about the electromagnetic waves in free space?

1) Electric and magnetic fields have a phase difference of $\pi/2$.
2) The speed of the wave is $c = B/E$.
3) Energy distribution of electric and magnetic fields are unequal.
4) Electromagnetic waves transport both energy and momentum.

Answer:

1) Electric and magnetic fields are **in-phase** with each other, hence phase difference is **0**
2) The speed of the wave is $c = \frac{E}{B} = \frac{1}{\sqrt{\mu_0 \varepsilon_0}}$ in vacuum or free space
3) Energy distribution of electric and magnetic fields are equal

Answer: (4)

30) The maximum velocity of photoelectrons emitted by a photo emitter is 7×10^5 m/s. If the specific charge of an electron is 1.75×10^{11} C/kg, stopping potential of the emitter is

1) 0.7 V 2) 1.4 V 3) 2.8 V 4) 3.5 V

Answer: (2)

$$e\times V_s = \frac{1}{2} m v^2$$

$$V_s = \frac{1}{2}\frac{v^2}{\left(\frac{e}{m}\right)} = \frac{1}{2}\frac{\left(7\times10^5\right)^2}{1.75\times10^{11}} = 1.4V$$

31) If the velocity of a particle is reduced to one-third then the percentage increase in its de-Broglie wavelength is

1) 50% 2) 100% 3) 200% 4) 300%

Answer:

$$\lambda = \frac{h}{m\,v} \quad \text{and} \quad \lambda' = \frac{h}{m\left(\frac{v}{3}\right)} = 3\left(\frac{h}{m\,v}\right) = 3\lambda$$

$$\text{Change in de-Broglie wavelength} = 2\lambda$$

$$\text{Percentage change} = \frac{2\lambda}{\lambda}\times100\% = 200\%$$

Answer is (3)

32) A proton and an α-particle are accelerated through the same p.d.. The ratio of their de-Broglie wavelengths $(\lambda_p/\lambda_\alpha)$ is

1) 1 2) 2 3) $\sqrt{8}$ 4) $1/\sqrt{8}$

Answer :

For a charged particle : $\lambda = \dfrac{h}{\sqrt{2\,m\,q\,V}} \propto \dfrac{1}{\sqrt{m\,q}}$

For a proton : $\lambda_p \propto \dfrac{1}{\sqrt{m\,e}}$

For α - particle : $\lambda_\alpha \propto \dfrac{1}{\sqrt{(4m)\,(2e)}} = \dfrac{1}{\sqrt{8\,m\,e}}$

$\dfrac{\lambda_p}{\lambda_\alpha} = \dfrac{\sqrt{8\,m\,e}}{\sqrt{m\,e}} = \sqrt{8}$

Answer is (3)

33) Energy required for the electron excitation in Li^{++} from first orbit to third orbit is

1) 12.1 eV 2) 36.3 eV 3) 108.8 eV 4) 122.4 eV

Answer:

$E_n = \dfrac{-13.6 \times Z^2}{n^2}$ eV $\quad (Z = 3$ for Li$)$

$E_1 = \dfrac{-13.6 \times 9}{1^2} = -13.6 \times 9$

$E_3 = \dfrac{-13.6 \times 9}{3^2} = -13.6$

Excitation energy: $E_3 - E_1 = 13.6 \times 8 = 108.8$ eV

Answer is (3)

34) Pick out the wrong statement from the following:

1) As observed in spectrographs of high resolving power the H_α, H_β and H_γ lines are not single lines
2) According to Sommerfeld, the path of an electron around the nucleus is an ellipse
3) The speed of the electron moving in an elliptical orbit is a constant
4) The principal quantum number n takes integral values from 1 to ∞

Answer: (3)

According to Sommerfeld, the electrons revolve round the nucleus an elliptical orbit withvariable speed.

