PHYSICS

Dual Nature of Radiation and Matter

Speed TEST 25

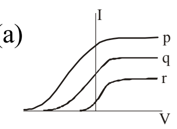
Chapter-wise

No. of Questions	Maximum Marks	Time
30	120	1 Hour

GENERAL INSTRUCTIONS

- This test contains 30 MCQ's. For each question only one option is correct. Darken the correct circle/ bubble in the Response Grid provided on each page.
- You have to evaluate your Response Grids yourself with the help of solutions provided at the end of this book.
- Each correct answer will get you 4 marks and 1 mark shall be deduced for each incorrect answer. No mark will be given/ deducted if no bubble is filled. Keep a timer in front of you and stop immediately at the end of 60 min.
- The sheet follows a particular syllabus. Do not attempt the sheet before you have completed your preparation for that syllabus.
- After completing the sheet check your answers with the solution booklet and complete the Result Grid. Finally spend time to analyse your performance and revise the areas which emerge out as weak in your evaluation.

1. Photoelectric effect experiments are performed using three different metal plates p, q and r having work functions $\phi_p = 2.0$ eV, $\phi_q = 2.5$ eV and $\phi_r = 3.0$ 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]

(a)


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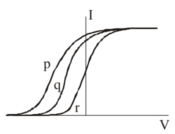

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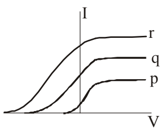

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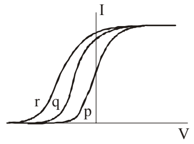


2. Two identical photocathodes receive light of frequencies f_1 and f_2. If the velocites of the photo electrons (of mass m) coming out are respectively v_1 and v_2, then

(a) $v_1^2 - v_2^2 = \frac{2h}{m}(f_1 - f_2)$ (b) $v_1 + v_2 = \left[\frac{2h}{m}(f_1 + f_2)\right]^{1/2}$

(c) $v_1^2 + v_2^2 = \frac{2h}{m}(f_1 + f_2)$ (d) $v_1 - v_2 = \left[\frac{2h}{m}(f_1 - f_2)\right]^{1/2}$

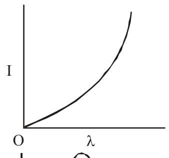
3. An X-ray tube is operated at 15 kV. Calculate the upper limit of the speed of the electrons striking the target.

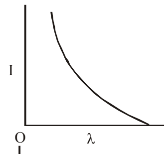
(a) 7.26×10^7 m/s (b) 7.62×10^7 m/s

(c) 7.62×10^7 cm/s (d) 7.26×10^9 m/s

RESPONSE GRID	1. ⓐⓑⓒⓓ	2. ⓐⓑⓒⓓ	3. ⓐⓑⓒⓓ

4. 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)


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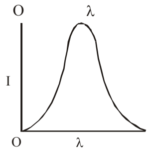
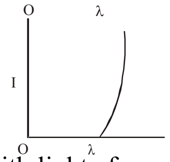


(d)


5. In a photoelectric experiment, with light of wavelength λ, the fastest electron has speed v. If the exciting wavelength is changed to 5λ/4, the speed of the fastest emitted electron will become

(a) $v\sqrt{\frac{5}{4}}$ (b) $v\sqrt{\frac{5}{3}}$

(c) less than $v\sqrt{\frac{5}{3}}$ (d) greater than $v\sqrt{\frac{5}{3}}$

6. 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) 1.5×10^{20} (b) 6×10^{18}
(c) 62×10^{20} (d) 3×10^{19}

7. The wavelength λ_e of an electron and λ_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) $\lambda_p \propto \lambda_e^2$

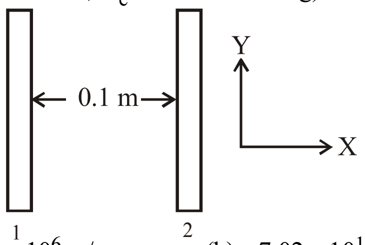
8. The cathode of a photoelectric cell is changed such that the work function changes from W_1 to W_2 ($W_2 > W_1$). If the current before and after changes are I_1 and I_2, all other conditions remaining unchanged, then (assuming $h\nu > W_2$)

