Speed Test-25

1. **(d)** Wavelength of particle $(\lambda_1) = \frac{h}{mv} = \frac{h}{(1\times10^{-3})\times v}$

where v is the velocity of the particle.
Wavelength of electron

$$(\lambda_2) = \frac{h}{(9.1\times10^{-31})\times(3\times10^6)}$$

But $\lambda_1 = \lambda_2$

$$\therefore \frac{h}{(1\times10^{-3})\times v} = \frac{h}{(9.1\times10^{-31})\times(3\times10^6)}$$

$$\Rightarrow v = \frac{9.1\times10^{-31}\times3\times10^6}{10^{-3}}$$

$$= 2.73\times10^{-21}\ ms^{-1}$$

2. **(a)** For electron De-Broglie wavelength,

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

For photon $E = pc$

$\Rightarrow$ De-Broglie wavelength, $\lambda_{Ph} = \frac{hc}{E}$

$$\therefore \quad \frac{\lambda_e}{\lambda_{Ph}} = \frac{h}{\sqrt{2mE}}\times\frac{E}{hc} = \left(\frac{E}{2m}\right)^{1/2}\frac{1}{c}$$

3. **(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

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

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

4. **(b)** $\lambda_{min} = 1$ Å (given)

$$\because \lambda_{min} = \frac{1240}{E}\ (eV)\ (nm)$$

$$\text{Thus, } E = \frac{1240(eV)(nm)}{0.01(nm)} = 12400\ eV$$

$E = 12.4$ KeV

5. **(a)** The maximum kinetic energy of an electron accelerated through a potential difference of V volt is $\frac{1}{2}mv^2 = eV$

$$\therefore \text{ maximum velocity } v = \sqrt{\frac{2eV}{m}}$$

$$v = \sqrt{\frac{2\times1.6\times10^{-19}\times15000}{9.1\times10^{-31}}}$$

$v = 7.26\times10^7$ m/s

6. **(b)** Photoelectrons are emitted in A alone. Energy of electron needed if emitted from $A = \frac{h\upsilon}{e}eV$

$$\therefore \quad E_A = \frac{(6.6\times10^{-34})\times(1.8\times10^{14})}{1.6\times10^{-19}} = 0.74\ eV$$

$$E_B = \frac{(6.6\times10^{-34})\times(2.2\times10^{14})}{1.6\times10^{-19}} = 0.91\ eV$$

Incident energy 0.825 eV is greater than E_A (0.74 eV) but less than E_B (0.91 eV).

7. **(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 λ, $E_1 > E_3 > E_2$.

8. **(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.

9. **(b)** $\lambda_0 = \frac{c}{v_0} = \frac{3\times10^8}{5\times10^{14}} = 6\times10^{-7}\,m = 6000Å$

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

hence, $\lambda \to 0$.

11. **(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 is planck's constant and c is speed of light.

$$N = \frac{200\times25}{100}\times\frac{\lambda}{hc}$$

$$= \frac{200\times25\times0.6\times10^{-6}}{100\times6.2\times10^{-34}\times3\times10^8} = 1.5\times10^{20}$$

12. **(d)** For photon E = hν

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

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

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

From De Broglie Eqn.

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

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

13. **(a)** $h\nu = W_0 + E_k = 3.5 + 1.2 = 4.7\,eV$

14. **(a)** $\phi = 6.2\ eV = 6.2\times1.6\times10^{-19}\ J$

$V = 5$ volt

$$\frac{hc}{\lambda} - \phi = eV_0$$

$$\Rightarrow \lambda = \frac{hc}{\phi + eV_0}$$

$$= \frac{6.6\times10^{-34}\times3\times10^8}{1.6\times10^{-19}(6.2+5)} \approx 10^{-7}\,m$$

This range lies in ultra violet range.