35) Rayleigh scattering law is not applicable to

1) Water molecules 2) Gas molecules
3) Particles very small compared to wavelength of light 4) large dust particles

Answer: (4)

36) The material used in Ruby lasers is

1) Naturally occurring Ruby 2) Amorphous Al_2O_3
3) Crystalline Al_2O_3 doped with chromium 4) Chromium crystal doped withaluminium

Answer is (3)

37) Choose the WRONG statement out of the following.
1) X–rays are used in of study of crystal structure.
2) Like visible light, X–rays are diffracted at anobstacle.
3) X–rays can cause ionization of the atoms of a gases.
4) X–rays are deflected by electric and magnetic fields.

Answer: (4)Electromagnetic waves cannot be deflected by electric and magnetic fields.

38) Which of the following is not correct regarding the photon?
1)$\nu = E/h$ 2)Momentum of photon = h/λ 3) Mass of photon = $h/c\lambda$ 4) $\lambda = \nu/c$

Answer (4):$c = \lambda\nu$ or $\lambda = c/\nu$

39) If photons of wavelength 60nm are incident on hydrogen, then the maximum kinetic energy of emitted electrons will be
1) 3 eV 2) 5eV 3)7eV 4) 9eV

Answer:

$$E = \frac{h\,c}{\lambda} = \frac{6.625\times10^{-34}\times3\times10^{8}}{6\times10^{-8}\times1.6\times10^{-19}} = 20.7\text{eV}$$

Kinetic energy = 20.7 - 13.6 = 7.1eV, (13.6eV of energy to ionize the hydrogen)

Answer is (3)

40) The work function of a surface of a photosensitive material is 6.2eV. The wavelength of the incident radiation for which the stopping potential is 5V lies in the
1) Infra-red 2) Visible light 3)Ultraviolet light 4) X-ray

Answer: (3)

As stopping potential is 5V , kinetic energy of photoelectrons,E_k = 5 eV.

Energy of incident photon = W + E_k = 6.2 +5 = 11.2 eV which lies inUV region

41) The kinetic energies of photoelectrons emitted from a metal are K_1 and K_2 when it is irradiated with lights of wavelength λ_1 and λ_2 respectively. The work function of the metal is

1) $\dfrac{K_1\lambda_1 - K_2\lambda_2}{\lambda_2 - \lambda_1}$ 2) $\dfrac{K_1\lambda_1 + K_2\lambda_2}{\lambda_2 + \lambda_1}$ 3) $\dfrac{K_1\lambda_2 - K_2\lambda_1}{\lambda_2 - \lambda_1}$ 4) $\dfrac{K_1\lambda_2 + K_2\lambda_1}{\lambda_2 + \lambda_1}$

Answer: (1)

$$\frac{h\,c}{\lambda_1} = W + K_1 \Rightarrow h\,c = W\,\lambda_1 + K_1\,\lambda_1 \quad \text{......................(1)}$$

$$\frac{h\,c}{\lambda_2} = W + K_2 \Rightarrow h\,c = W\,\lambda_2 + K_2\,\lambda_2 \quad \text{.....................(2)}$$

From (1) and (2) $W\,\lambda_2 + K_2\,\lambda_2 = W\,\lambda_1 + K_1\,\lambda_1$

or $W\,\lambda_2 - W\,\lambda_1 = K_1\,\lambda_1 - K_2\,\lambda_2$

$$\therefore\ W = \frac{K_1\,\lambda_1 - K_2\,\lambda_2}{\lambda_2 - \lambda_1}$$

42) In Sommerfeld's atomic model corresponding to principal quantum number n = 3, there will be

1) 3 circular orbits
2) 3 elliptical orbits
3) 1 circular and 2 elliptical orbits
4) 2 circular and 1 elliptical orbits

Answer: (3)

43) Consider the spectral line resulting in the transition from n = 2 to n = 1, in atoms / ions given below. The highest frequency radiation is emitted by

1) Hydrogen atom 2) Deuterium atom 3) Singly ionized helium 4) Doubly ionized lithium

Answer:

$$E_n = \frac{-13.6 \times Z^2}{n^2} \text{ eV}$$

Among the given atoms/ions Z is more for lithium. Hence the energy difference will be more in case of lithium. The highest frequency radiation is emitted by doubly ionized lithium.

