# DUAL NATURE OF RADIATION AND MATTER

## FACT/DEFINITION TYPE QUESTIONS

1. Cathode ray consists of
   (a) photons (b) electrons
   (c) protons (d) $\alpha$-particles
2. A discharge takes place between the two electrodes on applying the electric field to the gas in the discharge tube. The cause of this fluorescence was attributed to
   (a) the radiations which appeared to be coming from the anode
   (b) the radiation which appeared to be coming from the cathode
   (c) the protons coming from the cathode
   (d) the protons coming from the anode
3. The presently accepted value of charge/mass $\left(\frac{e}{m}\right)$ is
   (a) $1.66 \times 10^{-19}$ c/kg (b) $9.1 \times 10^{11}$ c/kg
   (c) $1.76 \times 10^{11}$ c/kg (d) $9.1 \times 10^{19}$ c/kg
4. In which of the following, emission of electrons does not take place?
   (a) Thermionic emission
   (b) X-rays emission
   (c) Photoelectric emission
   (d) Secondary emission
5. Photoelectric emmision occurs only when the incident light has more than a certain minimum
   (a) power (b) wavelength
   (c) intensity (d) frequency
6. Which of the following when falls on a metal will emit photoelectrons ?
   (a) UV radiations (b) Infrared radiation
   (c) Radio waves (d) Microwaves
7. Particle like behavior of light arises from the fact that each quanta of light has definite ...X... and a fixed value of ...Y.. just like a particle, Here, X and Y refer to
   (a) frequency, energy
   (b) shape, volume
   (c) energy, frequency
   (d) energy, momentum
8. The wave nature of light was established by
   (i) Maxwell's equations (ii) Fraunhoffer's lines
   (iii) Hertz experiment (iv) Einstein's theory
   (a) (i) and (ii) only (b) (ii) and (iv) only
   (c) (i) and (iii) only (d) (iii) and (iv) only
9. The work-function of a metal is
   (a) the minimum current required to take out electron from the metal surface
   (b) the maximum frequency required to take out electron from the metal surface
   (c) the minimum amount of energy required to take out the electron from the metal surface
   (d) None of these
10. The work function of a metal is independent of
    (i) nature of the surface of the metal
    (ii) dimensions of the metal
    (iii) properties of the metal
    (iv) abundance of the metal
    (a) (i) only (b) (i) and (iii)
    (c) (ii) and (iii) (d) (ii) and (iv)
11. The theory of quantisation of electric charge was given by
    (a) William Crookes (b) J. J. Thomson
    (c) R.A. Millikan (d) Wilhelm Hallwachs
12. In photoelectric effect, electrons are ejected from metals, if the incident light has a certain minimum
    (a) wavelength (b) frequency
    (c) amplitude (d) angle of incidence
13. Which of the following metals is not sensitive to visible light?
    (a) Caesium (b) Sodium
    (c) Rubidium (d) Cadmium

14. A photosensitive substance emits _____ when illuminated by light.

(a) only protons (b) only neutrons

(c) electrons and protons (d) only electrons

15. The photoelectric current does not depend upon the

(i) frequency of incident light

(ii) work function of the metal

(iii) stopping potential

(iv) intensity of incident light

(a) (i) and (iv) only (b) (ii) and (iii) only

(c) (iii) only (d) (ii) only

16. The stopping potential is directly related to

(a) the work function of the metal

(b) intensity of incident radiation

(c) the saturation current for the given frequency

(d) the kinetic energy gained by the photoelectrons

17. The wave theory of light does not explain

(a) polarisation (b) diffraction

(c) photocurrent (d) interference

18. Photoelectric effect can be explained by

(a) wave theory of light

(b) Bohr's theory

(c) quantum theory of light

(d) corpuscular theory of light

19. In Einstein's picture of Photoelectric emission, the photoelectric emission does not take place by

(a) continuous emission of energy from radiation

(b) continuous absorption of energy from radiation

(c) discrete absorption of energy from radiation

(d) discrete emission of energy from radiation

20. The particle nature of light is not confirmed by

(a) photoelectric effect

(b) scattering of X-rays by electrons

(c) diffraction of electrons

(d) compton effect

21. Photons are deflected by

(a) electric field only

(b) magnetic field only

(c) electromagnetic field

(d) None of these

22. Electrically, photons are

(a) positively charged

(b) negatively charged

(c) neutral

(d) strongly charged, may be positive or negative

23. In a photon-particle collision, the quantity that does not remain conserved is

(a) total energy (b) total momentum

(c) number of photons (d) None of these

24. Of the following properties, the photon does not possess

(a) rest mass (b) momentum

(c) energy (d) frequency

25. It is essential to consider light as a stream of photons to explain

(a) diffraction of light (b) refraction of light

(c) photoelectric effect (d) reflection of light

26. Photoelectric effect was discovered by

(a) Hertz (b) Hallwachs

(c) Lenard (d) Millikan

27. The momentum of a photon of wavelength $\lambda$ is

(a) $h\lambda$ (b) $h/\lambda$ (c) $\lambda/h$ (d) $h/c\lambda$

28. The photoelectrons emitted from a metal surface are such that their velocity

(a) is zero for all

(b) is same for all

(c) lies between zero and infinity

(d) lies between zero and a finite maximum

29. Photoelectric effect shows

(a) wave like behaviour of light

(b) paritcle like behaviour of light

(c) both wavelike and paticle like behaviour

(d) neither wave like nor particle like behaviour of light

30. A photoelectric cell converts

(a) light energy into heat energy

(b) light energy to sound energy

(c) light energy into electric energy

(d) electric energy into light energy

31. Light of a particular frequency $\nu$ is incident on a metal surface. When the intensity of incident radiation is increased, the photoelectric current

(a) decreases

(b) increases

(c) remains unchanged

(d) sometimes increases and sometimes decreases

32. The photoelectric effect is based on the law of conservation of

(a) momentum (b) energy

(c) angular momentum (d) mass

33. The photoelectric effect can be understood on the basis of

(a) wave theroy of light only

(b) electromagnetic theory of light only

(c) quantum theory of light only

(d) None of these

34. When light is incident on a metal surface the maximum kinetic energy of emitted electrons

(a) vary with intensity of light

(b) vary with frequency of light

(c) vary with speed of light

(d) vary irregularly

35. The maximum energy of electrons released in a photocell is independent of
(a) the frequency of the incident light
(b) the intensity of the incident light
(c) the nature of the cathode
(d) All of the above

36. Einstein's photoelectric equation states that $h\nu = W_0 + E_k$.
In this equatin, $E_k$ refers to the
(a) kinetic energy of all the emitted electrons
(b) mean kinetic energy of the emitted electrons
(c) maximum kinetic energy of the emitted electrons
(d) minimum kinetic energy of the emitted electrons

37. In the photoeletric effect, electrons are emitted
(a) at a rate that is proportional to the amplitude of the incident radiation
(b) with a maximum velocity proportional to the frequency of the incident radiation
(c) at a rate that is independent of the emitter
(d) only if the frequency of the incident radiations is above a certain threshold value

38. The minimum energy required to eject an electron, from the metal surface is called
(a) atomic energy (b) mechanical energy
(c) electrical energy (d) workfunction

39. The work function for photoelectric effect
(a) is different for different metals
(b) is same for all metals
(c) depends upon the intensity of incident light
(d) depends upon the frequency of incident light

40. Photoelectric effect is the phenomenon in which
(a) photons come out of a metal when it is hit by a beam of electrons.
(b) photons come out of the nucleus of an atom under the action of an electric field.
(c) electrons come out of a metal with a constant velocity
(d) which depends on the frequency and intensity of incident light wave.