(a) $I_1 = I_2$ (b) $I_1 < I_2$
(c) $I_1 > I_2$ (d) $I_1 < I_2 < 2I_1$

9. In photoelectric effect the work function of a metal is 3.5 eV. The emitted electrons can be stopped by applying a potential of –1.2 V. Then

(a) the energy of the incident photon is 4.7 eV
(b) the energy of the incident photon is 2.3 eV
(c) if higher frequency photon be used, the photoelectric current will rise
(d) when the energy of photon is 3.5 eV, the photoelectric current will be maximum

10. Two insulating plates are both uniformly charged in such a way that the potential difference between them is $V_2 - V_1 = 20$ V. (i.e., plate 2 is at a higher potential). The plates are separated by d = 0.1 m and can be treated as infinitely large. An electron is released from rest on the inner surface of plate 1. What is its speed when it hits plate 2? ($e = 1.6 \times 10^{-19}$ C, $m_e = 9.11 \times 10^{-31}$ kg)



(a) 2.65×10^6 m/s (b) 7.02×10^{12} m/s
(c) 1.87×10^6 m/s (d) 32×10^{-19} m/s

11. 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) 4×10^{15} Hz (b) 5×10^{15} Hz
(c) 1.6×10^{15} Hz (d) 2.5×10^{15} Hz

12. When the energy of the incident radiation is incredased by 20%, the kinetic energy of the photoelectrons emitted from a metal surface increased from 0.5 eV to 0.8 eV. The work function of the metal is :

(a) 0.65 eV (b) 1.0 eV (c) 1.3 eV (d) 1.5 eV

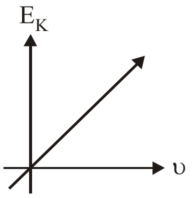
13. The maximum velocity of an electron emitted by light of wavelength λ incident on the surface of a metal of work-function φ is

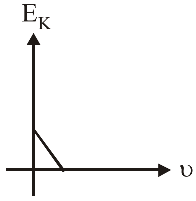
(a) $\sqrt{\frac{2(hc + \lambda\phi)}{m\lambda}}$ (b) $\frac{2(hc + \lambda\phi)}{m\lambda}$

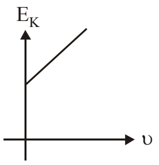
(c) $\sqrt{\frac{2(hc - \lambda\phi)}{m\lambda}}$ (d) $\sqrt{\frac{2(h\lambda - \phi)}{m}}$

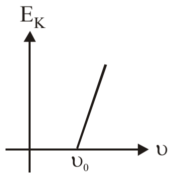
RESPONSE GRID					
	4. ⓐⓑⓒⓓ	5. ⓐⓑⓒⓓ	6. ⓐⓑⓒⓓ	7. ⓐⓑⓒⓓ	8. ⓐⓑⓒⓓ
	9. ⓐⓑⓒⓓ	10. ⓐⓑⓒⓓ	11. ⓐⓑⓒⓓ	12. ⓐⓑⓒⓓ	13. ⓐⓑⓒⓓ

14. 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) 

15. 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) $E_1 = E_2 = E_3$

16. In photoelectric effect, stopping potential for a light of frequency n_1 is V_1. If light is replaced by another having a frequency n_2 then its stopping potential will be

(a) $V_1 - \frac{h}{e}(n_2 - n_1)$ (b) $V_1 + \frac{h}{e}(n_2 + n_1)$

(c) $V_1 + \frac{h}{e}(n_2 - 2n_1)$ (d) $V_1 + \frac{h}{e}(n_2 - n_1)$

17. A certain metallic surface is illuminated with monochromatic light of wavelength λ. The stopping potential for photo-electric current for this light is $3V_0$. If the same surface is illuminated with light of wavelength 2λ, the stopping potential is V_0. The threshold wavelength for this surface for photo-electric effect is

(a) 4λ (b) $\frac{\lambda}{4}$ (c) $\frac{\lambda}{6}$ (d) 6λ

18. The ratio of the respective de Broglie wavelengths associated with electrons accelerated from rest with the voltages 100 V, 200 V and 300 V is