Answer: (4)

44) In which of the following systems will the radius of the first orbit (n = 1) be minimum?

1) Hydrogen atom 2) Deuterium atom 3) Singly ionized helium 4) Doubly ionized lithium

Answer :

Radius of n^{th} orbit of hydrogen like atom is given by $r_n \propto \frac{n^2}{Z}$

Answer is (4)

More the Z, lesser will be the radius. For lithium Z =3 is highest among the given atoms/ions.

45) The wavelength of the matter waves is independent of

1) mass 2) velocity 3) momentum 4) charge

Answer: (4)

De-Broglie hypothesis is applicable to both charged and uncharged particles and wavelength is independent of charge of the particle.

46) A photon of energy 9 eV is incident on a surface whose threshold frequency is 1.6×10^{15} Hz. The kinetic energy of the emitted electrons is

1) 2.37 eV 2) 7.4 eV 3) 9 eV 4) 10.6 eV

Answer: (4)

$$W = h\,\nu_o = 6.625 \times 1.6 \times 10^{15}\,\text{J} = \frac{6.625 \times 10^{-34} \times 1.6 \times 10^{15}\,\text{J}}{1.6 \times 10^{-19}} = 6.625 \text{ eV}$$

$$h\,\nu = W + E_k \quad \text{or} \quad \text{Kinetic energy: } E_k = h\,\nu - W = 9 - 6.625 = 2.375 \text{ eV}$$

47) The momentum of a neutron of de-Broglie wavelength 0.1 nm is

1) 6.6×10^{-24} kg ms^{-1} 2) 6.6×10^{-14} kg ms^{-1} 3) 6.6×10^{-34} kg ms^{-1} 4) 6.6×10^{-4} kg ms^{-1}

Answer: (1)

$$\text{Momentum}: p = \frac{h}{\lambda} = \frac{6.6 \times 10^{-34}}{0.1 \times 10^{-9}} = \frac{6.6 \times 10^{-34}}{10^{-10}} = 3.3 \times 10^{-24}$$

Answers to Additional Questions

INTRODUCTION TO ATOMIC PHYSICS

1) Infrared rays are used in long distance photography because

1) They travel with the velocity of light in vacuum.

2) They can be easily produced.

3) Due to their long wavelength, scattering is low.

4) Due to their small wavelength, scattering is high.

Answer: (3) $I \propto \frac{1}{\lambda^4}$; Wave length of IR rays more, so scattering is low.

2) An electromagnetic radiation has energy of 13.2keV. Then the radiation belongs to the region of

1) Infra-red 2) Visible light 3)Ultraviolet light 4) X-ray

Answer: (4) X-ray,

$$\lambda = \frac{hc}{E} = \frac{6.6\times10^{-34}\times3\times10^{8}}{13.2\times10^{3}\times1.6\times10^{-19}} \approx \frac{0.95\times10^{-26}}{10^{-16}} = 0.95\times10^{-10}\,\text{m which is the wavelength of X-ray.}$$

3) Flash spectrum that occurs at a total solar eclipse is

1) Line absorption spectrum 2)Line emission spectrum

3) Band emission spectrum 4) Band absorption spectrum

Answer: (2)

4) Band spectrum is obtained whenever the incandescent vapour of the excited substance is in

1) Atomic state 2)Molecular state 3)Ionised state 4) Atomic or Molecular state

Answer: (2)Molecular state

5) A radio transmitter radiates 0.1kW power at a wavelength 198.6 nm. The number of photons emitted per second by it is

1) 10^{10} 2) 10^{20} 3) 10^{30} 4) 10^{4}

Answer : (2)

Energy of a photon: $E = \frac{h\,c}{\lambda} = \frac{6.6\times10^{-34}\times3\times10^{8}}{1.986\times10^{-7}} \approx 10\times10^{-19} = 10^{-18}\,\text{J}$

Power: $P = \frac{n\,E}{t}$

$\Rightarrow n = \frac{P\,t}{E} = \frac{0.1\times10^{3}\times1}{10^{-18}} = 10^{20}$

6) Consider the following statements about electromagnetic waves and choose the correct ones.