41. A photoelectric cell is a device which
(a) converts light into electricity
(b) converts electricity into light
(c) stores light
(d) stores electricity

42. Einstein's work on photoelectric effect provided support for the equation
(a) $E = h\nu$ (b) $E = mc^2$
(c) $E = \frac{-Rhc}{n^2}$ (d) $K.E. = \frac{1}{2}mv^2$

43. Which of the following shows particle nature of light?
(a) Refraction (b) Interference
(c) Polarization (d) Photoelectric effect

44. Einstein's photoelectric equation is $E_k = h\nu - \phi$. In this equation $E_k$ refers to
(a) kinetic energy of all the emitted electrons
(b) mean kinetic energy of emitted electrons
(c) maximum kinetic energy of emitted electrons
(d) minimum kinetic energy of emitted electrons

45. A photon will have less energy, if its
(a) amplitude is higher
(b) frequency is higher
(c) wavelength is longer
(d) wavelength is shorter

46. The energy of photon of wavelength $\lambda$ is
(a) $c\lambda/h$ (b) $h\lambda/c$
(c) $hc/\lambda$ (d) $c/h\lambda$

47. A photo sensitive metal is not emitting photo-electrons when irradiated. It will do so when threshold is crossed. To cross the threshold we need to increase
(a) intensity (b) frequency
(c) wavelength (d) None of these

48. According to Einstein's photoelectric equation, the plot of the kinetic energy of the emitted photo electrons from a metal Vs the frequency of the incident radiation gives as straight the whose slope
(a) depends both on the intensity of the radiation and the metal used
(b) depends on the intensity of the radiation
(c) depends on the nature of the metal used
(d) is the same for the all metals and independent of the intensity of the radiation

49. _____ and _____ led to understanding of atomic structures.
(i) Fresnel diffraction
(ii) cathode rays
(iii) X-rays
(iv) electrons
(a) (i) and (ii) (b) (ii) and (iii)
(c) (i) and (iv) (d) (iii) and (iv)

50. A steel ball of mass m is moving with a kinetic energy K. The de-Broglie wavelength associated with the ball is
(a) $\frac{h}{2mK}$ (b) $\sqrt{\frac{h}{2mK}}$
(c) $\frac{h}{\sqrt{2mK}}$ (d) None of these

51. Electron volt (ev) is the unit of
(a) energy (b) potential
(c) current (d) charge

52. In Heinrich Hertz's experiment on the production of electromagnetic waves by means of spark discharge, it was observed that high voltage sparks across the detector loop were _____ when the emitter plate was illuminated by _____ light
(a) degraded, infra-red (b) degraded, ultraviolet
(c) enhanced, ultraviolet (d) enhanced, infra-red

53. The de Broglie wavelength corresponding to a particle of mass '*m*' and charge 'q' accelerated from rest to a potential *V* is given by
(a) $\lambda = \frac{h}{mqV}$ (b) $\lambda = \frac{h}{2mqV}$
(c) $\lambda = \frac{h}{\sqrt{2mqV}}$ (d) $\lambda = \frac{h}{2mqV^2}$

54. For an electron accelerated from rest through a potential *V*, the de Broglie wavelength associated will be
(a) $\frac{1.772}{\sqrt{V}}$ nm (b) $\frac{1.227}{\sqrt{V}}$ μm
(c) $\frac{1.227}{\sqrt{V}}$ nm (d) $\frac{1.772}{\sqrt{V}}$ μm

55. According to Heisenberg's uncertainty principle, it is true that
(a) we can precisely specify the momentum and energy of an electron
(b) we cannot precisely specify the momentum and wavelength associated with an electron.
(c) we cannot precisely specify the momentum and position of electron at the same time.
(d) we can precisely specify the momentum and position of electron at the same time.

56. If a photon and an electron have same de-Broglie wavelength, then
(a) both have same kinetic energy
(b) proton has more K.E. than electron
(c) electron has more K.E. than proton
(d) both have same velocity

57. The graph of $V_0$ (stopping potential) *vs* ν (frequency) is
(a) a straight line with slope $\left(\frac{\phi_0}{e}\right)$
(b) a straight line with slope $\left(-\frac{h}{\nu_0}\right)$
(c) a straight line with slope $\left(-\frac{h}{e}\right)$
(d) a straight line with slope $\left(\frac{h}{e}\right)$

58. Which of the following experiment confirms the wave nature of electron?
(a) Millikan's oil drop experiment
(b) Davisson and Germer experiment
(c) Young's double slit experiment
(d) Geiger-Marsden experiment

59. In Davison-Germer experiment, an electron beam is incident on a crystal. The reflected beam consists of
(a) photons (b) protons
(c) x-rays (d) electrons

60. In the Davisson and Germer experiment, the velocity of electrons emitted from the electron gun can be increased by
(a) increasing the potential difference between the anode and filament
(b) increasing the filament current
(c) decreasing the filament current
(d) decreasing the potential difference between the anode and filament

## STATEMENT TYPE QUESTIONS

61. Which of the following is/are false regarding cathode rays?
I. They produce heating effect
II. They don't deflect in electric field
III. They cast shadow
IV. They produce fluorescence
(a) I only (b) II only
(c) I, II and III (d) I, II, III and IV

62. Energy required by an electron for electron emission can be supplied to a free electron by
I. hammering the metal surface
II. heating the metal surface
III. applying electric field
IV. applying magnetic field
Which of the above statements is/are correct ?
(a) Only I (b) I, II and IV
(c) II, III and IV (d) II and III

63. Experimental study of photoelectric effect shows that
I. Photocurrent ∝ intensity of light.
II. saturation current ∝ intensity of light.
III. photoemission occurs only at frequency greater than threshold frequency.
IV. photoemission is an instantaneous process.
The correct statements are
(a) I and II (b) I, II and III
(c) I, III and IV (d) I, II, III and IV

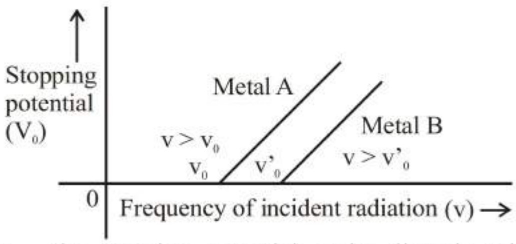
64. According to photoelectric equation $K_{max} = h\nu - \phi_0$, The photoelectric emission will not be possible if
I. $K_{max}$ is negative II. $\nu_0 > \nu$
III. $K_{max}$ is positive IV. $\nu_0 < \nu$
(a) I and II (b) I and IV
(c) III and II (d) III and IV

65. Electromagnetic radiations with high intensity have
I. high amplitude II. high frequency
III. high wavelength IV. high speed
Which of the above is/are correct?
(a) I only (b) II and III
(c) I and II (d) IV only

66. Which of the following cannot be explained on the basis of photoelectric theory?
I. Instantaneous emission of photoelectrons
II. Existence of threshold frequency
III. Sufficiently intense beam of radiation can emit photoelectrons
IV. Existence of stopping potential
(a) III and IV (b) II, III and IV
(c) III only (d) II only

67. To observe the effect of intensity of light on photocurrent,
I. collector is maintained at positive potential with respect to emitter.
II. frequency of incident light is kept fixed.
III. accelerating potential is fixed.
IV. distance of surce from emitter is kept constant.
Which of the above statements are correct ?
(a) I and II (b) II and III
(c) III and IV (d) I, II and III

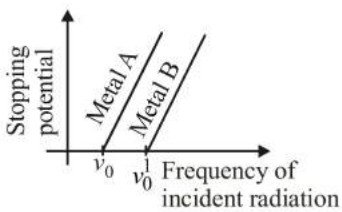
68. From the graph it is clear that




I. the stopping potential varies linearly with the frequency of incident radiation for the given metal.
II. the work function of metal *A* is greater than that for metal *B*.
III. the stopping potential is zero below the minimum cut off frequency.
IV. the stopping potential is independent of the intensity of incident radiation.
(a) I and III only (b) I, III and IV
(c) II and IV only (d) I, II and IV

69. Consider the following statements and select the correct Statement(s).
I. The stopping potential depends on the nature of emitter material
II. The stopping potential depends on the frequency of incident light.
III. The stopping potential depends on the intensity of incident radiation.
(a) I only (b) II only
(c) I and II (d) I, II and III

70. Variation of stopping potential $V_0$ with frequency $v$ of incident radiation for photosensitive materials *A* and *B* are shown.




