Self Practice Paper (SPP)

1. Yellow light of 557 nm wavelength is incident on a cesium surface. It is found that no photo electrons flow in the circuit when the cathode-anode voltage drops below 0.25V. Then the threshold wavelength for photo electric effect from cesium is
(1) 577 nm (2) 653 nm (3) 734 nm (4) 191 nm

2. Helium atom emits a photon of wavelength 0.1 A. The recoil energy of the atom due to the emission of photon will be
(1) 2.04 eV (2) 4.91 eV (3) 1.67 eV (4) 9.10 eV

3. Electrons with energy 80keV are incident on the tungsten target of an X-ray tube. K shell electrons of tungsten have -72.5keV energy. X-rays emitted by the tube contain only

(1) a continuous X-ray spectrum (Bremsstrahlung) with a minimum wavelength of ~ 0.155Å.

(2) a continuous X-ray spectrum (Bremsstrahlung) with all wavelengths.

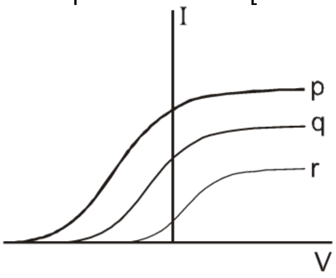
(3) the characteristic X-ray spectrum of tungsten.

(4) a continuous X-ray spectrum (Bremsstrahlung) with a minimum wavelength of ~ 0.155Å and the characteristic X-ray spectrum of tungsten.

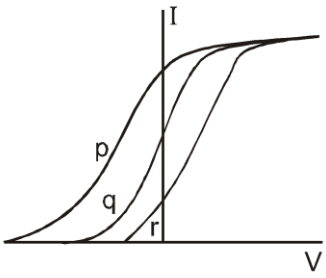
4. Imagine an atom made up of a proton and a hypothetical particle of double the mass of the electron but having the same charge as the electron. Apply the Bohr atom model and consider all possible transitions of this hypothetical particle to the first excited level. The longest wavelength photon that will be emitted has wavelength λ (given in terms of the Rydberg constant R for the hydrogen atom) equal to
[JEE '2000, Screening 1 + 1/35]
(1) 9/(5R) (2) 36/(5R) (3) 18/(5R) (4) 4/R

5. For the case discussed above,the wavelength of light emitted in the visible region by He^{+} ions after collisions with H atoms is
(1) 6.5×10^{-7} m (2) 5.6×10^{-7} m (3) 4.8×10^{-7} m (4) 4.0×10^{-7} m

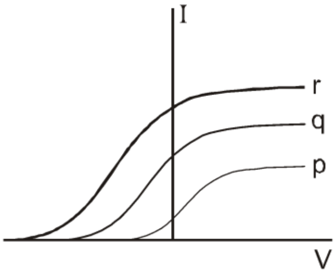
6. Photoelectric effect experiments are performed using three different metal plates p, q and r having work functions φ_p = 2.0 eV, φ_q = 2.5 eV and φ_r = 3.0 eV respectively. A light beam containing wavelengths of 550 nm, 450 nm and 350 nm with equal intensities illuminates each of the plates. The correct I-V graph for the experiment is [Take hc = 1240 eV nm]



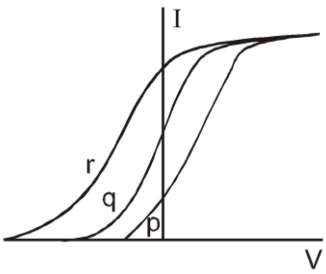
(1)



(2)



(3)



(4)

7. If λ_{Cu} is the wavelength of K_α X-ray line of copper (atomic number 29) and λ_{Mo} is the wavelength of the K_α X-ray line of molybdenum (atomic number 42), then the ratio $\lambda_{Cu}/\lambda_{Mo}$ is close to