(a) 1 : 2 : 3 (b) 1 : 4 : 9 (c) $1 : \frac{1}{\sqrt{2}} : \frac{1}{\sqrt{3}}$ (d) $1 : \frac{1}{2} : \frac{1}{3}$

19. 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

20. Photoelectric emission is observed from a metallic surface for frequencies v_1 and v_2 of the incident light rays ($v_1 > v_2$). If the maximum values of kinetic energy of the photoelectrons emitted in the two cases are in the ratio of 1 : k, then the threshold frequency of the metallic surface is

(a) $\frac{v_1 - v_2}{k - 1}$ (b) $\frac{kv_1 - v_2}{k - 1}$

(c) $\frac{kv_2 - v_1}{k - 1}$ (d) $\frac{v_2 - v_1}{k}$

21. In an electron gun, the potential difference between the filament and plate is 3000 V. What will be the velocity of electron emitting from the gun?

(a) 3×10^8 m/s (b) 3.18×10^7 m/s

(c) 3.52×10^7 m/s (d) 3.26×10^7 m/s

22. A 5 watt source emits monochromatic light of wavelength 5000 Å. When placed 0.5 m away, it liberates photoelectrons from a photosensitive metallic surface. When the source is moved to a distance of 1.0 m, the number of photoelectrons liberated will be reduced by a factor of

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

23. X-rays are produced in X-ray tube operating at a given accelerating voltage. The wavelength of the continuous X-rays has values from

(a) 0 to ∞

(b) λ_{min} to ∞, where $\lambda_{min} > 0$

(c) 0 to λ_{max}, where $\lambda_{max} < \infty$

(d) λ_{min} to λ_{max}, where $0 < \lambda_{min} < \lambda_{max} < \infty$

24. In the photoeletric effect, electrons are emitted

(a) at a rate that is proportional to the amplitude of the incident radiation

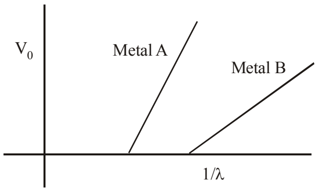
(b) with a maximum velocity proportional to the frequency of the incident radiation

(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

RESPONSE GRID					
	14. ⓐⓑⓒⓓ	15. ⓐⓑⓒⓓ	16. ⓐⓑⓒⓓ	17. ⓐⓑⓒⓓ	18. ⓐⓑⓒⓓ
	19. ⓐⓑⓒⓓ	20. ⓐⓑⓒⓓ	21. ⓐⓑⓒⓓ	22. ⓐⓑⓒⓓ	23. ⓐⓑⓒⓓ
	24. ⓐⓑⓒⓓ				

25. In an experiment on photoelectric effect, a student plots stopping potential V_0 against reciprocal of the wavelength λ of the incident light for two different metals A and B. These are shown in the figure.



Looking at the graphs, you can most appropriately say that:

(a) Work function of metal B is greater than that of metal A
(b) For light of certain wavelength falling on both metal, maximum kinetic energy of electrons emitted from A will be greater than those emitted from B.
(c) Work function of metal A is greater than that of metal B
(d) Students data is not correct

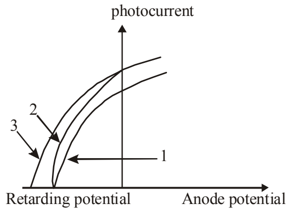
26. Light of wavelength 500 nm is incident on a metal with work function 2.28 eV. The de Broglie wavelength of the emitted electron is:

(a) $< 2.8 \times 10^{-9}\, m$ (b) $\geq 2.8 \times 10^{-9}\, m$
(c) $\leq 2.8 \times 10^{-12}\, m$ (d) $< 2.8 \times 10^{-10}\, m$

27. An electron of mass m and charge e initially at rest gets accelerated by a constant electric field E. The rate of change of de-Broglie wavelength of this electron at time t ignoring relativistic effects is

(a) $\frac{-h}{eEt^2}$ (b) $\frac{-eht}{E}$ (c) $\frac{-mh}{eEt^2}$ (d) $\frac{-h}{eE}$

28. The figure shows a plot of photo current versus anode potential for a photo sensitive surface for three different radiations. Which one of the following is a correct statement?