From graph we conclude that
I. maximum kinetic energy of photoelectrons varies linearly with frequency.
II. a frequency lower than a certain frequency photoemission is not possible.
III. density of metal *A* is more than that of *B*.
IV. metal *A* contains more electrons than that of *B*.
(a) I and II (b) I and IV
(c) III and IV (d) II and III

71. Which of the following statements are true?
I. In the interaction with matter, radiation behaves as if it is made up of particle called photons.
II. Each photon has energy $E = hv$ and momentum $P = hv/c$.
III. photons are electrically neutral and are not deflected by electric and magnetic field.
IV. In a photon particle collision, photon number is conserved.
(a) I and II (b) I, II and III
(c) I, III and IV (d) I, II and IV

## MATCHING TYPE QUESTIONS

72. Match the Columns I and II.

| Column I | Column II |
|---|---|
| (A) Field emission | (1) Heat is supplied to the metal surface |
| (B) Photoelectric emission | (2) Electric field is applied to the metal surface |
| (C) Thermionic emission | (3) Light of suitable frequency illuminates the metal surface |
| (D) Secondary emission | (4) Striking fast moving electrons on the metal surface. |

(a) (A) → (2); (B) → (3); C → (1); (D) → (4)
(b) (A) → (1); (B) → (3); C → (2); (D) → (4)
(c) (A) → (4); (B) → (1); C → (3); (D) → (2)
(d) (A) → (4); (B) → (3); C → (2); (D) → (1)

73.

| Column I | Column II |
|---|---|
| (A) Electromagnetism | (1) Hertz |
| (B) Detection of electromagnetic waves | (2) Roentgen |
| (C) X-rays | (3) J.J. Thomson |
| (D) Electron | (4) Maxwell |

(a) (A) → 1; (B) → 4; (C) → 3; (D) → 2
(b) (A) → 2; (B) → 3; (C) → 1; (D) → 4
(c) (A) → 3; (B) → 2; (C) → 4; (D) → 1
(d) (A) → 4; (B) → 1; (C) → 2; (D) → 3

**74.** **Column I** | **Column II**

| | Column I | | Column II |
|---|---|---|---|
| (A) | Einstein Photoelectric equation | (1) | $\lambda = \frac{h}{p}$ |
| (B) | de-Broglie relation | (2) | $K_{max} = h\nu - \phi_0$ |
| (C) | Threshold frequency | (3) | $\Delta x \Delta p \simeq h$ |
| (D) | Heisenberg's uncertainty principle | (4) | $\nu = \frac{\phi_0}{h}$ |

(a) (A) → (2); (B) → (3); (C) → (1); (D) → (4)
(b) (A) → (1); (B) → (3); (C) → (2); (D) → (4)
(c) (A) → (4); (B) → (1); (C) → (3); (D) → (2)
(d) (A) → (4); (B) → (3); (C) → (2); (D) → (1)

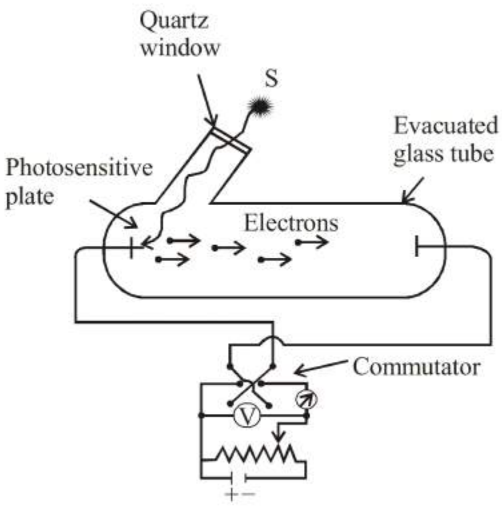
**75.** Match the quantities given in column I with their definitions in column II.

| | Column I | | Column II |
|---|---|---|---|
| (A) | Photocurrent | (1) | The minimum energy required by electron to escape from the metal surface |
| (B) | Saturation current | (2) | The minimum retarding potential |
| (C) | Stopping potential | (3) | The number of photoelectric emitted per second |
| (D) | Work function | (4) | The maximum number of photoelectrons emitted per second |

(a) (A) → (1); (B) → (2); (C) → (3); (D) → (4)
(b) (A) → (3); (B) → (4); (C) → (2); (D) → (1)
(c) (A) → (2); (B) → (1); (C) → (4); (D) → (1)
(d) (A) → (4); (B) → (3); (C) → (1); (D) → (2)

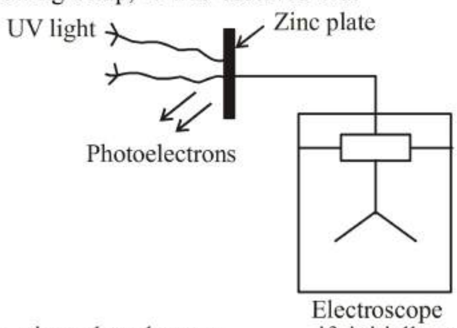
## DIAGRAM TYPE QUESTIONS

**76.** In the given set-up, the photoelectric current cannot be varied by varying the




(a) potential of plate A w.r.t. the plate C
(b) intensity of incident light
(c) material of plate A
(d) material of plate C

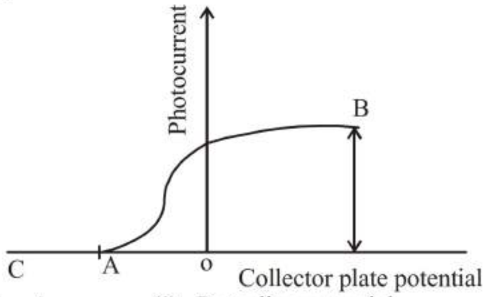
**77.** In Hallwach's experiment on photoelectric emission with following setup, it was observed that




The zinc plate became _____ if initially negatively charged.
(a) positively charged (b) negatively charged
(c) uncharged (d) more positively charged

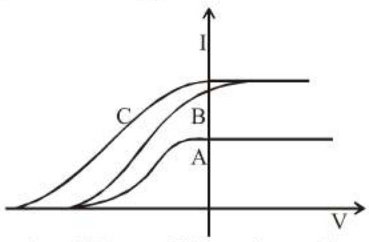
**78.** The zinc plate became _____ if initially positively charged (see fig. above).
(a) positively charged (b) more positively charged
(c) negatively charged (d) uncharged

**79.** In the given graph of photoelectric current versus collector plate potential the quantities (A), (B), and (C) represent



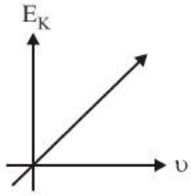

(i) A (1) Retarding potential
(ii) B (2) Stopping potential
(iii) C (3) Saturation current
(a) (i) – 2; (ii) – 1; (iii) – 3
(b) (i) – 2; (ii) – 3; (iii) – 1
(c) (i) – 3; (ii) – 2; (iii) – 1
(d) (i) – 1; (ii) – 2; (iii) – 3

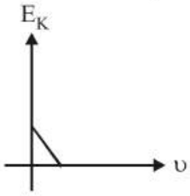
**80.** In a photoelectric experiment, anode potential (v) is plotted against plate current (I)

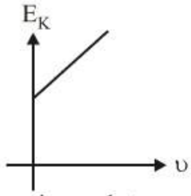


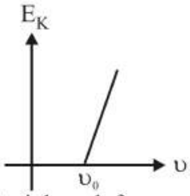

(a) A and B will have different intensities while B and C will have different frequencies
(b) B and C will have different intensities while A and C will have different frequencies
(c) A and B will have different intensities while A and C will have equal frequencies
(d) A and B will have equal intensities while B and C will have different frequencies

**81.** Which one of the following graphs represents the variation of maximum kinetic energy ($E_K$) of the emitted electrons with frequency υ in photoelectric effect correctly ?