A) EM waves having wavelength 1000 times smaller than visible light waves are called X-rays.

B) Ultraviolet waves are used sterilization of water and surgical equipment’s.

C) de-Broglie waves are electromagnetic in nature.

D) Electromagnetic waves exhibit polarization while sound waves do not.

1) (A), (B) and (C) 2)(A), (B) and (D)3) (B), (C) and (D) 4)(A), (C) and (D)

Answer: (2)

7) The ratio of specific charge of the electron and nucleus of hydrogen atom is nearly

1) 1 2) 2 3) 4 4) 1836

Answer: (4) 1836, Required $= \frac{\text{Specific charge of electron}}{\text{Specific charge of proton}} = \frac{e/m_e}{e/m_p} = \frac{m_p}{m_e} = \frac{1836m_e}{m_e} = 1836$

8) Identify the correct arrangement of electromagnetic radiations in ascending order of frequency.

1) γ- rays, X- rays, Visible light, radio waves.

2) Ultraviolet rays, visible light, X-rays, Infra-red rays.

3) Radio waves, micro waves, visible light, UV rays.

4) Infra-red rays, UV rays, γ- rays, X- rays.

Answer: (3)
In increasing order of frequency - Radio waves, micro waves,Infra-red rays, visible light, UV rays, X-rays, γ- rays.

9) In determining specific charge of electrons by Dunnington, electrons are made to negotiate a circular path by

1) Electric field only 3) Both electric and magnetic fields in the same directions

2) Magnetic field only 4) Mutually perpendicular electric and magnetic fields

Answer: (4)

PHOTOELECTRIC EFFECT

1) Photons with energies twice and ten times the work function of a metal are incident successively on a metal. The ratio of the maximum energies of the photoelectrons emitted in the two cases is respectively

1) 1 : 5 2)5 : 1 3)1 : 3 4) 1 : 9

Answer: (4)

Energies of photons, E_1=2W, E_2=10W

E =W + E_k, W is work function, E_k is kinetic energy

Kinetic energies: $E_{K1} = 2W - W = W$ and $E_{K2} = 10W - W = 9W$

Ratio of energies: $E_{K1} : E_{K2} = W : 9W = 1 : 9$

2) Work function for copper is 4.4 eV. The potential difference that must be applied to stop the fastest electrons released when light of wavelength 100 nm is incident is

1) 4 V 2)8 V 3)16 V 4)20 V

Answer : (2)

Energy of a incident photon: $E = \frac{hc}{\lambda} = \frac{6.6\times10^{-34}\times3\times10^{8}}{1\times10^{-7}} \approx 20\times10^{-19}\,J = \frac{20\times10^{-19}}{1.6\times10^{-19}} \approx 12.5eV$

Kinetic energy = $E - W = 12.5 - 4.4 = 8eV \quad \therefore V_s = 8V$

3) On plotting frequency of incident radiation along X axis and stopping potential along Y axis, a straight line is obtained. Its slope is

1) h/e 2)e/h 3) h 4)1/h

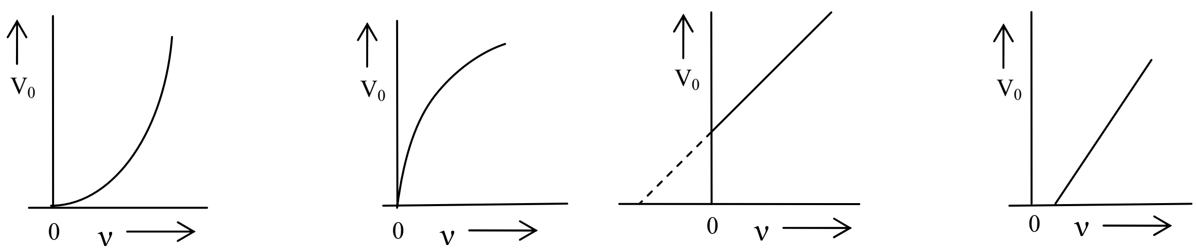
Answer: (1)

$$e \times V_s = \frac{1}{2} m v^2 = h\nu - W$$

or $V_s = \frac{h}{e}\nu - \frac{W}{e}$ is of the form $y = mx + c$

Slope $= m = \frac{h}{e}$

4) For a photoelectric cell, the graph in figure showing the variation of the cut-off voltage(V_0) with frequency (ν) of incident light is



