THE VILLAGE
INTERNATIONAL SCHOOL

Grade XII

Chapter 11 – DUAL NATURE OF RADIATION AND MATTER

Question Bank

Multiple choice type questions;

1. The photoelectric effect can be explained on the basis of

(a) Corpuscular theory (b) Wave theory

(c) electromagnetic theory (d) quantum theory

2. Which of the following has minimum stopping potential?

(a) Blue (b) Yellow

(c) Violet (d) Red

3. When radiation is incident on a photoelectron emitter, the stopping potential is found to be 9 V. If e/m for the electron is $1{\cdot}8 \times 10^{11}$ C/kg, the maximum velocity of the ejected electron is

(a) 6×10^5 m/s (b) 8×10^5 m/s

(c) 10^6 ms^{-1} (d) $1{\cdot}8 \times 10^6$ ms^{-1}

4. Two photons, each of energy 2·5 eV are simultaneously incident on the metal surface. If the work function of the metal is 4·5 eV, then from the surface of metal

(a) one electron will be emitted with energy 0·5 *eV*

(b) two electrons will be emitted with energy 0·25 eV

(c) more than two electrons will be emitted

(d) not a single electron will be emitted

5. The maximum velocity of an electron emitted by light of wavelength λ incident on the surface of a metal of work function ϕ, is [h = Planck's constant, *c* = speed of light and *m* = mass of electron]

(a) $\left[\frac{2(hc+\lambda\varphi)}{m\lambda}\right]^{1/2}$ (b) $\frac{2(hc-\lambda\varphi)}{m\lambda}$

(c) $\left[\frac{2(hc-\lambda\varphi)}{m\lambda}\right]^{1/2}$ (d) $\left[\frac{2(hc-\varphi)}{m}\right]^{1/2}$

6. The photoelectric work function for a metal surface is 4· 125 e V. The cut off wavelength for this surface is

(a) 4125 Å (b) 2062.5 Å
(c) 3000 Å (d) 6000 Å

7. The slope of frequency of incident light and stopping potential for a given surface will be

(a) h (b) h/e
(c) eh (d) e

8. The threshold wavelength for a metal having work function φ_o is λ_o· What is the threshold wavelength for a metal whose work function is $\varphi_o/2$?

(a) 4 λ_o (b) 2 λ_o
(c) λ_o /2 (d) λ_o /4

9. The work function for metals A, B and C are respectively 1 ·92 e V, 2·0 e V and 5·0 e V. According to Einstein's equation, the metals which will emit photoelectrons for a radiation of wavelength 4100 Å is/are

(a) none (b) A only
(c) A and B only (d) B and c only

10. The wavelength of matter wave is independent of

(a) mass (b) velocity
(c) momentum (d) charge

Assertion and Reason type questions;

DIRECTIONS. In each of the following questions, read the two statements and choose if

(A) both Assertion and Reason are true and the Reason is correct explanation of the Assertion.

(B) both Assertion and Reason are true, but the Reason is not a correct explanation of the Assertion.

(C) Assertion is true and Reason is false.

(D) both, Assertion and Reason are false.

11. **Assertion**: Light of frequency 1 ·5 times the threshold frequency is incident on photo-sensitive material. If the frequency is halved and intensity is doubled, the photo current remains unchanged.

Reason: The photo electric current varies directly with the intensity of light and frequency of light.

(a) A (b) B (c) C (d) D

12. **Assertion**: Photoelectric effect demonstrates the wave nature of light.
Reason: The number of photoelectrons is proportional to the frequency of light.
(a) A (b) B (c) C (d) D
13. **Assertion** An electron microscope can achieve better resolving power than an optical microscope.
Reason: The de-Broglie wavelength of the electrons emitted from an electron gun with velocity 500 m/s is much less than 500 nm.
(a) A (b) B (c) C (d) D
14. **Assertion**: The de-Broglie wavelength of a neutron when its kinetic energy is k is λ. Its wavelength is 2λ when its kinetic energy is 4 *k.*
Reason: The de-Broglie wavelength λ is proportional to square root of the kinetic energy.
(a) A (b) B (c) C (d) D
15. **Assertion**: The de-Broglie wavelength equation has significance for any microscopic or submicroscopic particles.
Reason: The de-Broglie wavelength is inversely proportional to the mass of the object if velocity is constant.
(a) A (b) B (c) C (d) D

Short answers type questions;

16. There are materials which absorb photons of shorter wavelength and emit photons of longer wavelength. Can there be stable substances which absorb photons of larger wavelength and emit light of shorter wavelength.

Ans. In the first case, the energy of the incident photon on a material is high and the energy of emitted photon is low.
In the second case, the energy of the incident photon is low and the energy of emitted photon is high. It means in second case the material has to supply the energy for the emission of photon. This cannot happen for stable substances.