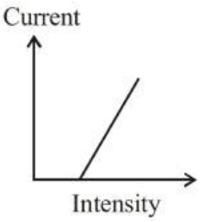
(a) 

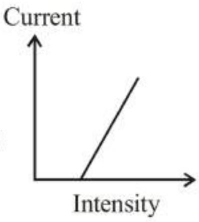

(b) 

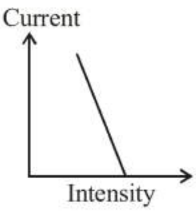

(c) 

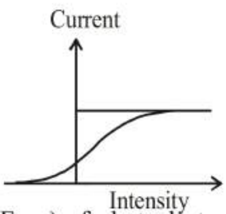

(d) 


**82.** For a given photosensitive material and frequency (> threshold frequency) of incident radiation, the photoelectric current varies with the intensity of incident light as

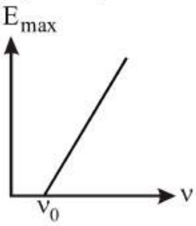
(a) 


(b) 


(c) 


(d) 


**83.** The maximum kinetic energy ($E_{max}$) of photoelectrons emitted in a photoelectric cell varies with frequency (ν) as shown in the graph. The slope of the graph is equal to



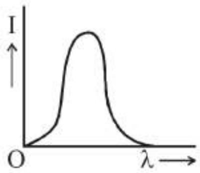

(a) charge of the electron

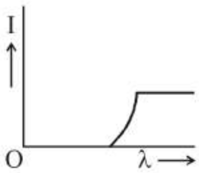
(b) $\frac{e}{m}$ of the electron

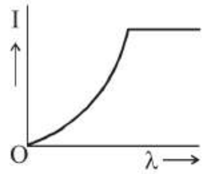
(c) work function of the emitter

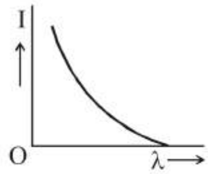
(d) Plank's constant

**84.** The anode voltage of a photocell is kept fixed. The wavelength λ of the light falling on the cathode is gradually changed. The plate current I of the photocell varies as follows

(a) 


(b) 


(c) 


(d) 


## ASSERTION- REASON TYPE QUESTIONS

**Directions** : Each of these questions contain two statements, Assertion and Reason. Each of these questions also has four alternative choices, only one of which is the correct answer. You have to select one of the codes (a), (b), (c) and (d) given below.

(a) Assertion is correct, reason is correct; reason is a correct explanation for assertion.

(b) Assertion is correct, reason is correct; reason is not a correct explanation for assertion

(c) Assertion is correct, reason is incorrect

(d) Assertion is incorrect, reason is correct.

**85.** **Assertion :** In process of photoelectric emission, all emitted electrons do not have same kinetic energy.

**Reason :** If radiation falling on photosensitive surface of a metal consists of different wavelength then energy acquired by electrons absorbing photons of different wavelengths shall be different.

**86.** **Assertion :** Though light of a single frequency (monochromatic) is incident on a metal, the energies of emitted photoelectrons are different.

**Reason :** The energy of electrons emitted from inside the metal surface, is lost in collision with the other atoms in the metal.

**87.** **Assertion :** The phtoelectrons produced by a monochromatic light beam incident on a metal surface have a spread in their kinetic energies.

**Reason :** The work function of the metal is its characteristics property.

**88.** **Assertion :** Photoelectric saturation current increases with the increase in frequency of incident light.

**Reason :** Energy of incident photons increases with increase in frequency and as a result photoelectric current increases.

**89.** **Assertion :** Photosensitivity of a metal is high if its work function is small.

**Reason :** Work function = $hf_0$ where $f_0$ is the threshold frequency.

**90.** **Assertion :** The photon behaves like a particle.

**Reason :** If E and P are the energy and momentum of the photon, then $p = E/c$.

**91.** **Assertion :** In an experiment on photoelectric effect, a photon is incident on an electron from one direction and the phtoelectron is emitted almost in the opposite direction. It violate the principle of conservation of linear momentum.

**Reason :** It does not violate the principle of conservation of linear momentum.

92. **Assertion :** Two sources of equal intensity always emit equal number of photons in any time interval.

**Reason :** Two sources of equal intensity may emit equal number of photons in any time interval.

93. **Assertion :** Two photons of equal wavelength must have equal linear momentum.

**Reason :** Two photons of equal linear momentum will have equal wavelength.

94. **Assertion :** The kinetic energy of photoelectrons emitted from metal surface does not depend on the intensity of incident photon.

**Reason :** The ejection of electrons from metallic surface is not possible with frequency of incident photons below the threshold frequency.

## CRITICAL THINKING TYPE QUESTIONS

95. In a photoelectric experiment the stopping potential for the incident light of wavelength 4000Å is 2 volt. If the wavelength be changed to 3000 Å, the stopping potential will be

(a) 2V (b) zero
(c) less than 2 V (d) more than 2 V

96. 4eV is the energy of incident photon and the work function is 2eV. The stopping potential will be

(a) 2V (b) 4V (c) 6V (d) $2\sqrt{2}$V

97. The photoelectric work function for a metal surface is 4.125 eV. The cut-off wavelength for this surface is

(a) 4125 Å (b) 3000 Å (c) 6000 Å (d) 2062 Å

98. A photocell is illuminated by a small bright source placed 1 m away. When the same source of light is placed 2 m away, the number of electrons emitted by photocathode are reduced by a factor of

(a) 1/8 (b) 1/16 (c) 1/2 (d) 1/4

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

(a) 4 eV (b) 6.2 eV (c) 2 eV (d) 2.2 eV

100. For intensity I of a light of wavelenght 5000Å the photoelectron saturation current is 0.40 μA and stopping potential is 1.36 V, the work function of metal is

(a) 2.47 eV (b) 1.36 eV
(c) 1.10 eV (d) 0.43 eV

101. The maximum velocity of an electron emitted by light of wavelength λ incident on the surface of a metal of work-function $\phi$ is

(a) $\sqrt{\frac{2(hc+\lambda\phi)}{m\lambda}}$ (b) $\frac{2(hc+\lambda\phi)}{m\lambda}$

(c) $\sqrt{\frac{2(hc-\lambda\phi)}{m\lambda}}$ (d) $\sqrt{\frac{2(h\lambda-\phi)}{m}}$

102. A photon of $1.7 \times 10^{-13}$ joule is absorbed by a material under special circumstances. The correct statement is

(a) Electrons of the atom of absorbed material will go the higher energy states
(b) Electron and positron pair will be created
(c) Only positron will be produced
(d) Photoelectric effect will occur and electron will be produced

103. The frequency and work function of an incident photon are v and $\phi_0$. If $v_0$ is the threshold frequency then necessary condition for the emission of photoelectron is

(a) $v < v_0$ (b) $v = \frac{v_0}{2}$
(c) $v \geq v_0$ (d) None of these

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

(a) $E_1 > E_3 > E_2$ (b) $E_2 > E_3 > E_1$
(c) $E_1 > E_2 > E_3$ (d) $E_1 = E_2 = E_3$

105. The work function of aluminium is 4.2 eV. If two photons, each of energy 3.5 eV strike an electron of aluminium, then emission of electrons

(a) will be possible
(b) will not be possible
(c) Data is incomplete
(d) Depends upon the density of the surface

106. The magnitude of the de-Broglie wavelength (λ) of electron (e), proton (p), neutron (n) and α-particle (α) all having the same energy of 1 MeV, in the increasing order will follow the sequence

(a) $\lambda_e, \lambda_p, \lambda_n, \lambda_\alpha$ (b) $\lambda_e, \lambda_n, \lambda_p, \lambda_\alpha$
(c) $\lambda_\alpha, \lambda_n, \lambda_p, \lambda_e$ (d) $\lambda_p, \lambda_e, \lambda_\alpha, \lambda_n$

107. The potential difference that must be applied to stop the fastest photoelectrons emitted by a nickel surface, having work function 5.01 eV, when ultraviolet light of 200 nm falls on it, must be

(a) 2.4 V (b) –1.2 V
(c) –2.4 V (d) 1.2 V

108. In photoelectric emission process from a metal of work function 1.8 eV, the kinetic energy of most energetic electrons is 0.5 eV. The corresponding stopping potential is

(a) 1.8 V (b) 1.2 V
(c) 0.5 V (d) 2.3 V

109. The threshold frequency for a photosensitive metal is $3.3 \times 10^{14}$ Hz. If light of frequency $8.2 \times 10^{14}$ Hz is incident on this metal, the cut-off voltage for the photoelectric emission is nearly