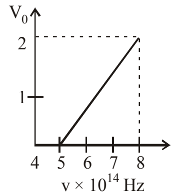


(a) Curves (1) and (2) represent incident radiations of same frequency but of different intensities.
(b) Curves (2) and (3) represent incident radiations of different frequencies and different intensities.
(c) Curves (2) and (3) represent incident radiations of same frequency having same intensity.
(d) Curves (1) and (2) represent incident radiations of different frequencies and different intensities.

29. The de-Broglie wavelength of neutron in thermal equilibrium at temperature T is

(a) $\frac{30.8}{\sqrt{T}}$ Å (b) $\frac{3.08}{\sqrt{T}}$ Å
(c) $\frac{0.308}{\sqrt{T}}$ Å (d) $\frac{0.0308}{\sqrt{T}}$ Å

30. The stopping potential (V_0) versus frequency (v) plot of a substance is shown in figure, the threshold wavelength is



(a) 5×10^{14} m
(b) 6000 Å
(c) 5000 Å
(d) Cannot be estimated from given data

RESPONSE GRID	
	25. ⓐⓑⓒⓓ 26. ⓐⓑⓒⓓ 27. ⓐⓑⓒⓓ 28. ⓐⓑⓒⓓ 29. ⓐⓑⓒⓓ 30. ⓐⓑⓒⓓ

PHYSICS CHAPTERWISE SPEED TEST-25

Total Questions	30	Total Marks	120
Attempted		Correct	
Incorrect		Net Score	
Cut-off Score	40	Qualifying Score	50
Success Gap = Net Score – Qualifying Score			
Net Score = (Correct × 4) – (Incorrect × 1)			

HINTS & SOLUTIONS (PHYSICS – Chapter-wise Tests)

Speed Test-25

1. (a) The energy possessed by photons of wavelength 550 nm is $\frac{1240}{550} = 2.25\,\text{eV}$

The energy possessed by photons of wavelength 450 nm is $\frac{1240}{450} = 2.76\,\text{eV}$

The energy possessed by photons of wavelength 350 nm is $\frac{1240}{350} = 3.54\,\text{eV}$

For metal plate *p* :

$$\phi_p = 2\,eV.$$

All the wavelengths are capable of ejecting electrons. Therefore, the current is maximum. Also as the work function is lowest in *p*, the kinetic energy of ejected electron will be highest and therefore, the stopping potential is highest.

For metal plate *q* :

$$\phi_q = 2.5\,eV.$$

Photons of wavelength 550 nm will not be able to eject electrons and therefore, the current is smaller than *p*. The work function is greater than *q* therefore the stopping potential is lower in comparison to *p*.

For metal plate *r* :

$$\phi_r = 3\,eV$$

Only wavelength of 350 nm will be able to eject electrons and therefore, current is minimum. Also the stopping potential is least.

2. (a) For one photocathode

$$hf_1 - W = \frac{1}{2}mv_1^2 \qquad \text{....(i)}$$

For another photo cathode

$$hf_2 - W = \frac{1}{2}mv_2^2 \qquad \text{....(ii)}$$

Subtracting (ii) from (i) we get

$$(hf_1 - W) - (hf_2 - W) = \frac{1}{2}mv_1^2 - \frac{1}{2}mv_2^2$$

$$\therefore\ h(f_1 - f_2) = \frac{m}{2}(v_1^2 - v_2^2)$$

$$\therefore\ v_1^2 - v_2^2 = \frac{2h}{m}(f_1 - f_2)$$

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

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

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

$$\text{v} = 7.26\times10^{7}\ \text{m/s}$$

4. (b) As λ decreases, y increases and hence the speed of photoelectron increases. The chances of photo electron to meet the anode increases and hence photo electric current increases.

5. (c) Since, stopping potential is independent of distance hence new stopping potential will remain unchanged i.e., new stopping potential = V_0.

6. (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.

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

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

7. (d) As $\text{P} = \frac{\text{E}}{\text{C}}$

$$\lambda_p = \frac{\text{h c}}{\text{E}} \qquad \text{...(i)}$$

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

From equations (i) and (ii)

$$\lambda_p \propto \lambda_e^2$$

8. (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 $I_1 = I_2$.

