# DPP - Daily Practice Problems

**Date :** ____ **Start Time :** ____ **End Time :** ____

# PHYSICS

**CP23**

**SYLLABUS :** Dual Nature of Radiation and Matter

**Max. Marks : 74** **Time : 60 min.**

**GENERAL INSTRUCTIONS**

- The Daily Practice Problem Sheet contains 20 Questions divided into 5 sections.
  **Section I** has **6** MCQs with ONLY 1 Correct Option, **3** marks for each correct answer and **–1** for each incorrect answer.
  **Section II** has **4** MCQs with ONE or MORE THAN ONE Correct options.
  For each question, marks will be awarded in one of the following categories:
  Full marks: **+4** If only the bubble(s) corresponding to all the correct option(s) is (are) darkened.
  Partial marks: **+1** For darkening a bubble corresponding to each correct option provided NO INCORRECT option is darkened.
  Zero marks: If none of the bubbles is darkened.
  Negative marks: **–2** In all other cases.
  **Section III** has **4** Single Digit Integer Answer Type Questions, **3** marks for each Correct Answer and 0 marks in all other cases.
  **Section IV** has Comprehension Type Questions having **4** MCQs with ONLY ONE corect option, 3 marks for each Correct Answer and 0 marks in all other cases.
  **Section V** has **2** Matching Type Questions, **2** mark for the correct matching of each row and 0 marks in all other cases.
- You have to evaluate your Response Grids yourself with the help of Solutions.

### Section I - Straight Objective Type

This section contains 6 multiple choice questions. Each question has 4 choices (a), (b), (c) and (d), out of which **ONLY ONE** is correct.

**1.** Radiation of wavelength $\lambda$, is incident on a photocell. The fastest emitted electron has speed v. If the wavelength is changed to $\frac{3\lambda}{4}$, the speed of the fastest emitted electron will be:

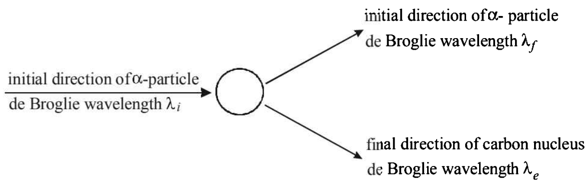
(a) $= v\left(\frac{4}{3}\right)^{\frac{1}{2}}$ (b) $= v\left(\frac{3}{4}\right)^{\frac{1}{2}}$

(c) $> v\left(\frac{4}{3}\right)^{\frac{1}{2}}$ (d) $< v\left(\frac{4}{3}\right)^{\frac{1}{2}}$

| RESPONSE GRID | 1. ⓐⓑⓒⓓ |
|---|---|

*Space for Rough Work*

2. An $\alpha$-particle having a de-Broglie wavelength $\lambda_i$ collides with a stationary carbon nucleus. The $\alpha$-particle moves off in a different direction as shown below.




After the collision, the de Broglie wavelengths of the $\alpha$-particle and the carbon nucleus are $\lambda_f$ and $\lambda_e$ respectively. Which of the following relations about de–Broglie wavelengths is correct

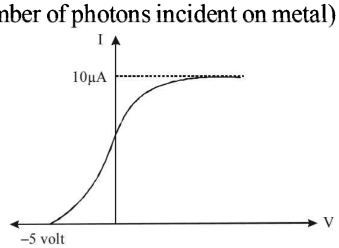
(a) $\lambda_i < \lambda_f$ (b) $\lambda_i > \lambda_f$ (c) $\lambda_f = \lambda_e$ (d) $\lambda_i = \lambda_e$

3. To decrease the cut-off wavelength of continuous X-rays by 25%, the potential difference across X-ray tube must be

(a) increased by $\frac{100}{3}\%$ (b) decreased by $\frac{100}{3}\%$
(c) increased by 25% (d) decreased by 25%

4. In the photoelectric experiment, if we use a monochromatic light, the I-V curve is as shown. If work function of the metal is 2eV, estimate the power of light used. (Assume efficiency of photoemission = $10^{-3}\%$, i.e., number of photoelectrons emitted are $10^{-3}\%$ of number of photons incident on metal)

(a) 2W
(b) 5W
(c) 7W
(d) 10W




5. The ratio of the $\lambda_{min}$ in a Coolidge tube to $\lambda_{deBroglie}$ of the electrons striking the target depends on accelerating potential $V$ as

(a) $\frac{\lambda_{min}}{\lambda_{de\,Broglie}} \propto \sqrt{V}$ (b) $\frac{\lambda_{min}}{\lambda_{de\,Broglie}} \propto V$

(c) $\frac{\lambda_{min}}{\lambda_{de\,Broglie}} \propto \frac{1}{\sqrt{V}}$ (d) $\frac{\lambda_{min}}{\lambda_{de\,Broglie}} \propto \frac{1}{V}$.