(a) 2V (b) 3V
(c) 5V (d) 1V

110. Two radiations of photons energies 1 eV and 2.5 eV, successively illuminate a photosensitive metallic surface of work function 0.5 eV. The ratio of the maximum speeds of the emitted electrons is

(a) 1 : 4 (b) 1 : 2 (c) 1 : 1 (d) 1 : 5

**111.** A source $S_1$ is producing, $10^{15}$ photons per second of wavelength 5000 Å. Another source $S_2$ is producing $1.02 \times 10^{15}$ photons per second of wavelength 5100Å Then, (power of $S_2$) to the (power of $S_1$) is equal to :
(a) 1.00 (b) 1.02 (c) 1.04 (d) 0.98

**112.** A 200 W sodium street lamp emits yellow light of wavelength 0.6 μm. Assuming it to be 25% efficient in converting electrical energy to light, the number of photons of yellow light it emits per second is
(a) $1.5 \times 10^{20}$ (b) $6 \times 10^{18}$
(c) $62 \times 10^{20}$ (d) $3 \times 10^{19}$

**113.** Monochromatic radiation emitted when electron on hydrogen atom jumps from first excited to the ground state irradiates a photosensitive material. The stopping potential is measured to be 3.57 V. The threshold frequency of the materials is
(a) $4 \times 10^{15}$ Hz (b) $5 \times 10^{15}$ Hz
(c) $1.6 \times 10^{15}$ Hz (d) $2.5 \times 10^{15}$ Hz

**114.** For photoelectric emission from certain metal the cut-off frequency is ν. If radiation of frequency 2ν impinges on the metal plate, the maximum possible velocity of the emitted electron will be (m is the electron mass)
(a) $\sqrt{h\nu / m}$ (b) $\sqrt{2h\nu / m}$
(c) $2\sqrt{h\nu / m}$ (d) $\sqrt{h\nu / (2m)}$

**115.** Sodium and copper have work functions 2.3 eV and 4.5 eV respectively. Then the ratio of the wavelengths is nearest to
(a) 1 : 2 (b) 4 : 1 (c) 2 : 1 (d) 1 : 4

**116.** The work function of a substance is 4.0 eV. The longest wavelength of light that can cause photoelectron emission from this substance is approximately
(a) 310 nm (b) 400 nm
(c) 540 nm (d) 220 nm

**117.** The work functions of Silver and Sodium are 4.6 and 2.3 eV, respectively. The ratio of the slope of the stopping potential versus frequency plot for Silver to that of Sodium is
(a) 1 (b) 2
(c) 4 (d) zero

**118.** The photoelectric threshold of Tungsten is 2300Å. The energy of the electrons ejected from the surface by ultraviolet light of wavelength 1800Å is
(a) 0.15 eV (b) 1.5 eV (c) 15 eV (d) 150 eV

**119.** Ultraviolet radiation of 6.2 eV falls on an aluminium surface (workfunction 4.2 eV). The kinetic energy in joule of the faster electron emitted is approximately
(a) $3 \times 10^{-21}$ (b) $3 \times 10^{-19}$
(c) $3 \times 10^{-17}$ (d) $3 \times 10^{-15}$

**120.** Radiations of intensity 0.5 W/m$^2$ are striking a metal plate. The pressure on the plate is
(a) $0.166 \times 10^{-8}$ N/m$^2$ (b) $0.332 \times 10^{-8}$ N/m$^2$
(c) $0.111 \times 10^{-8}$ N/m$^2$ (d) $0.083 \times 10^{-8}$ N/m$^2$

**121.** Radiations of two photon's energy, twice and ten times the work function of metal are incident on the metal surface successsively. The ratio of maximum velocities of photoelectrons emitted in two cases is
(a) 1 : 2 (b) 1 : 3 (c) 1 : 4 (d) 1 : 1

**122.** If the momentum of electron is changed by $P$, then the de Broglie wavelength associated with it changes by 0.5%. The initial momentum of electron will be
(a) $200P$ (b) $400P$
(c) $\frac{P}{200}$ (d) $100P$

**123.** If the kinetic energy of a free electron doubles, it's de-Broglie wavelength changes by the factor
(a) 2 (b) $\frac{1}{2}$
(c) $\sqrt{2}$ (d) $\frac{1}{\sqrt{2}}$

**124.** The energy of a photon of green light of wavelength 5000Å is
(a) $3.459 \times 10^{-19}$ joule (b) $3.973 \times 10^{-19}$ joule
(c) $4.132 \times 10^{-19}$ joule (d) $8453 \times 10^{-19}$ joule

**125.** If the energy of a photon is 10 eV, then its momentum is
(a) $5.33 \times 10^{-23}$ kg m/s (b) $5.33 \times 10^{-25}$ kg m/s
(c) $5.33 \times 10^{-29}$ kg m/s (d) $5.33 \times 10^{-27}$ kg m/s

**126.** A proton and α-particle are accelerated through the same potential difference. The ratio of their de-Broglie wavelength will be
(a) 1 : 1 (b) 1 : 2 (c) 2 : 1 (d) $2\sqrt{2} : 1$

**127.** The ratio of de-Broglie wavelengths of proton and α-particle having same kinetic energy is
(a) $\sqrt{2} : 1$ (b) $2\sqrt{2} : 1$ (c) 2 : 1 (d) 4 : 1

**128.** A monochromatic source of light operating at 200 W emits $4 \times 10^{20}$ photons per second. Find the wavelength of light.
(a) 400 mm (b) 200 nm
(c) $4 \times 10^{-10}$ Å (d) None of these

**129.** The wavelength $\lambda_e$ of an electron and $\lambda_p$ of a photon are of same energy E are related by
(a) $\lambda_p \propto \lambda_e$ (b) $\lambda_p \propto \sqrt{\lambda_e}$
(c) $\lambda_p \propto \frac{1}{\sqrt{\lambda_e}}$ (d) $\lambda_p \propto \lambda_e^2$

**130.** A material particle with a rest mass $m_0$ is moving with speed of light c. The de-Broglie wavelength associated is given by
(a) $\frac{h}{m_0 c}$ (b) $\frac{m_0 c}{h}$ (c) zero (d) ∞

**131.** A proton has kinetic energy E = 100 keV which is equal to that of a photon. The wavelength of photon is $\lambda_2$ and that of proton is $\lambda_1$. The ratio of $\lambda_2/\lambda_1$ is proportional to
(a) $E^2$ (b) $E^{1/2}$ (c) $E^{-1}$ (d) $E^{-1/2}$

# HINTS AND SOLUTIONS

## FACT/DEFINITION TYPE QUESTIONS

1. (b) Cathode ray consists of electrons
2. (b) The fluorescence was caused due to the radiations appeared to be coming from the cathode called cathode rays.
3. (c) 4. (b)
5. (d) For occurence of photoelectric effect, the incident light should have frequency more than a certain minimum which is called the threshold frequency ($v_0$).

   We have, $\frac{1}{2}mv^2 = h\nu - h\nu_0$

   For photoelectric effect emission $\nu > \nu_0$

   where ν is the frequency of the incident light.
6. (a) Emission of electron from a substance under the action of light is photoelectric effect. Light must be at a sufficiently high frequency. It may be visible light, U.V, X-rays. So U.V. cause electron emission.
7. (d) Einstein arrived at the important result that the light quantum can also be associated with momentum $h\nu/c$ A definite value of energy as well as momentum is a strong sign that the light quantum can be associated with a particle. This particle was later named photon.
8. (c) The Maxwell's equations of electromagnetism and Hertz experiment on the generation and detection of electromagnetic waves in 1887, strongly established the wave nature of light.
9. (c) A certain minimum amount of energy is required to pull the electron out from the surface of the metal. This minimum energy required by an electron to escape from the metal surface is called the work function of the metal.
10. (d) The work function of a metal depends upon the properties of the metal and the nature of its surface.
11. (c) R.A. Millikan's famous oil-drop experiment led him to propose the theory of quantisation of electric charge.
12. (b) The minimum frequency above which the electrons are ejected from the metal surface, is called the threshold frequency for that metal. No electrons are emitted if the frequency of the incident light is less than the threshold frequency.
13. (d) Cadmium is sensitive to ultraviolet light while the rest are sensitive even to visible light.
14. (d) All photosensitive substances emit electrons when illuminated by light.
15. (c) Beyond the threshold frequency the photoelectric current increases with increase in intensity.
16. (d) For the given frequency of incident light

    $K_{max} = eV_0$

    where $K_{max}$ is the maximum kinetic energy gained by photoelectron and $V_0$ is the minimum retarding potential for which the photocurrent stops.

