CPP-09
SS JEE(M) & ADVANCED

Physics

Chapterwise Practise Problems (CPP) for JEE (Main & Advanced)

Chapter - Dual Nature of Radiation & Matter and Atoms

Level-1

SECTION - A

Straight Objective Type

This section contains multiple choice questions. Each question has 4 choices (A), (B), (C) and (D) for its answer, out of which **ONLY ONE** is correct.

1. A K_α transition photon emitted by one hydrogen atom strikes a second hydrogen atom in ground state and undergoes photoelectric absorption with an L shell electron. What energy does the ejected electron have?

(A) 13.6 eV (B) 10.2 eV
(C) 3.4 eV (D) 6.8 eV

2. A small particle of mass m moves in such a way that the potential energy $U = \frac{1}{2}mw^2r^2$ where w is constant and r is the distance of the particle from the origin. Assume Bohr's model of quantization of angular momentum and circular orbits. Find the radius of the n^{th} allowed orbit.

(A) $r = \left[\frac{nh}{2\pi mw}\right]^{1/2}$ (B) $r = \left[\frac{n^2h}{2\pi mw}\right]^{1/2}$
(C) $r = \left[\frac{nh^2}{2\pi mw}\right]^{1/2}$ (D) $r = \left[\frac{nh}{4\pi^2 mw}\right]^{1/2}$

3. Two non relativistic small particles (which are not moving with the speed close to the speed of light) x_1 and x_2 have de-Broglie wavelengths 30Å and 20Å respectively, combined to form a small particle x_3 with mass equal to sum of masses of x_1 and x_2. The de-Broglie wavelength of particle x_3 can not be

(A) 60 Å (B) 12 Å
(C) 20 Å (D) 80 Å

4. A beam of light has three wavelengths 4144Å, 4972Å, 6216Å with a total intensity of 3.6×10^{-3} W/m^2 equally distributed amongst the three wavelengths. The beam falls normally on 1 cm^2 of a clean metallic surface of work function 2.3 eV. The number of photoelectrons liberated in 2 s is closest to(assume every capable photon ejects an electron)

(A) 11×10^{11} (B) 8×10^{11}
(C) 5×10^{11} (D) 2×10^{11}

5. Radius of nucleus is given by the relation $R = R_oA^{\frac{1}{3}}$ where $R_0 = 1.3\times10^{-15}$ m and A is mass number. For a nucleon inside a nucleus, de-Broglie wavelength is given by the diameter of the nucleus. Average kinetic energy of a nucleon in the nucleus based on above information will be proportional to

(A) $\frac{1}{R_0^2A^{5/4}}$ (B) $\frac{1}{R_0^2A^{5/2}}$
(C) $\frac{1}{R_0^2A^{5/3}}$ (D) $\frac{1}{R_0A^{4/3}}$

6. A spherical ball of mass m and radius r is dropped in air of coefficient of viscosity η. The de-Broglie wavelength of ball when it is moving with terminal speed is (Neglect the force of buoyancy)

(A) $\frac{6\pi h\eta}{m^2g}$ (B) $\frac{6\pi h\eta r}{mg}$
(C) $\frac{6\pi h\eta r}{m^2g}$ (D) $\frac{6\pi h^2\eta r}{m^2g}$

7. A very large metal plate carries a charge of Q = – 1C. The work function for the metal is ϕ = 3 eV. The plate is illuminated by a 60 Watt light source with a wavelength λ of 330nm. How long does it take to completely discharge the plate ? (Assume that every efficient photon ejects electron which is instantly removed from the sheet surface. (All photons ejected from light source fall normally on the metal plate)

(A) 0.625 s (B) 0.0625 s
(C) 6.25 s (D) 0.00625 s

8. The electron in a H – atom makes a transition from $n_1 \to n_2$ where n_1 and n_2 are the principal quantum number of the states. Assume Bohr's model to be valid. The time period of the electron in initial state is 27 times that in final state. Find the possible value of n_1 and n_2