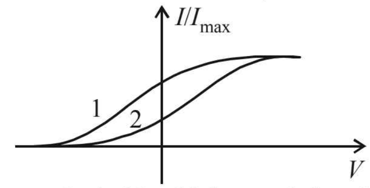
6. The electric field of a light wave at a point is $E = (100\text{ N/c}) \sin[(3 \times 10^{15}\text{ s}^{-1})t] \sin[(6 \times 10^{15}\text{s}^{-1})t]$ where $t$ is time in seconds. This light falls on a metal surface having work function of 2 $eV$, then maximum possible kinetic energy of photoelectrons is about

(a) 16 eV (b) 7 eV (c) 6 eV (d) 4 eV

## Section II - Multiple Correct Answer Type

This section contains 4 multiple correct answer(s) type questions. Each question has 4 choices (a), (b), (c) and (d), out of which **ONE OR MORE** is/are correct.

7. Two photocathodes are illuminated by the light emitted by a single source. The dependence of photocurrent versus voltages between cathode and anode is shown by curves 1 and 2 as shown in the figure. ($I/I_{max}$ represents ratio of photocurrent to saturaion current)

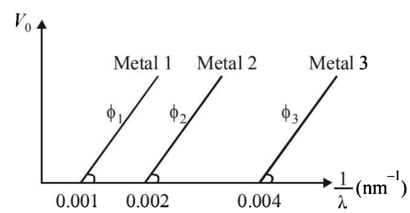



(a) Photocathode 1 has higher work function than 2
(b) Photocathode 2 has higher work function than 1
(c) Saturation current may be different for 1 and 2
(d) Saturation current must be same for 1 and 2

8. The collector plate in an experiment on photoelectric effect is kept vertically above the emitter plate. Light source is put on and a saturation photocurrent is recorded. An electric field is switched on which has a vertically downward direction. Which of the following is/are incorrect?

(a) the photocurrent will increase
(b) the kinetic energy of the electrons will increase
(c) the stopping potential will decrease
(d) the threshold wavelength will increase

9. The graph between the stopping potential ($V_0$) and $\left(\frac{1}{\lambda}\right)$ is shown in the figure. $\phi_1$, $\phi_2$ and $\phi_3$ are work functions. Which of the following is/are correct?




(a) $\phi_1 : \phi_2 : \phi_3 = 1 : 2 : 4$
(b) $\phi_1 : \phi_2 : \phi_3 = 4 : 2 : 1$
(c) $\tan\theta \propto \frac{hc}{e}$
(d) ultravioletlight can be used to emit photoelectrons from metal 2 and metal 3 only

**RESPONSE GRID**

2. ⓐⓑⓒⓓ 3. ⓐⓑⓒⓓ 4. ⓐⓑⓒⓓ 5. ⓐⓑⓒⓓ 6. ⓐⓑⓒⓓ
7. ⓐⓑⓒⓓ 8. ⓐⓑⓒⓓ 9. ⓐⓑⓒⓓ

*Space for Rough Work*

10. Photoelectric effect supports quantum nature of light because
   (a) there is a minimum frequency of light below which no photoelectrons are emitted
   (b) the maximum kinetic energy of photo electrons depends only on the frequency of light and not on its intensity
   (c) even when the metal surface is faintly illuminated, the photoelectrons leave the surface immediately
   (d) electric charge of the photoelectrons is quantized

## Section III - Integer Type

This section contains 4 questions. The answer to each of the questions is a single digit integer ranging from 0 to 9.

11. A silver sphere of radius 1 cm and work function 4.7 eV is suspended from an insulating thread in free space. It is under continuous illumination of 200 nm wavelength of light. As photoelectrons are emitted, the sphere gets charged and acquires a potential. The maximum number of photoelectrons emitted from the sphere is $A \times 10^z$ (where $1 < A < 10$). The value of 'z' is

12. The work functions of Silver and Sodium are 4.6 and 2.3 eV, respectively. Determine the ratio of the slope of the stopping potential versus frequency plot for Silver to that of Sodium.