15. **(c)** Applying Einstein's formula for photo-electricity

$$h\nu = \phi + \frac{1}{2}mv^2; \qquad h\nu = \phi + K$$

$$\phi = h\nu - K$$

If we use 2ν frequency then let the kinetic energy becomes K'

So,
$$h\,.\,2\nu = \phi + K'$$
$$2h\nu = h\nu - K + K'$$
$$K' = h\nu + K$$

16. **(a)** $\because \lambda_0 = \frac{hc}{\phi}$

$$\therefore (\lambda_0)_{sodium} = \frac{6.6\times10^{-34}\times3\times10^8}{2\times1.6\times10^{-19}} = 6188\ Å$$

$$\because \lambda_0 \propto \frac{1}{\phi} \Rightarrow \frac{(\lambda_0)_{sodium}}{(\lambda_0)_{copper}} = \frac{(\phi)_{copper}}{(\phi)_{sodium}}$$

$$\Rightarrow (\lambda_0)_{copper} = \frac{2}{4}\times6188 = 3094\ Å$$

To eject photo-electrons from sodium the longest wavelength is 6188 Å and that for copper is 3094 Å.

Hence for light of wavelength 4000 Å, sodium is suitable.

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

18. **(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, wavelength becomes $\frac{\lambda}{\sqrt{2}}$

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

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

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

20. **(a)** The work function has no effect on photoelectric current so long as $h\nu > W_0$. The photoelectric current is proportional to the intensity of incident light. Since there is no change in the intensity of light, hence $I_1 = I_2$.

21. **(c)** $n \to 2 - 1$

$E = 10.2$ eV

$kE = E - \phi$

$Q = 10.20 - 3.57$

$h\upsilon_0 = 6.63$ eV

$$\upsilon_0 = \frac{6.63\times1.6\times10^{-19}}{6.67\times10^{-34}} = 1.6\times10^{15}\text{ Hz}$$

22. **(d)** $h\nu = W + \frac{1}{2}mv^2$ or $\frac{hc}{\lambda} = W + \frac{1}{2}mv^2$

Here $\lambda = 3000\text{ Å} = 3000\times10^{-10}$ m

and W = 1 eV = 1.6×10^{-19} joule

$$\therefore \frac{(6.6\times10^{-34})(3\times10^{8})}{3000\times10^{-10}}$$

$$= (1.6\times10^{-19}) + \frac{1}{2}\times(9.1\times10^{-31})v^2$$

Solving we get, $v \cong 10^6$ m/s

23. **(b)** According to Einstein's photoelectric equation, $h\nu = \phi_0 + K_{max}$

We have

$h\nu = \phi_0 + 0.5$ ...(i)

and $1.2h\nu = \phi_0 + 0.8$ ...(ii)

Therefore, from above two equations $\phi_0 = 1.0$ eV.

24. **(c)** $\lambda_{max.} = \frac{2d\sin\theta}{n_{min.}} = \frac{2\times15\times\sin90^\circ}{1} = 30\text{Å}$

25. **(d)** $W_0 = h\nu_1 - eV_1$

$= h\,\nu_2 - e\,V_2$

$eV_2 = h(\nu_2 - \nu_1) + eV_1$

$$V_2 = \frac{h(n_2 - n_1)}{e} + V_1$$

26. **(b)** $KE_{max} = h\nu - \phi$

$1eV = h\nu - 1.9eV \Rightarrow h\nu = 2.9$ eV

Now threshold wavelength (maximum wavelength), $\lambda_0 = \frac{hc}{E}$

$$\Rightarrow \lambda_0 = \frac{6.6\times10^{-34}\times3\times10^{8}}{1.9\times1.6\times10^{-19}} = 6513\text{ Å}$$

And threshold frequency

$$\nu_0 = \frac{c}{\lambda_0} = \frac{3\times10^8}{6513\times10^{-10}} = 4.6\times10^{14}\text{Hz}$$

27. **(b)** $E = W_0 + K_{max}$ ...(i)

$\Rightarrow hf = W_A + K_A$ ...(ii)

and $2hf = W_B + K_B = 2W_A + K_B \left(\because \frac{W_A}{W_B} = \frac{1}{2}\right)$

Dividing equation (i) by (ii)

$$\frac{1}{2} = \frac{W_A + K_A}{2W_A + K_B} \Rightarrow \frac{K_A}{K_B} = \frac{1}{2}$$

28. **(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.