17. **Do all the electrons that absorb a photon come out as photoelectrons**?
Ans. No, most electrons get scattered into the metal by absorbing a photon. Only a few come out of the surface of metal whose energy becomes greater than the work function of metal.
18. **Why is this fact (two photon absorption) not taken into consideration in our discussion of the stopping potential**?
Ans. The probability of absorbing 2 photons by the same electron is very low. Hence such emission will be negligible.

19. **On what principle is an electron microscope based**?
Ans. An electron microscope is based on de-Broglie hypothesis. According to it, a beam of electrons behaves as a wave which can be converged or diverged by magnetic or electric field lenses like a beam of light using optical lenses.
20. A proton and an electron have same velocity. Which one has greater de-Broglie wavelength and why?
Ans. De-Broglie wavelength λ = h/mv, i.e., De-Broglie wavelength of electron is more than that of proton.
Numerical;
21. Calculate the
(a) momentum, and
(b) de Broglie wavelength of the electrons accelerated through a potential difference of 56 V.
Solution: -

$$\frac{1}{2}mv^2 = eV$$

$$v^2 = \frac{2eV}{m}$$

$$\therefore v = \sqrt{\frac{2 \times 1.6 \times 10^{-19} \times 56}{9.1 \times 10^{-31}}}$$

$$= \sqrt{19.69 \times 10^{12}} = 4.44 \times 10^6 \text{ m/s}$$

After this momentum, can be calculated.
For de-Broglie wavelength $\lambda = \frac{12.27}{\sqrt{V}}$ Å

22. What is the
(a) momentum,
(b) speed, and
(c) de Broglie wavelength of an electron with kinetic energy of 120 eV.
Solution; - same as previous question,
23. The wavelength of light from the spectral emission line of sodium is 589 nm. Find the kinetic energy at which
(a) an electron, and
(b) a neutron, would have the same de Broglie wavelength.

Solution; -

$$K = \frac{1}{2} m_e v^2$$

$$\lambda = \frac{h}{m_e v}$$

$$\therefore v^2 = \frac{h^2}{\lambda^2 m_e^{\,2}} \qquad \ldots (2)$$

$$K = \frac{1}{2}\frac{m_e h^2}{\lambda^2 m_e^{\,2}} = \frac{h^2}{2\lambda^2 m_e} \qquad \ldots (3)$$

$$= \frac{\left(6.6 \times 10^{-34}\right)^2}{2 \times \left(589 \times 10^{-9}\right)^2 \times 9.1 \times 10^{-31}}$$

$$\approx 6.9 \times 10^{-25} \text{ J}$$

$$= \frac{6.9 \times 10^{-25}}{1.6 \times 10^{-19}} = 4.31 \times 10^{-6} \text{ eV} = 4.31 \mu\text{eV}$$

In the same way KE of neutron can be calculated.

24. What is the de-Broglie wavelength of
(a) a bullet of mass 0.040 kg travelling at the speed of 1.0 km/s,
(b) a ball of mass 0.060 kg moving at a speed of 1.0 m/s, and
(c) a dust particle of mass 1.0×10^{-9} kg drifting with a speed of 2.2 m/s?

(a) $\lambda = \frac{h}{mv}$

$$= \frac{6.6 \times 10^{-34}}{0.040 \times 1000} = 1.65 \times 10^{-35} \text{ m}$$

In the same way other 2 can be calculated**.**

25. An electron and a photon each have a wavelength of 1.00 nm. Find
(a) their momenta,
(b) the energy of the photon, and
(c) the kinetic energy of electron.

(a) $p = \frac{h}{\lambda} \quad \therefore p = \frac{6.63 \times 10^{-34}}{1 \times 10^{-9}} = 6.63 \times 10^{-25} \text{ kg m s}^{-1}$

(b) $\overline{F}$ $\quad \therefore E = \dfrac{6.63 \times 10^{-34} \times 3 \times 10^{8}}{1 \times 10^{-9} \times 1.6 \times 10^{-19}}$

$= 1243.1 \text{ eV} = 1.243 \text{ keV}$

(c) $K = \frac{1}{2}$ $\quad \therefore K = \dfrac{1}{2} \times \dfrac{\left(6.63 \times 10^{-25}\right)^2}{9.1 \times 10^{-31}} = 2.415 \times 10^{-19} \text{ J}$

$= \dfrac{2.415 \times 10^{-19}}{1.6 \times 10^{-19}} = 1.51 \text{ eV}$

ANSWERS OF MCQs; -1. (d),2. (d), 3. (d), 4. (d), 5. (c), 6. (c), 7. (b), 8. (b), 9. (c), 10. (d), 11. (d), 12. (d), 13. (c), 14. (d), 15. (a)