1) 2) 3) 4)

Answer: (4)

5) A photosensitive metal is incident with radiations of wavelength 400 nm and then with radiations of wavelength 800 nm. What will be the difference in the maximum energy of the photoelectrons

1) 0.5 eV 2) 1 eV 3) 1.5 eV 4) 2 eV

$$\frac{hc}{\lambda_1} = W + E_{K1} \text{.......(1)} \quad \text{and} \quad \frac{hc}{\lambda_2} = W + E_{K2} \text{.......(2)}$$

$$(1)-(2) \Rightarrow E_{K1} - E_{K2} = hc\left(\frac{1}{\lambda_1} - \frac{1}{\lambda_2}\right)$$

$$= 20\times10^{-26}\left(\frac{1}{4\times10^{-7}} - \frac{1}{8\times10^{-7}}\right)$$

$$= 20\times10^{-26}\left(\frac{1}{8\times10^{-7}}\right) = 2.5\times10^{-19}\,\text{J} \approx 1.5\text{eV}$$

Answer is (3)

6) Monochromatic light of frequency ν_1 irradiates a photocell and the stopping potential is found to be V_1. What is the new stopping potential of the cell if it is irradiated by monochromatic light of frequency ν_2?

1) $V_1 + \frac{h}{e}(\nu_2 - \nu_1)$ 2) $V_1 - \frac{h}{e}(\nu_2 - \nu_1)$ 3) $V_1 + \frac{h}{e}(\nu_1 + \nu_2)$ 4) $V_1 - \frac{h}{e}(\nu_1 + \nu_2)$

Answer:

$h\nu_1 = W + eV_1$ ......(1) and $h\nu_2 = W + eV_2$ ....(2)

$(2)-(1) \Rightarrow (eV_2 - eV_1) = (h\nu_2 - h\nu_1)$

$$V_2 - V_1 = \frac{(h\nu_2 - h\nu_1)}{e} \Rightarrow V_2 = V_1 + \frac{h}{e}(\nu_2 - \nu_1)$$

Answer is (1)

DUAL NATURE OF MATTER

1) If the kinetic energy of a particle is reduced to one-fourth then the percentage increase in the de-Broglie wavelength is

1) 41% 2)100% 3)144% 4) 200%

Answer :

For a particle : $\lambda = \frac{h}{\sqrt{2mE}}$ and $\lambda' = \frac{h}{\sqrt{2m\left(E/4\right)}} = 2\left(\frac{h}{\sqrt{2mE}}\right) = 2\lambda$

Increase in de - broglie wavelength $= 2\lambda - \lambda = \lambda$

Percentage increase in de - Broglie wavelength is 100%

Answer is (2)

2) If E_1, E_2 and E_3 are the respective kinetic energies of an electron, an alpha particle and a proton each having the same de-Broglie wavelength then

1) $E_1 > E_3 > E_2$ 2)$E_2 > E_3 > E_1$ 3)$E_1 > E_2 > E_3$ 4)$E_1 = E_2 = E_3$

Answer :

$\lambda = \frac{h}{\sqrt{2mE}}$ or $E \propto \frac{1}{m}$, When kinetic energy 'λ' is same for all the particles

Heaviest particle will have smallest energy and lightest particle will have greatest energy

Here $m_e < m_p < m_\alpha$, $E_1 > E_3 > E_2$ Hence the answer is (1)

3) Wavelength of a γ- ray photon whose energy is half the rest mass energy of an electron is nearly

