Dual Nature of Radiation and Matter

Assertion & Reason Type Questions

Directions: In the following questions, a statement of Assertion (A) is followed by a statement of Reason (R). Mark the correct choice as:

a. Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).

b. Both Assertion (A) and Reason (R) are true but Reason (R) is not the correct explanation of Assertion (A).

c. Assertion (A) is true but Reason (R) is false.

d. Both Assertion (A) and Reason (R) are false.

Q1. Assertion (A): For the radiation of a frequency greater than the threshold frequency, photoelectric current is proportional to the intensity of the radiation.

Reason (R): Greater the number of energy quanta available, greater is the number of electrons absorbing the energy quanta and greater is number of electrons coming out of the metal. **(CBSE SQP 2023-24)**

Answer : (a) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).

Q2. Assertion (A): Photoelectric effect demonstrates the wave nature of light.

Reason (R): The number of photoelectrons is proportional to the frequency of light.

Answer : (d) Photoelectric effect demonstrates the particle nature of light. Number of emitted photoelectrons depends upon the intensity of light.

Q3. Assertion (A): The photoelectrons produced by a monochromatic light beam incident on a metal surface have a spread in their kinetic energies.

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

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Answer : (a) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).

Q4. Assertion (A): Photosensitivity of a metal is high if its work function is small.

Reason (R): Work function = hv_0 where v_0 is the threshold frequency.

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

Q5. Assertion (A): Light is produced in gases in the process of electric discharge through them at high pressure.

Reason (R): At high pressure electrons collide with gaseous atoms and reach at excited state.

Answer : (d) Light is produced in gases in the process of electric discharge at low pressure. When accelerated electrons collide with atoms of the gas, atoms get excited. The excited atoms return to their normal state and in this process light radiations are emitted.

Q6. Assertion (A): Kinetic energy of photoelectrons emitted by a photosensitive surface depends upon the intensity of incident photon.

Reason (R): The ejection of electrons from metallic surface is possible with frequency of incident photon below the threshold frequency.

Answer : (d) According to Einstein equation KE = $hv - hv_0$; i.e., KE depends upon the frequency. Photoelectron emitted only if incident frequency is more than threshold frequency.

Q7. Assertion (A): The specific charge of positive rays is not constant.

Reason (R): The mass of ions varies with speed.

Answer :

(b) The specific charge (e/m) of the positive rays is not universal constant because these rays may consist of ions of different elements.

Q8. Assertion (A): When the speed of an electron increases its specific charge decreases.

Reason (R): Specific charge is the ratio of the charge to mass.

Answer :

(b) Charge does not change with speed but mass, varies with the speed as per relation $m = \frac{m_0}{\sqrt{1-\frac{v^2}{c^2}}}$.

Hence, specific charge e/m $\left(\frac{\text{electron}}{\text{mass}}\right)$ decreases with increase in speed.

Q9. Assertion (A): Mass of moving photon varies inversely as the wavelength.

Reason (R): Energy of the particle = Mass (speed of light)^2.

Answer : (b) Mass of moving photon,

$$m = \frac{h\nu}{c^2} = \frac{h}{c\lambda}$$

$$m \propto \frac{1}{\lambda}$$

According to Einstein's mass-energy equivalence, $E = mc^2$

Q10. Assertion (A): The de-Broglie wavelength of a molecule varies inversely as the square root of temperature.

Reason (R): The root mean square velocity of the molecule depends on the temperature.

Answer :

(a) de-Broglie wavelength associated with gas molecules varies as $\lambda \propto \frac{1}{\sqrt{T}}$.

Q11. 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 wave length then energy acquired by electrons absorbing photons of different wave lengths shall be different.

Q12. 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.

Q13. Assertion: The photoelectrons 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.

Q14. 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.

Q15. 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.

Q16. Assertion: The photon behaves like a particle.

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

Q17. Assertion: In an experiment on photoelectric effect, a photon is incident on an electron from one direction and the photoelectron 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.

Q18. 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.

Q19. Assertion: Two photons of equal wavelength must have equal linear momentum.

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

Q20. 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.

ANSWER KEY 11 to 20

Q11 : (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.

Q12 : (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.

Q13 : (b) The kinetic energy of emitted photoelectrons varies from zero to a maximum value. Work function depends on metal used.

Q14 : (d) Photoelectric saturation current is independent of frequency. It only depends on intensity of light.

Q15 : (b) Less work function means less energy is required for ejecting out the electrons.

Q16 : (a) **Q17 :** (d)

Q18 : (d) Total number of emitted photons depends on energy of each photon. The energy of photons of two sources may be different.

Q19 : (d) To photons of equal wavelength will have equal momentum (magnitude), but direction of momentum may be different.

Q20 : (b)