13. A photon of energy 8.6 eV is incident on a metal surface of threshold freequency $1.6 \times 10^{15}$ Hz, then the maximum kinetic energy (in ev) of photoelectrons emitted is ($h = 6.6 \times 10^{-34}$ Js)

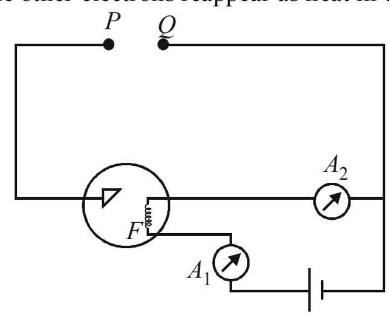
14. A monochromatic source of light operating at 200W emits $4 \times 10^{20}$ photons per second. The wavelength of the light is 100x nm. Find the value of x.

## Section IV - Comprehension Type

**Directions (Qs. 15-18) :** Based upon the given paragraphs, 4 multiple choice questions have to be answered. Each question has 4 choices (a), (b), (c) and (d), out of which **ONLY ONE** is correct.

### PARAGRAPH-1

The diagram shows the basic setup for the production of X-rays. $A_1$ and $A_2$ are two ammeters, which have readings 2.55 $A$ and 2.566A respectively. $F$ is a filament which is also the cathode. The potential difference applied between $P$ and $Q$ is 50000V. Assume that all X-ray photons have the maximum possible energy and that one X-ray photons is emitted for every 100 electrons incident on the target. You may assume that the kinetic energy of the other electrons reappear as heat in the tube.




15. The number of X-ray photons produced per second is approximately
   (a) $10^{12}$ (b) $10^{15}$ (c) $10^{18}$ (d) $10^{21}$

16. The rate at which heat is produced in the X-ray tube is approximately
   (a) 79.2 W (b) 204W (c) 2040 W (d) 792 W

### PARAGRAPH-2

A physicist wishes to eject electrons by shining light on a metal surface. The light source emits light of wavelength of 450 nm. The table lists the only available metals and their work functions.

| Metal | $W_0$ (eV) |
|---|---|
| Barium | 2.5 |
| Lithium | 2.3 |
| Tantalum | 4.2 |
| Tungsten | 4.5 |

17. Which option correctly identifies the metal that will produce the most energetic electrons and their energies ?
   (a) Lithium, 0.45 eV (b) Tungston, 1.75 eV
   (c) Lithium, 2.30 eV (d) Tungston, 2.75 eV

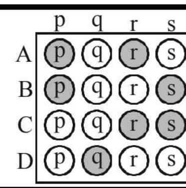
18. Suppose photoelectric experiment is done separately with these metals with light of wavelength 450 nm. The maximum magnitude of stopping potential amongst all the metals is-
   (a) 2.75 volt (b) 4.5 volt
   (c) 0.45 volt (d) 0.25 volt

| RESPONSE GRID | |
|---|---|
| | 10. ⓐⓑⓒⓓ 11. ⓪①②③④⑤⑥⑦⑧⑨ 12. ⓪①②③④⑤⑥⑦⑧⑨ |
| | 13. ⓪①②③④⑤⑥⑦⑧⑨ 14. ⓪①②③④⑤⑥⑦⑧⑨ |
| | 15. ⓐⓑⓒⓓ 16. ⓐⓑⓒⓓ 17. ⓐⓑⓒⓓ 18. ⓐⓑⓒⓓ |

***Space for Rough Work***

## Section V - Matrix-Match Type

This section contains 2 questions. It contains statements given in two columns, which have to be matched. Statements in column I are labelled as A, B, C and D whereas statements in column II are labelled as p, q, r and s. The answers to these questions have to be appropriately bubbled as illustrated in the following example. If the correct matches are A-p, A-r, B-p, B-s, C-r, C-s and D-q, then the correctly bubbled matrix will look like the following:




**19.** In the photoelectric effect experiment, if $v$ is frequency of radiation and $I$ is intensity in terms of number of photons incident per second per unit area, then match the following

| **Column-I** | **Column -II** |
|---|---|
| (A) If $v$ is increased keeping $I$ and work function constant | (p) stopping potential increases |
| (B) If $I$ is increased keeping $v$ and work function constant. | (q) saturation current increases |
| (C) If distance between cathode and anode is increased. | (r) maximum kinetic energy of photoelectron increases |
| (D) Work function is decreased keeping $v$ and $I$ constant | (s) stopping potential remains same |