1) 5×10^{-12} m 2)5×10^{-8} m 3)7×10^{-12} m 4)7×10^{-2} m

Answer :

$$E = \frac{0.51\,\text{MeV}}{2} = 0.255\times1.6\times10^{-13}\,J \approx 0.4\times10^{-13} = 4\times10^{-14}\,J$$

$$\lambda = \frac{hc}{E} = \frac{20\times10^{-26}}{4\times10^{-14}} = 5\times10^{-12}$$

Hence the answer is (1)

4) A marble of mass 30g is moving with a speed of 180 kmph. The de-Broglie wavelength associated with is nearly

1) 10 m 2)10^{-10} m 3) 4×10^{-34} Å 4) 4×10^{-24} Å

Answer :

Given mass : m = 30g = 0.03kg, velocity : v = 180kmph = $50ms^{-1}$

$$\text{de-broglie wavelength}: \lambda = \frac{h}{mv} = \frac{6.6\times10^{-34}}{0.03\times50} = \frac{6.6\times10^{-34}}{1.5} \approx 4\times10^{-34}\,m = 4\times10^{-24}\,\overset{o}{A}$$

Hence the answer is (4)

5) Choose the only correct statement out of the following.

1) only a charged particle in motion is accompanied by matter waves
2) only subatomic particles in motion are accompanied by matter waves
3) any particle in motion, whether charged or uncharged, is accompanied by matter waves
4) no particle, whether at rest or in motion, is ever accompanied by matter waves

Answer: (3)

6) The de-Broglie wavelength associated with an electron when it is accelerated through a p.d. of 40 kV is

1) 0.614 pm 2)6.14 pm 3)61.4 Å 4) 0.0614 pm

Answer : (2)

$$\lambda = \frac{12.27}{\sqrt{40\times1000}}\,\overset{o}{A} = \frac{12.27}{200}\,\overset{o}{A} = 0.06135\,\overset{o}{A} = 6.14pm$$

7) The de-Broglie wavelength of a particle moving with velocity 10^8 m/s is equal to the wavelength of a photon. The ratio of kinetic energy of the particle to the energy of the photon is

1) 1/8 2) 1/6 3)¼ 4) ½

8) Electrons used in an electron microscope are accelerated by a voltage of 25kV. If the voltage is increased to 100kV then the de-Broglie wavelength associated with the electrons would

1) Increases to 2 times 2) increases to 4 times 3)decreases by 2 times 4)decreases by 4 times

Answer : (3)

$$\lambda \propto \frac{1}{\sqrt{V}} \Rightarrow \frac{\lambda_2}{\lambda_1} = \sqrt{\frac{V_1}{V_2}} = \sqrt{\frac{25\,kV}{100\,kV}} = \frac{1}{2} \Rightarrow \lambda_2 = \frac{\lambda_1}{2}$$

9) Electrons behave like waves in G.P. Thomson experiment because they

1) Ionize the gas
2) Are affected by electric field
3) Are deflected by magnetic field
4) Diffracted by a crystal

Answer: (4)

10) Wave nature of matter is revealed by

1) Photoelectric effect 2) Raman effect 3) Electron diffraction 4) Compton effect

Answer: (3)

11) The de-Broglie wavelength of electron is 0.5nm, the retarding potential to stop it is

1) 2V 2) 3V 3)4V 4) 6V

Answer : (2)

$$\lambda = \frac{12.27}{\sqrt{V}} \overset{o}{A} \quad \text{or} \quad \sqrt{V} = \frac{12.27}{\lambda} \overset{o}{A} = \frac{12.27\times10^{-10}}{0.5\times10^{-9}\,m} = 24.54\times10^{-1} = 2.454$$

$$V = (2.454)^2 = 6.4V$$

12) The momentum of electron having de-Broglie wavelength 100Å is

1) 6.6×10^{-32}g cm/s 2) 6.6×10^{-25}g cm/s 3)6.6×10^{-21}g cm/s 4) 6.6×10^{-29}g cm/s