29. **(d)** $K_{max} = \frac{hc}{\lambda} - W = \frac{hc}{\lambda} - 5.01$

$$= \frac{12375}{\lambda(\text{in Å})} - 5.01$$

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

$\simeq 1.2$ V

30. **(b)**

31. **(b)** $\lambda \propto \frac{1}{\sqrt{V}}$

$$\Rightarrow \frac{\lambda_1}{\lambda_2} = \sqrt{\frac{V_2}{V_1}} = \sqrt{\frac{100\text{keV}}{25\text{keV}}} = 2$$

$$\Rightarrow \lambda_2 = \frac{\lambda_1}{2}$$

32. **(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.

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

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

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

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

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

34. **(b)** By using $h\nu - h\nu_0 = K_{max}$

$\Rightarrow h(\nu_1 - \nu_0) = K_1$ ..... (i)

And $h(\nu_2 - \nu_0) = K_2$ ..... (ii)

$\Rightarrow \frac{\nu_1 - \nu_0}{\nu_2 - \nu_0} = \frac{K_1}{K_2} = \frac{1}{K}$, Hence $\nu_0 = \frac{k\nu_1 - \nu_2}{K-1}$.

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

36. **(c)** As we know

$\lambda \propto \frac{1}{\sqrt{V}}$

$$\therefore \frac{1}{\sqrt{100}} : \frac{1}{\sqrt{200}} : \frac{1}{\sqrt{300}} = 1 : \frac{1}{\sqrt{2}} : \frac{1}{\sqrt{3}}$$

37. **(d)** Number of emitted electrons N_E

$\propto$ Intensity

$$\propto \frac{1}{(\text{Distance})^2}$$

Therefore, as distance is doubled, N_E decreases by (1/4) times.

38. **(d)** Photoelectrons are emitted if the frequency of incident light is greater than the threshold frequency.

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

$$\Rightarrow V_0 = \frac{h}{e}(8.2\times10^{14} - 3.3\times10^{14})$$

$$= \frac{6.6\times10^{-34}\times4.9\times10^{14}}{1.6\times10^{-19}} \approx 2V.$$

40. **(d)** $\frac{hc}{\lambda} - \phi = eV_0$

$$V_0 = \frac{hc}{e\lambda} - \frac{\phi}{e}$$

For metal A For metal B

$$\frac{\phi_A}{hc} = \frac{1}{\lambda} \qquad \frac{\phi_B}{hc} = \frac{1}{\lambda}$$

As the value of $\frac{1}{\lambda}$ (increasing and decreasing) is not specified hence we cannot say that which metal has comparatively greater or lesser work function (ϕ).

41. **(c)**

42. **(d)** Potential difference = 100 V

K.E. acquired by electron = $e(100)$

$$\frac{1}{2}mv^2 = e(100) \Rightarrow v = \sqrt{\frac{2e(100)}{m}}$$

According to de Broglie's concept

$$\lambda = \frac{h}{mv}$$

$$\Rightarrow \lambda = \frac{h}{m\sqrt{\frac{2e(100)}{m}}}$$

$$= \frac{h}{\sqrt{2me(100)}} = 1.2\times10^{-10} = 1.2\text{Å}$$

43. **(d)** Since $p = nh\nu$

$$\Rightarrow n = \frac{p}{h\nu} = \frac{2\times10^{-3}}{6.6\times10^{-34}\times6\times10^{14}} = 5\times10^{15}$$

44. **(a)** From formula

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

$$= \frac{6.63\times10^{-34}}{\sqrt{2\times1.67\times10^{-27}\times1.38\times10^{-23}T}}m$$

[By placing value of h, m and k)

$$= \frac{30.8}{\sqrt{T}}\text{Å}$$

45. **(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.