**20. Match the following**

| **Column-I** | **Column-II** |
|---|---|
| (A) Radiation pressure | (p) particle nature of radiation |
| (B) Threshold wavelength | (q) Stopping potential |
| (C) Maximum kinetic energy of photoelectron | (r) Maximum wavelength of incident photons for photoelectric effect |
| (D) Quantisation of angular momentum of electron | (s) de Broglie hypothesis |

| RESPONSE GRID | |
|---|---|
| | 19. A - (p)(q)(r)(s); B - (p)(q)(r)(s); C - (p)(q)(r)(s); D - (p)(q)(r)(s) |
| | 20. A - (p)(q)(r)(s); B - (p)(q)(r)(s); C - (p)(q)(r)(s); D - (p)(q)(r)(s) |

## DAILY PRACTICE PROBLEM DPP CP23 - PHYSICS

| Total Questions | 20 | Total Marks | 74 |
|---|---|---|---|
| Attempted | | Correct | |
| Incorrect | | Net Score | |
| Cut-off Score | 24 | Qualifying Score | 35 |

$$\text{Net Score} = \sum_{i=\text{I}}^{\text{V}} \left[ \left( \text{correct}_i \times MM_i \right) - \left( In_i - NM_i \right) \right]$$

*Space for Rough Work*

1. **(c)** $h\nu_0{}^2 - h\nu_0 = \frac{1}{2}mv^2$

$\therefore \frac{4}{3}h\nu_0 - h\nu_0 = \frac{1}{2}mv'^2$

$\therefore \frac{v'^2}{v^2} = \frac{\frac{4}{3}\nu - \nu_0}{\nu - \nu_0}$ $\quad \therefore v' = v\sqrt{\frac{\frac{4}{3}\nu - \nu_0}{\nu - \nu_0}}$

$\therefore v' > v\sqrt{\frac{4}{3}}$

2. **(a)** Final speed of α-particle will be less than the initial speed therefore,

$$\left(\frac{h}{\lambda_f}\right) < \left(\frac{h}{\lambda_i}\right) \text{ or } \lambda_f > \lambda_i$$

3. **(a)** $\lambda_{min} = \frac{hc}{ev_0}$

$\lambda_1 = \frac{hc}{ev_1}$ ; $\lambda_2 = \frac{hc}{ev_2}$

$\frac{\lambda_2}{\lambda_1} = \frac{v_1}{v_2} \Rightarrow \frac{3}{4} = \frac{v_1}{v_2}$

$\frac{v_2}{v_1} = \frac{4}{3} \Rightarrow \left(\frac{v_2 - v_1}{v_1}\right) \times 100 = \frac{100}{3}$

Hence, P.D. must be increased by $\frac{100}{3}\%$.

4. **(c)** The energy of incident photons is given by

$h\nu = eV_s + \phi_0 = 2 + 5 = 7\text{eV}$

($V_s$ is stopping potential and $\phi_0$ is work function)

Saturation current $= 10^{-5}$ A

$= \frac{\eta P}{h\nu}e = \frac{10^{-5}P}{7 \times e}e$ ($\eta$ is photon emission efficiency)

$\therefore$ P = 7W

5. **(c)** $\lambda_{min} = \frac{hc}{eV}$

and $\lambda_{\text{de-Broglie}} = \frac{h}{\rho} = \frac{h}{\sqrt{2meV}}$.

6. **(d)** $\omega_{max} = 3 \times 3 \times 10^{15}$;

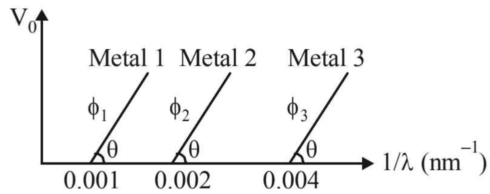
$v_{max} = \frac{3 \times 3 \times 10^{15}}{2\pi}$ Hz

$K.E_{max} = hv_{max} - W = 4\ eV$

7. **(b, c)** $\phi = hv - k_{max}$ and $k_{max} = |eV_s|$

8. **(a, b, c)**

9. **(a, c)** $\phi_1 : \phi_2 : \phi_3 = eV_{0_1} : eV_{0_2} : eV_{0_3}$




$= V = V_{0_1} : V_{0_2} : V_{03} = 0.001 : 0.002 : 0.004 = 1:2:4$

Therefore option (a) is correct

By Einstein's photoelectric equation. $\frac{hc}{\lambda} - \phi = eV$

$\Rightarrow \quad V = \frac{hc}{e\lambda} - \frac{\phi}{e}$ ...(i)

Comparing equation (i) by $y = mx + c$, we get the slope of the line

$m = \frac{hc}{e} = \tan\theta$

$\Rightarrow$ Option (c) is correct.