Answer : (3)

$$\text{Momentum} : p = \frac{h}{\lambda} = \frac{6.6\times10^{-34}}{10^{-8}} = 6.6\times10^{-26}\,\text{kg ms}^{-1}$$

$$= 6.6\times10^{-26}\times\left(10^3\,g\right)\left(10^2\,cm\right)s^{-1} = 6.6\times10^{-21}\,g\ cm/s$$

13) Electron microscope works on the principle of

1) Particle nature of electron 2) Wave nature of electron

3) Wave nature of light 4) Quantum nature of light

Answer: (2)

BOHR'S ATOM MODEL

1) The ratio of kinetic energy of n = 2 state electron for the hydrogen atom to that of He^+ ion is

1) 1 2) 2 3)½ 4) ¼

Answer: (4)

Kinetic energy of electron in the n^{th} orbit is $E_n = \frac{13.6\times Z^2}{n^2}$ eV

As state for hydrogen helium are same(given n=2),

$E_n \propto Z^2$

$$\frac{E_H}{E_{He}} = \left(\frac{1}{2}\right)^2 = \frac{1}{4}$$

2) An electron in a hydrogen atom has moved from n =1 to n = 5 orbit, then

1) Both potential energy and kinetic energy of the system increases.

2)Both potential energy and kinetic energy of the system decreases.

3)Potential energy of the system decreases and kinetic energy of the system increases.

4) Potential energy of the system increases and kinetic energy of the system decreases.

Answer: (4)PE increases, KE decreases and alsototal energy of the system increases.

3) In case of hydrogen atom the ratio of energy difference between second orbit and third orbit to the energy difference between the first orbit and the second orbit is

1) 9/4 2)4/9 3)5/27 4) 27/5

4) The minimum required to strip off energy of 10 times ionized sodium atom (Z = 11) of its last electron is

1) 13.6 eV 2)13.6 × 11 eV 3) 13.6 × 11^2 eV 4)(13.6/11) eV

Answer: (3)

Ionisation Energy $= 13.6\times Z^2$ eV (Z=11 for sodium)

5) The de-Broglie wavelength of the electron in the first excited state of the hydrogen atom is nearly

1) 0.53 Å 2)1.67 Å 3)3.33 Å 4) 6.66 Å

Answer: (3)

$$\lambda=\frac{2\pi r}{n}=\frac{2\pi r}{2}=2\times 3.14\times\ 0.53\overset{o}{A}=3.33\overset{o}{A}$$

6) The transition of the electron from n = 4 to n =3 in a hydrogen like atom results in UV radiation. Infra-red radiation will be obtained in the transition

1) n = 2 to n =1 2)n = 3 to n =2 3)n = 4 to n =2 4) n = 5 to n =4

Answer: (4)

Energy of Infra red is less than UV energy

Energy difference between the levels will be less in the transition n = 5 to n = 4 only

7) The ionization potential of hydrogen atom is 13.6 V. Hydrogen atoms in the ground state are excited by electromagnetic radiation of energy 12.75 eV. How many spectral lines will be emitted by the hydrogen atom?

1) 1 2) 2 3)3 4) 6

Answer: (4)

$\because\ 12.75\text{ eV} = -0.85\text{ eV} - (-13.6\text{ eV})$

Transition is from 4^{th} orbit to 1^{st} orbit. $\therefore\ n = 4$

Possible number of spectral lines $=\frac{n(n-1)}{2}=\frac{4(4-1)}{2}=6$

8) Fine structure of spectral lines is accounted in Sommerfield atom model by considering

1) Elliptical orbits around the nucleus 2) Spin of electron

3)Relativistic change in mass of electron in elliptical orbits 4) Space quantisation of orbits

Answer: (3)

9) The area of the electron orbit for the ground state of H-atom is A. The area when it is in the first excited state is

1) 2A 2)4A 3)8A 4) 16A

Area in ground state $=A=\pi r^2$, In the first excited state area, $A'=\pi(4r)^2$=16A

10) The ionization potential of hydrogen atom is 13.6V. The energy needed to be supplied tionize hydrogen atom in the first excited state.