(1) 1.99 (2) 2.14 (3) 0.50 (4) 0.48

8. A metal surface is illuminated by light of two different wavelengths 248 nm and 310 nm. The maximum speeds of the photoelectrons corresponding to these wavelengths are u_1 and u_2, respectively. If the ratio $u_1 : u_2 = 2 : 1$ and hc = 1240 eV nm, the work function of the metal is nearly

(1) 3.7 eV (2) 3.2 eV (3) 2.8 eV (4) 2.5 eV

9. Consider a hydrogen atom with its electron in the n_{th} orbital. An electromagnetic radiation of wavelength 90 nm is used to ionize the atom. If the kinetic energy of the ejected electron is 10.4 eV, then the value of n is (hc = 1242 eV nm)

(1) 1 (2) 2 (3) 3 (4) 4

10. The orbital angular momentum for an electron revolving in an orbit is given by $\sqrt{\ell(\ell+1)}\ \frac{h}{2\pi}$. This momentum for an s-electron will be given by - **[AIEEE 2003 4/300]**

(1) $+\frac{1}{2}.\frac{h}{2\pi}$ (2) zero (3) $\frac{h}{2\pi}$ (4) $\sqrt{2}.\frac{h}{2\pi}$

11. In Bohr's model of hydrogen atom, the centripetal force is provided by the Coulomb attraction between the proton and the electron. If a_0 is the radius of the ground state orbit, m is the mass and e the charge of an electron and ε_0 is the vacuum permittivity, the speed of the electron is :

(1) zero (2) $\frac{e}{\sqrt{\varepsilon_0 a_0 m}}$ (3) $\frac{e}{\sqrt{4\pi\varepsilon_0 a_0 m}}$ (4) $\frac{\sqrt{4\pi\varepsilon_0 a_0 m}}{e}$

SPP Answers

1.	(2)	**2.**	(1)	**3.**	(4)	**4.**	(3)	**5.**	(3)	**6.**	(1)	**7.**	(2)
8.	(1)	**9.**	(2)	**10.**	(2)	**11.**	(3)						

SPP Solutions

1. stoping potential (V_s) = 0.25 V

$eV_s = hv + W$

Where W is work function $\Rightarrow$ W = $\frac{hc}{\lambda} - ev_s$

$= \frac{12400(A^o eV)}{5770A^o} - 0.25eV$ = 2.75 - 0.25

W = 1.90 eV

W = $\frac{hc}{\lambda_s}$

λ_s - thereshold wave length

$\lambda_s = hc/w$

$= \frac{12400 \quad A^o eV}{1.40(eV)} = 6526 \quad A'$

= 653 nm

2. Momentum of photon = momentum of helium

$P_p = \frac{\lambda}{\lambda_P} = P_{He}$

$P_{He} = \frac{\lambda}{0.1 \quad A^o} = \sqrt{2km}$

k = $\left(\frac{\lambda^2}{0.1 \quad A^o \times 2m_{He}}\right) = \frac{(\lambda C)^2}{0.1 \quad A^o \times C^2 \times 2m_{He}}$

$= \frac{(12400 \quad eVA^o)^2}{0.1 \quad A^o \times (3\times10^8)^2 \times 2 \times 4 \times 10^{-3}}$ = 2.04 eV

3. Minimum wavelength of continuous X-ray spectrum is given by -

λ_{min} (in $\oplus$ = $\frac{12375}{E(\text{in eV})}$

Here, E = energy of incident electrons (in eV)

= energy corresponding to minimum wavelength λ_{min} of X-rays

E = 80 keV

= 80 × 103 eV

$\therefore \lambda_{min}$ (in Å) $= \frac{12375}{80\times10^3}$

$\approx$ 0.155

Also the energy of the incident electrons (80 keV) is more than the ionization energy of the K-shell electrons (i.e. 72.5 keV). Therefore, characteristic X-ray spectrum will also be obtained because energy of incident electron is high enough to knock out the electron from K or L shells.