    $e$ = charge of electron.
17. (c) Photocurrent can be explained with particle nature of light.
18. (d)
19. (b) The photoelectric emission takes place by discrete absorption of energy from radiation.
20. (c) The diffraction of electrons show wave nature of electrons.
21. (d) Photons are not deflected by electric and magnetic fields as they are electrically neutral.
22. (c) Photons are quantum of light which are electrically neutral.
23. (c) In a photon – particle collision, the number of photons may not be conserved. The photon may be absorbed or a new photon may be created.
24. (a) Photon has no rest mass
25. (c) Photoelectric effect can be explained by quantum nature of light i.e. light as a stream of photons.
26. (a) Hertz discovered first the photoelectric effect in 1887.
27. (b) 28. (d)
29. (b) Photoelectric effect is accounted by particle like bahaviour of light (i.e. by quantum theory of light)
30. (c) Photoelectric cell converts light energy into electric energy.
31. (b) The photoelectric current $\propto$ Intensity of light.
32. (b) Photoelectric effect is based on law of conservation of energy.
33. (c)
34. (b) Max. K.E. = $h\nu - W_0$ ; so Max. K.E. $\propto \nu$
35. (c) Max. K.E. of phtoelectrons emitted is independent of intensity of incident light.
36. (c) In the given relation $E_k$ stands for maximum K.E. of emitted photoelectron.
37. (d) Photoelectrons are emitted if the frequency of incident light is greater than the threshold frequency.
38. (d) The minimum energy required for the emission of electrons is called work function.
39. (a) The work function of different metals is different.
40. (d) 41. (a)
42. (a) Einstein's photo electric effect & compton effect established particle nature of light. These effects can be explained only, when we assume that the light has particle nature (To explain, Interference & Diffraction the light must have wave nature. It means that light has both particle and wave nature, so it is called dual nature of light)
43. (d) 44. (c)
45. (c) Energy of a photon $E = \frac{hc}{\lambda}$ ; E is less if λ is longer
46. (c) Energy of a photon $E = hc/\lambda$
47. (b)
48. (d) From Eqn K.E = $h\nu - \phi$

    slope of graph of K.E & ν is h,

    which is same for all metals.
49. (d) The discovery of X-rays by Roentgen in 1895 and of electrons by J.J Thomson in 1897, were important milestones in the understanding of atomic structure.

50. (c) de-Broglie's relation, $\lambda = \frac{h}{p}$

momentum $p = \sqrt{2mE}$

$$\Rightarrow \lambda = \frac{h}{\sqrt{2mE}} = \frac{h}{\sqrt{2mK}} \quad (\because E = K)$$

51. (a) 1 electron volt (ev) = $1.6 \times 10^{-19}$ joule

52. (c) The ultraviolet light provided sufficient energy for the electrons to escape from the surface of detector (metal) loop and hence the current increased.

53. (c) The kinetic energy of the particle

$$K = \frac{1}{2}mv^2 = qV = \frac{p^2}{2m}$$

$$\Rightarrow \quad p = \sqrt{2mK} = \sqrt{2mqV}$$

$$\because \ \lambda = \frac{h}{p} = \frac{h}{\sqrt{2mqV}}$$

54. (c) $\lambda = \frac{1.227}{\sqrt{V}}$ nm, as $\lambda = \frac{h}{p} = \frac{h}{\sqrt{2meV}}$

Substituting the numerical values of $h$, $m$ and $e$ we get the result.

55. (c)

56. (c) $\lambda = \frac{h}{m_p v_p} = \frac{h}{m_e v_e}$; then $m_p v_p = m_e v_e$ or $\frac{v_p}{v_e} = \frac{m_e}{m_p}$

$$\frac{E_p}{E_e} = \frac{\frac{1}{2}m_p v_p^2}{\frac{1}{2}m_e v_e^2} = \frac{m_p}{m_e} \times \left(\frac{m_e}{m_p}\right)^2 = \frac{m_e}{m_p} < 1$$

$\therefore \ E_p < E_e$

57. (d) Since $eV_0 = h\nu - \phi_0$

where $V_0$ = max. potential

$$\text{or} \quad V_0 = \left(\frac{h}{e}\right)\nu - \frac{\phi}{e}$$

58. (b)

59. (d) The order of time is nano second.

60. (a) In the Davisson and Germer experiment, the velocity of electrons emitted from the electron gun can be increased by increasing the potential difference between the anode and filament.

## STATEMENT TYPE QUESTIONS

61. (b) Cathode rays get deflected in the electric field.

62. (d) The minimum energy required for the electron emission from the metal surface can be supplied to the free electrons by anyone of the following physical processes.

(i) **Thermionic emission** By suitably heating, sufficient thermal energy can be imparted to the free electrons to enable them to come out of the metal.

(ii) **Photoelectric emission** When light of suitable frequency illuminates a metal surface, electrons are emitted from the metal surface. These photo (light)-generated electrons are called photoelectrons.

(iii) **Field emission** By applying a very strong electric field (of the order of $10^8$ V $m^{-1}$) to a metal, electrons can be pulled out of the metal, as in a spark plug.

63. (a) The greater the intensity of radiation the greater the amplitude of electric and magnetic field.

64. (d)

(i) For a given photosensitive material and frequency of incident radiation (above the threshold frequency), the photoelectric current is directly proportional to the intensity of incident light.

(ii) For a given photosensitive material and frequency of incident radiation, saturation current is found to be proportional to the intensity of incident radiation whereas the stopping potential is independent of its intensity.

(iii) For a given photosensitive material, there exists a certain minimum cut-off frequency of the incident radiation, called the threshold frequency, below which no emission of photoelectrons takes place, no matter how intense the incident light is. Above the threshold frequency, the stopping potential or equivalently the maximum kinetic energy of the emitted photoelectrons increases linearly with the frequency of the incident radiation but is independent of its intensity.

(iv) The photoelectric emission is an instantaneous process without any apparent time lag (~ $10^{-9}$ or less), even when the incident radiations is made exceedingly dim.

65. (a) According to Einstein's photoelectric equation $k_{max} = h\nu - h\nu_0$ if $\nu_0 > \nu$ $k_{max}$ –(ve)

66. (c) The photoelectric equation

$K_{max} = h\nu - \phi_0$

Explains that the intensity of incident radiation will increase photocurrent only beyond the threshold frequency.

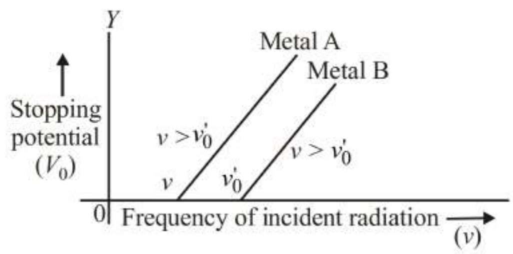
67. (d) To study effect of intensity, the collector A is maintained at a positive potential with respect to emitter C so that electrons ejected from C are attracted towards collector A. Keeping the frequency of the incident radiation and the accelerating potential fixed, the intensity of light is varied and the resulting phtoelectric current is measured each time. It is found that the photocurrrent increases linearly with intensity of incident light.

68. (b)

69. (c) The stopping potential is independent of intensity of incident radiation.

70. (a)

(i) The graph shows that the stopping potential $V_0$ varies linearly with the frequency of incident radiation for a given photosensitive material.




Variation of stopping potential $V_0$ with frequency $\nu$ of incident radiation for a given photosensitive material.

(ii) There exists a certain minimum cut-off frequency $v_0$ for which the stopping potential is zero.