1) 13.6 eV 2)3.4 eV 3)6.8 eV 4) 27.2 eV

Answer: (2)

11) An electron jumps from first excited state to ground state of hydrogen atom, then the percentage change in speed of electron

1) 25% 2) 50% 3) 100% 4) 200%

Answer: (3)

Velocity doubles when an electron jumps from first excited state to ground state.

12) An electron jumps from the 4^{th} orbit to 2^{nd} orbit of hydrogen atom. Given the Rydberg's constant $R = 10^5 cm^{-1}$, the frequency (in Hz) of emitted radiation will be

1) $\frac{3}{16}\times10^{5}$ 2) $\frac{3}{16}\times10^{15}$ 3) $\frac{9}{16}\times10^{15}$ 4) $\frac{3}{4}\times10^{15}$

SCATTERING OF LIGHT

1) Raman effect is explained on the basis of

1) Corpuscular theory of light   2) Wavetheory of light

3) Electromagnetic theory of light   4) Quantum theory of light

Answer: (4) Particle nature of light or quantum nature.

2) Pick out the incorrect statement from the following

1) Stokes lines have wavelengths greater than that of the incident light

2) Stokes lines are more intense than the anti-stokes lines

3) The intensity of stokes lines is found to depend on temperature

4) Stokes and anti-stokes lines are polarized

Answer: (3) The intensity of **stokes** lines is independent of temperature and the intensity of **anti-stokes** lines is found to depend on temperature

3) The blue colour of the sky is due to the fact that

1) Red light is absorbed   2) Blue light is preferentially absorbed

3) Blue light ispreferentially scattered   4) Blue is the natural colour of the sky

Answer: (3) Intensity of scattered light : $I \propto \frac{1}{\lambda^4}$

Blue light ispreferentially scattered as they have lesser wavelength.

4) In a given direction, the intensities of scattered light substance for two beams of light are in the ratio 81: 16. The ratio of frequency of the first beam to the frequency of the second beam is

1) 3:2   2) 2:3   3) 9:4   4)4:9

Answer: (1)

Intensity of scattered light : $I \propto \frac{1}{\lambda^4} \propto \nu^4$ where ν is the frequency.

$$\frac{I_1}{I_2} = \left(\frac{\nu_1}{\nu_2}\right)^4 = \frac{81}{16}$$

$$\frac{\nu_1}{\nu_2} = \frac{3}{2} \Rightarrow \nu_1 : \nu_2 = 3:2$$

LASERS

1) Average life time of metastable state is

1) 10^{-3}s 2)10^{-8}s 3)10^{-14}s 4) 10^{-20}s

Answer: (1)

2) The output of Ruby Laser is pulsed because

1)Ruby rod gets heated. 3) Optical pumping cannot be continuous.

2) Stimulated emission is delayed.

4) Stimulated emission occurs faster than population inversion.

Answer: (4)

3) The red colour of Ruby laser light is due to electron transition between energy levels of

1) Aluminium 2)Oxygen 3) Chromium 4) All of these

Answer: (3)

4) The most relevant property involved in the cutting of metals by a laser beam is

1) Monochromaticity 2) Coherence 3) Directionality4) Sharp focus

Answer: (4)

5) If r_a = rate of absorption, r_b = rate of spontaneous emission and r_c = rate of stimulated emission, then for Laser action the condition to be satisfied is

1) $r_b > r_a$ 2)$r_c > r_a$ 3)$r_c > r_b$ 4) both (2) and (3)

Answer: (4)

6) Photonics is concerned with

1) Lasers 2) Fibre optics 3) Optical computing 4) All these

Answer: (4)

7) In Ruby laser stimulated emission is due to transition from

1) One excited state to lower excited state 2) metastable state to a certain lower state

3) metastable to an excited state 4) metastable state to ground state only

Answer: (4)

8) Ruby laser belongs to the class of

1) Solid state lasers 2) Gas lasers 3) Liquid lasers 4) Semiconductor diode laser

Answer: (1)