→ Question based on continuous and characteristic spectrum was also asked in screening 2001. Remember that source of continuous spectrums acceleration of electron, while source of characteristic spectrum is de-excitation of electron.

4. In hydrogen atom $E_n = -\frac{Rhc}{n^2}$

Also $E_n \propto m$

where m is the mass of the electron. Here the electron has been replaced by a particle whose mass is double of an electron. Therefore, for this hypothetical atom energy in nth orbit will be given by -

$$E_n = -\frac{2Rhc}{n^2}$$

The longest wavelength lmax (or minimum energy) photon will correspond to the transition of particle from n = 3 to n = 2

$$\therefore \quad \frac{hc}{\lambda_{max}} = E_3 - E_2 = Rhc\left(\frac{1}{2^2} - \frac{1}{3^2}\right)$$

This gives

$$\lambda_{max} = \frac{18}{5R}$$

5. The wavelength corresponding to transition from n = 4 to n = 3 in He^+ corresponds to visible region. Its wavelength is :

$$\frac{hc}{\lambda} = 13.6 \times 4\left[\frac{1}{9} - \frac{1}{16}\right]$$

$$\frac{4.1\times10^{-15}\times3\times10^{8}}{\lambda\ (m)} = 13.6\times4\times\frac{7}{9\times16} \Rightarrow \lambda = \frac{4.1\times10^{-15}\times3\times10^{8}}{13.6\times4\times\frac{7}{9\times16}}\ m$$

$\lambda = 4.68 \times 10^{-7}$ m. So, **Ans (3).**

6.

$$E_{\lambda_1=550\ nm} = \frac{1240}{550}eV = 2.25\ eV$$

$$E_{\lambda_2=450\ nm} = \frac{1240}{450}eV = 2.8\ eV$$

$$E_{\lambda_3=350\ nm} = \frac{1240}{350}eV = 3.5\ eV$$

For metal r, only λ_3 is able to generate photoelectron.
For metal q, only λ_2 and λ_3 are able to generate photoelectron.
For metal p, all wavelength are able to generate photoelectron.
Hence photoelectric current will be maximum for p and least for r.

7. Using Mosley's law, for K_α line : $\sqrt{\upsilon} = a(z - b)$ where b = 1

$$\upsilon \propto \frac{1}{\lambda} \quad \therefore \quad \frac{\sqrt{\frac{1}{\lambda_{cu}}}}{\sqrt{\frac{1}{\lambda_{mo}}}} = \frac{a(29-1)}{a(42-1)} \Rightarrow \frac{\lambda_{cu}}{\lambda_{mo}} = \frac{41\times41}{28\times28} = \frac{1681}{784} = 2.144$$

8. 248 nm ≡ 1240 / 248 ev = 5 ev
310nm ≡ 1240 / 310 ev = 4 ev

$$\frac{K.E_1}{K.E_2} = \frac{4}{1} = \frac{5ev - W}{4ev - W} \Rightarrow 16 - 4W = S - W \Rightarrow 11 = 3W \Rightarrow W = \frac{11}{3} = 3.67\ ev \cong 3.7\ ev$$

9.

$$\frac{hC}{\lambda} - \left\{13.6eV.\frac{1}{n^2}\right\} = 10.4 \Rightarrow \frac{1242eV}{90} - \frac{13.6}{n^2} = 10.4$$

$$\frac{41.4}{3} - \frac{13.6}{n^2} = 10.4 \Rightarrow 13.8 - 10.4 = \frac{13.6}{n^2}$$

$\Rightarrow 3.4 = \frac{13.6}{n^2}$ $\Rightarrow n_2 = 4$ $\Rightarrow n = 2$

10. For s-electron, $\ell = 0$

11. $\frac{mv^2}{a_0} = \frac{1}{4\pi\varepsilon_0}.\frac{e^2}{a_0^2}$ $\Rightarrow$ $v = \frac{e}{\sqrt{4\pi \in_0 a_0 m}}$.