9. (a) $h\nu = W_0 + E_k = 3.5 + 1.2 = 4.7\ \text{eV}$

10. (a) $\text{eV} = \frac{1}{2}\text{mv}^2$

$$\Rightarrow \text{v} = \sqrt{\frac{2\text{eV}}{\text{m}}} = \sqrt{\frac{2\times1.6\times10^{-19}\times20}{9.1\times10^{-31}}}$$

$$= 2.65\times10^{6}\ \text{m/s}$$

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

$E = 10.2$ eV

$kE = E - \phi$

$Q = 10.20 - 3.57$

$h\upsilon_0 = 6.63$ eV

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

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

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.

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

14. **(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.

15. **(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, $E_1 > E_3 > E_2$.

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

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

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

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

17. **(a)** As we know,

$$eV_s = \frac{hc}{\lambda} - \Psi$$

$$3eV_o = \frac{hc}{\lambda} - \Psi \quad ...(1)$$

$$eV_o = \frac{hc}{2\lambda} - \Psi \quad ...(2)$$

$$3eV_o = \frac{3hc}{2\lambda} - 3\Psi \quad ...(3)$$

Multiplying eqn. (2) by (3) and subtracting it from eqn.(1)

$$\Psi = \frac{hc}{4\lambda}$$

So, threshold wavelength,

$$\lambda_{th} = \frac{hc}{\Psi} = \text{———}$$

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

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

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

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

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

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

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

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

20. **(b)** By using $hv - hv_0 = K_{max}$

$\Rightarrow h(v_1 - v_0) = K_1$ ..... (i)

And $h(v_2 - v_0) = K_2$ ..... (ii)

$$\Rightarrow \frac{v_1 - v_0}{v_2 - v_0} = \frac{K_1}{K_2} = \frac{1}{K}, \text{ Hence } v_0 = \frac{kv_1 - v_2}{K - 1}.$$

21. **(d)** $V = 3000$ volt.

$$\frac{1}{2}mv^2 = eV \Rightarrow v = \sqrt{\frac{2eV}{m}}$$

$$\therefore \quad v = \sqrt{\frac{2 \times 1.6 \times 10^{-19} \times 3000}{9.1 \times 10^{-31}}}$$

$= 32.6 \times 10^6 = 3.26 \times 10^7$ m/s.

22. **(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.

23. **(b)**

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

25. **(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

or lesser work function (ϕ).

26. **(b)** Work function ϕ of metal = 2.28 eV

Wavelength of light $\lambda = 500\text{ nm} = 500 \times 10^{-9}\text{m}$

$$KE_{max} = \frac{hc}{\lambda} - \phi$$

$$KE_{max} = \frac{6.6\times10^{-34}\times3\times10^{8}}{5\times10^{-7}} - 2.82$$

$$KE_{max} = 2.48 - 2.28 = 0.2\text{ ev}$$

$$\lambda_{min} = \frac{h}{p} = \frac{h}{\sqrt{2m(KE)_{max}}}$$

$$= \frac{\frac{20}{3}\times10^{-34}}{\sqrt{2\times9\times10^{-31}\times0.2\times1.6\times10^{-19}}}$$

$$\lambda_{min} = \frac{25}{9} \times 10^{-9}$$

$= 2.80 \times 10^{-9}$ nm $\quad \therefore \lambda \geq 2.8 \times 10^{-9}$ m

27. **(a)** Here, $u = 0$; $a = \frac{eE}{m}$; $v = ?$; $t = t$

$$\therefore \quad v = u + at = 0 + \frac{eE}{m}t$$

de-Broglie wavelength, $\lambda = \frac{h}{mv} = \frac{h}{m(eEt/m)} = \frac{h}{eEt}$

Rate of change of de-Broglie wavelength

$$\frac{d\lambda}{dt} = \frac{h}{eE}\left(-\frac{1}{t^2}\right) = \frac{-h}{eEt^2}$$

28. **(a)** Retarding potential depends on the frequency of incident radiation but is independent of intensity.

29. **(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)

$$= \frac{30.8}{\sqrt{T}}\text{Å}$$

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