From the graph it is clear than,

$\frac{1}{\lambda_{0_1}} = 0.001\text{nm}^{-1} \Rightarrow \lambda_{0_1} = \frac{1}{0.001} = 1000\text{mn}$

Also $\frac{1}{\lambda_{0_2}} = 0.002\text{nm}^{-1} \Rightarrow \lambda_{0_2} = 500\text{nm}$ and

$\lambda_{0_2} = 250\text{nm}$

Violet colour light will have wavelength less than 400 nm. Therefore this light will be unable to show photo electric effect on plate, 3 $\Rightarrow$ Option (d) is wrong.

10. **(a, b, c)**

11. **7**

Stopping potential $= \frac{1}{e}\left[\frac{hc}{\lambda} - \phi\right]$ where hc = 1240eV –nm

$= \frac{1}{e}\left[\frac{1240}{200} - 4.7\right] = \frac{1}{e}[6.2 - 4.7]$

$= \frac{1}{e} \times 1.5eV = 1.5\text{V}$

But $V = \frac{1}{4\pi\varepsilon_0}\frac{q}{r} = \frac{1}{4\pi\varepsilon_0}\frac{ne}{r}$

$\therefore n = \frac{Vr(4\pi\varepsilon_0)}{e} = \frac{1.5 \times 10^{-2}}{9 \times 10^9 \times 1.6 \times 10^{-19}}$

$\therefore n = 1.04 \times 10^7$

Comparing it with $A \times 10^z$ we get, z = 7

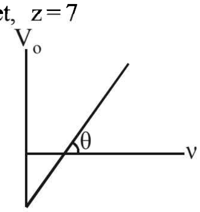
12. **1** For photoelectric effect

$\frac{h\nu}{e} - \frac{\phi_0}{e} = V_o$

The slope is

$\tan\theta = \frac{h}{e} = \text{constant}$

$\therefore$ The ratio will be 1.



**13.** **2**

Work funciton $W_0 = h\nu_0 = 6.6 \times 10^{-34} \times 1.6 \times 10^{15}$

$= 1.056 \times 10^{-18}$ J $= 6.6$ eV

From $E = W_0 + K_{max} \Rightarrow K_{max} = E - W_0 = 2$ eV

**14.** **4**

If $E$ is the energy of each photon, then

$$nE = P$$

$$\therefore \quad E = \frac{P}{n} = \frac{200}{4\times10^{20}} = 50\times10^{-20} J$$

If $\lambda$ is the wavelength of light, then

$$E = \frac{hc}{\lambda}$$

$$\therefore \quad \lambda = \frac{hc}{E} = \frac{(6.63\times10^{-34})\times(3\times10^{8})}{500\times10^{-20}} = 400 \text{ nm}$$

**15.** **(b)** The current $= 2.566 - 2.55 = 0.016$

$\therefore$ No. of $e^- = \dfrac{0.016}{1.6\times10^{-19}} = 10^{17} e^-$

for every 100 $e^-(s)$ 1 photon is produced

$\Rightarrow$ No. of X-ray photons $= \dfrac{10^{17}}{100} = 10^{15}$

**16.** **(d)** Power available from X-ray tube is :

$P = VI = 50000 \times 0.016$

$P = 800$ Watt

Since efficiency of X-rays production is 1% therefore 99% of available power is converted into heat

$P_{heat} = 0.99 \times 800$ W $= 99 \times 8$ W

$P_{heat} = 792$ W

**17.** **(a)** $\Delta E = W_0 + E$ ; $(E_k) = \Delta E - W_0$

For maximum value of $(E_k)$, $W_0$ should be minimum

$W_0$ for lithium $= 2.3$ eV

$\therefore$ $(E_k) = 2.75 - 2.3 = 0.45$ eV

**18.** **(c)** The maximum magnitude of stopping potential will be for metal of least work function.

$\therefore$ required stopping potential is

$$V_s = \frac{h\nu - \phi_0}{e} = 0.45 \text{ volt.}$$

**19.** **A→p, r; B→q, s; C→s; D→p, r**

**20.** **A → p, B → r, C→ q, D → s**