These observations have two implications.

(iii) The maximum kinetic energy of the photoelectrons varies linearly with the frequency of incident radiation, but is independent of its intensity.

(iv) For a frequency $v$ of incident radiation lower than the cut-off frequency $v_0$, no photoelectric emission is possible even if the intensity is large.

This minimum, cut-off frequency $v_0$, is called the threshold frequency. It is different for different metals.

**71.** **(b)**

(i) In interaction of radiation with matter, radiation behaves as if it is made up of particles called photons.

(ii) Each photon has energy $E\ (= hv)$ and momentum $p\ (= h\ v/c)$ and speed c, the speed of light.

(iii) All photons of light of a particular frequency $v$, or wavelength $\lambda$ have the same energy, $E\ (= hv = hc/\lambda)$ and momentum $P(= hv/c = h/\lambda)$, whatever the intensity of radiation may be. By increasing the intensity of light of given wavelength, there is only an increase in the number of photons per second crossing a given area, with each photon having the same energy.

Thus, photon energy is independent of intensity of radiation.

(iv) Photons are electrically neutral and are not deflected by electric and magnetic fields.

(v) In photon-particle collision (such as photoelectron collision), the total energy and total momentum are conserved.

however, the number of photons may not be conserved in a collision. The photon may be absorbed or a new photon may be created.

## MATCHING TYPE QUESTIONS

**72.** **(a)** (A) → (2); (B) → (3); (C) → (1); (D) → (4)

**73.** **(a)** (A) → (1); (B) → 4; (C) → (3); (D) → (2)

**74.** **(c)** (A) → (2); (B) → (1); (C) → (4); (D) → (3)

**75.** **(b)** (A) → (3); (B) → (4); (C) → (2); (D) → (1)

## DIAGRAM BASED QUESTIONS

**76.** **(c)** Changing the material of plate A will not affect the no. of photoelectrons emitted for the given material of plate C and intensity & frequency of light used.

**77.** **(c)**

**78.** **(b)** From his experiment hallwachs concluded that negatively charged particles were emitted from zinc plate under the action of ultraviolet light.

**79.** **(b)**

**80.** **(a)** From the graph it is clear that A and B have the same stopping potential and therefore the same frequency. Also B and C have the same intensity.

**81.** **(d)** $h\upsilon - h\upsilon_0 = E_K$, according to photoelectric equation, when $\upsilon = \upsilon_0$, $E_K = 0$.

Graph (d) represents $E_K - \upsilon$ relationship.

**82.** **(a)** For a given photosensitive material and $\propto$ frequency > threshold frequency photoelectric current $\propto$ intensity.

**83.** **(d)** Intensity $\propto 1/(\text{distance})^2$ ; No. of photoelectrons emitted is proportional to intensity of incident light.

**84.** **(d)** As $\lambda$ is increased, there will be a value of $\lambda$ above which photoelectrons will be cease to come out so photocurrent will become zero. Hence (d) is correct answer.

## ASSERTION- REASON TYPE QUESTIONS

**85.** **(b)** Both statement I and II are true; but even it radiation of single wavelength is incident on photosensitive surface, electrons of different KE will be emitted.

**86.** **(a)** When a light of single frequency falls on the electrons of inner layer of metal, then this electron comes out of the metal surface after a large number of collisions with atom of it's upper layer.

**87.** **(b)** The kinetic energy of emitted photoelectrons varies from zero to a maximum value. Work function depends on metal used.

**88.** **(d)** Photoelectric saturation current is independent of frequency. It only depends on intensity of light.

**89.** **(b)** Less work function means less energy is required for ejecting out the electrons.

**90.** **(a)** **91.** **(d)**

**92.** **(d)** Total number of emitted photons depends on energy of each photon. The energy of photons of two sources may be different.

**93.** **(d)** To photons of equal wavelength will have equal momentum (magnitude), but direction of momentum may be different.

**94.** **(b)**

## CRITICAL THINKING TYPE QUESTIONS

**95.** **(d)** $eV_s = \dfrac{hc}{\lambda} - W_0$. If $\lambda$ decreases, $V_s$ increases

**96.** **(a)** Einstein equation $E = h\upsilon_0 + K.E$

where E = energy of incident photon.

$h\upsilon_0$ = work function of metal

K.E = max. kinetic energy of $e^-$

$\therefore 4\text{ eV} = 2\text{ eV} + K.E$ or $K.E = 2\text{ eV}$

Stopping potential is the potential difference which may stop this $e^-$.

Let it be V, then $eV = 2e \Rightarrow V = 2$ volt.

**97.** **(b)** Since work function for a metal surface is $W = \dfrac{hc}{\lambda_0}$

where $\lambda_0$ is threshold wavelength or cut-off wavelength for a metal surface.

here $W = 4.125\text{ eV} = 4.125 \times 1.6 \times 10^{-19}$ Joule

$$\text{so } \lambda_0 = \frac{6.6 \times 10^{-34} \times 3 \times 10^8}{4.125 \times 1.6 \times 10^{-19}} = 3000\text{Å}$$

**98.** **(d)** Intensity $\propto 1/(\text{distance})^2$ ; No. of photoelectrons emitted is proportional to intensity of incident light.

**99.** **(d)** The electron ejected with maximum speed $v_{max}$ are stopped by electric field E = 4N/C after travelling a distance d = 1m

$$\frac{1}{2}mv_{max}^2 = eEd = 4eV$$

The energy of incident photon $= \frac{1240}{200} = 6.2$ eV

From equation of photo electric effect

$$\frac{1}{2}mv_{max}^2 = h\nu - \phi_0$$

$\therefore\ \phi_0 = 6.2 - 4 = 2.2$ eV

**100. (c)** By using $E = W_0 + K_{max}$

$E = \frac{12375}{5000} = 2.475$ eV and $K_{max} = eV_0 = 1.36$ eV

So $2.475 = W_0 + 1.36 \Rightarrow W_0 = 1.1$ eV.

**101. (c)** $\frac{1}{2}mv^2 = \frac{hc}{\lambda} - \phi \Rightarrow v = \sqrt{\frac{2(hc - \lambda\phi)}{\lambda m}}$

**102. (b)** For electron and positron pair production, minimum energy is 1.02 MeV.

Energy of photon is given $1.7 \times 10^{-3}J = \frac{1.7 \times 10^{-13}}{1.6 \times 10^{-19}}$

$= 1.06$ MeV.

Since energy of photon is greater than 1.02 MeV.

so electron positron pair will be created.

**103. (c)**

**104. (a)** According to relation, $E = \frac{1}{2}mv^2$

$$\sqrt{\frac{2E}{m}} = v$$

$$\lambda = \frac{h}{\sqrt{2mE}}$$

Because $m_1 < m_3 < m_2$

So for same $\lambda$, $E_1 > E_3 > E_2$.

**105. (b)** For emission of electrons incident energy of each photon must be greater than work function (threshold energy).

**106. (c)** $\lambda = \frac{h}{\sqrt{2mE}}$ So $h \propto \frac{1}{\sqrt{m}}$

since $m_\alpha > m_n > m_p > m_e$

so de-Broglie wave length in increasing order will be $\lambda_d$, $\lambda_m$, $\lambda_p$, $\lambda_e$

**107. (d)** $K_{max} = \frac{hc}{\lambda} - W = \frac{hc}{\lambda} - 5.01 = \frac{12375}{\lambda(\text{in Å})} - 5.01$

$$= \frac{12375}{2000} - 5.01 = 6.1875 - 5.01 = 1.17775 \simeq 1.2V$$

**108. (c)** The stopping potential is equal to maximum kinetic energy.

**109. (a)** $K.E. = h\nu - h\nu_{th} = eV_0$ ($V_0$ = cut off voltage)

$$\Rightarrow V_0 = \frac{h}{e}(8.2 \times 10^{14} - 3.3 \times 10^{14})$$

$$= \frac{6.6 \times 10^{-34} \times 4.9 \times 10^{14}}{1.6 \times 10^{-19}} \approx 2V.$$

**110. (b)** According to Einsten's photoelectric effect, the K.E. of the radiated electrons

$K.E_{max} = E - W$

$\frac{1}{2}mv_1^2 = (1 - 0.5)$ eV $= 0.5$ eV

$\frac{1}{2}mv_2^2 = (2.5 - 0.5)$ eV $= 2$ eV

$$\frac{v_1}{v_2} = \sqrt{\frac{0.5}{2}} = \frac{1}{\sqrt{4}} = \frac{1}{2}$$

**111. (a)** Energy emitted/sec by $S_1, P_1 = n_1\frac{hc}{\lambda_1}$

Energy emitted/sec by $S_2, P_2 = n_2\frac{hc}{\lambda_2}$

$$\therefore\ \frac{P_2}{P_1} = \frac{n_2}{n_1}\cdot\frac{\lambda_1}{\lambda_2}$$

$$= \frac{1.02 \times 10^{15}}{10^{15}}\cdot\frac{5000}{5100} = 1.0$$

**112. (a)** Give that, only 25% of 200W converter electrical energy into light of yellow colour

$$\left(\frac{hc}{\lambda}\right) \times N = 200 \times \frac{25}{100}$$

Where $N$ is the No. of photons emitted per second, $h$ = plank's constant, $c$, speed of light.

$$N = \frac{200 \times 25}{100} \times \frac{\lambda}{hc}$$

$$= \frac{200 \times 25 \times 0.6 \times 10^{-6}}{100 \times 6.2 \times 10^{-34} \times 3 \times 10^8}$$

$= 1.5 \times 10^{20}$

**113. (c)** $n \rightarrow 2 - 1$

$E = 10.2$ eV

$kE = E - \phi$

$Q = 10.20 - 3.57$

$h\upsilon_0 = 6.63$ eV

$$\upsilon_0 = \frac{6.63 \times 1.6 \times 10^{-19}}{6.67 \times 10^{-34}} = 1.6 \times 10^{15}\ \text{Hz}$$

**114. (b)** From photoelectric equation,

$h\nu' = h\nu + K_{max}$ ...(i)

$h.2\nu = h\nu + \frac{1}{2}mV^2_{max}$ $[\because \nu' = 2\nu]$

$$\Rightarrow h\nu = \frac{1}{2}mV^2_{max}$$

$$\Rightarrow V_{max} = \sqrt{\frac{2h\nu}{m}}$$

**115. (c)** $hc/\lambda_0 = W_0$; $\frac{(\lambda_0)_1}{(\lambda_0)_2} = \frac{(W_0)_2}{(W_0)_1} = \frac{4.5}{2.3} = 2:1.$

**116. (a)** For the longest wavelength to emit photo electron

$$\frac{hc}{\lambda} = \phi \Rightarrow \lambda = \frac{hc}{\phi}$$

$$\Rightarrow \lambda = \frac{6.63 \times 10^{-34} \times 3 \times 10^8}{4 \times 1.6 \times 10^{-19}} = 310\ \text{nm}$$

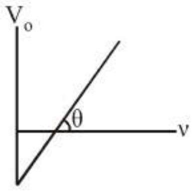
**117. (a)** For photoelectric effect

$$\frac{h\nu}{e}-\frac{\phi_o}{e}=V_o$$

The slope is

$$\tan\theta=\frac{h}{e}=\text{constant}$$

$\therefore$ The ratio will be 1.




**118. (a)** $E_k=\frac{hc}{c}\left(\frac{1}{\lambda}-\frac{1}{\lambda_0}\right)$ (in eV)

$$=\frac{6.6\times10^{-34}\times3\times10^8}{1.6\times10^{-19}}\left(\frac{10^{10}}{1800}-\frac{10^{10}}{2300}\right)=0.15\text{eV}$$

**119. (b)** $E_k=E-W_0=6.2-4.2=2.0\text{ eV}$
$=2.0\times1.6\times10^{-19}=3.2\times10^{-19}\text{ J}$

**120. (a)** We know that $P=Fv$ or $F=P/v$

$$F=\frac{0.5}{3\times10^8}=0.166\times10^{-8}\text{N}/\text{m}^2$$

**121. (b)** $\frac{1}{2}mv_1^2=2W_0-W_0=W_0$ and

$$\frac{1}{2}mv_2^2=10W_0-W_0=9W_0$$

$$\therefore\quad\frac{v_1}{v_2}=\sqrt{\frac{W_0}{9W_0}}=\frac{1}{3}$$

**122. (a)** The de-Broglie's wavelength associated with the moving electron $\lambda=\frac{h}{P}$

Now, according to problem

$$\frac{d\lambda}{\lambda}=-\frac{dp}{P}$$

$$\frac{0.5}{100}=\frac{P}{P'}$$

$$P'=200P$$

**123. (d)** de-Broglie wavelength,

$$\lambda=\frac{h}{p}=\frac{h}{\sqrt{2.m.(K.E)}}$$

$$\therefore\ \lambda\propto\frac{1}{\sqrt{K.E}}$$

If K.E is doubled, $\lambda$ becomes $\frac{\lambda}{\sqrt{2}}$

**124. (b)** $E=hc/\lambda=6.6\times10^{-34}\times3\times10^8/5000\times10^{-10}$
$=3.973\times10^{-19}\text{ J}$

**125. (d)** Momentum of a photon $\propto\frac{E}{c}=\frac{10\times1.6\times10^{-19}}{3\times10^8}$

$$=5.33\times10^{-27}\text{ kg ms}^{-1}$$

**126. (d)** $qV=\frac{1}{2}mv^2$ or $mv=\sqrt{2qVm}$ ;

So $\lambda=\frac{h}{mv}=\frac{h}{\sqrt{2qVm}}$ i.e. $\lambda\propto\frac{1}{\sqrt{qm}}$ ;

so $\frac{\lambda_p}{\lambda_\alpha}=\sqrt{\frac{q_\alpha m_\alpha}{q_p m_p}}=\sqrt{2\times4}=2\sqrt{2}$

**127. (c)** de-Broglie wavelength, $\lambda=\frac{h}{\sqrt{2mE_{K.E}}}$

$$\therefore\ \frac{\lambda_p}{\lambda_\alpha}=\sqrt{\frac{m_\alpha}{m_p}}=\sqrt{\frac{4m_p}{m_p}}\ [\because E_{K.E(\alpha)}=E_{K.E(p)}]$$

$$\therefore\ \frac{\lambda_p}{\lambda_\alpha}=\frac{2}{1}$$

**128. (a)** The energy of each photon $=\frac{200}{4\times10^{20}}=5\times10^{-19}\text{ J}$

Wavelength $=\lambda=\frac{hc}{E}$

$$=\frac{(6.63\times10^{-34})\times(3\times10^8)}{5\times10^{-19}}$$

$\Rightarrow\lambda=4.0\times10^{-7}=400\text{ nm}$

**129. (d)** As $P=\frac{E}{C}$

$$\lambda_p=\frac{\hbar C}{E}\qquad\text{...(i)}$$

$$\lambda_e{}^2=\frac{\hbar h}{\sqrt{2mE}}\qquad\text{...(ii)}$$

From equations (i) and (ii)

$\lambda_p\propto\lambda_e{}^2$

**130. (c)** $\lambda=\frac{h}{mv},\ v=\frac{m_0}{\sqrt{1-\left(\frac{v}{c}\right)^2}},\ v\to c,\ m\to\infty$

hence, $\lambda\to0$.

**131. (d)** For photon $E=h\nu$

$$E=\frac{hc}{\lambda}\Rightarrow\lambda_2=\frac{hc}{E}\qquad\text{...(i)}$$

for proton $E=\frac{1}{2}m_pv_p^2$

$$E=\frac{1}{2}\frac{m_p^2v_p^2}{m}\Rightarrow p=\sqrt{2mE}$$

From De Broglie Eqn.

$$p=\frac{h}{\lambda_1}\Rightarrow\lambda_1=\frac{h}{p}=\frac{h}{\sqrt{2mE}}\qquad\text{...(ii)}$$

$$\frac{\lambda_2}{\lambda_1}=\frac{hc}{E\times\frac{h}{\sqrt{2mE}}}\propto E^{-1/2}$$