(A) 1-2, 2-4, 3-6, 4-8, 5-10

(B) 1-3, 2-6, 3-9

(C) 2-4, 4-8, 8-16

(D) None

9. When the voltage applied to an X-ray tube is increased 1.5 times, the minimum wavelength of the continuous X-ray spectrum shifts by 26 pm. Find the initial voltage applied to the tube (approx)

(A) 16 kV (B) 20 kV

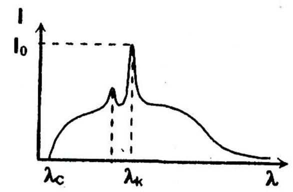
(C) 22 kV (D) 26 kV

SECTION - B

Multiple Correct Answer Type

This section contains multiple choice questions. Each question has 4 choices (A), (B), (C) and (D) for its answer, out of which **ONE OR MORE** is/are correct.

10. The intensity of X-rays from coollidge tube is plotted against wavelength λ as shown in the figure. Which of the following statements is/are correct ?



(A) on increasing the Z (atomic number) of target λ_k decreases

(B) on increasing the accelerating voltage of tube $\lambda_k - \lambda_c$ increases

(C) on increasing the power of cathode filament I_0 increases

(D) on increasing the power of cathode, λ_k decreases

11. A hydrogen atom in first excited state is given least energy E_0 so that it can emit 2nd largest wavelength - line in the Balmer series then:

(A) $E_0 \approx 2.05$ eV

(B) $E_0 \approx 2.55$ eV

(C) This atom can give maximum 3 different lines in emission spectrum

(D) This atom can give maximum 6 different lines in emission spectrum

12. If electron of the hydrogen atom is replaced by another particle of same charge but of double the mass, then

(A) Bohr radius will increase

(B) Ionization energy of the atom will be doubled

(C) Speed of the new particle in a given state will be lesser than the electron's speed in same orbit

(D) Gap between energy levels will now be doubled

13. When photons of energy 4.25 eV strike the surface of metal A, the ejected photoelectrons have maximum kinetic energy T_A eV and de-Broglie wavelength λ_A. The maximum kinetic energy of photoelectrons liberated from another metal B by photons of energy 4.70 eV is $T_B = (T_A - 1.5)$ eV. If de-Broglie wavelength of these photoelectrons is $\lambda_B = 2\lambda_A$, then

(A) Work function of A is 2.25 eV

(B) Work function of B is 4.20 eV

(C) $T_A = 2.00$ eV

(D) $T_B = 2.75$ eV

SECTION - C

Linked Comprehension Type

This section contains paragraph. Based upon this paragraph, some multiple choice questions have to be answered. Each question has 4 choices (A), (B), (C) and (D) for its answer, out of which **ONLY ONE OR MORE** is/are correct.

Paragraph for Question Nos. 14 to 16

If energy in the ground state is taken as zero then the energy levels of the tungsten atom with an electron knocked out are as follows :

Shell containing vacancy	K	L	M
Energy in KeV	69.5	11.3	2.3

14. The minimum value of the accelerating potential that can result in the production of all the characteristic K_α, K_β lines of tungsten, is

(A) 69.5 kV (B) 67.2 kV

(C) 58.2 kV (D) 2.3 kV

15. For this same accelerating potential, what is the value of minimum wavelength as observed in the continuous X-rays ?

(A) 18.5 pm (B) 17.8 pm

(C) 14.6 pm (D) 10.8 pm

16. The wavelength of the characteristic K_β X-rays will be

(A) 21.3 pm (B) 20.8 pm
(C) 18.5 pm (D) 16.2 pm

SECTION-D

Matrix-Match Type

This **Section D** have "match the following" type question. Question contains two columns, **Col-I** and **Col-II**. Match the entries in **Col-I** with the entries in **Col-II**. One or more entries in **Col-I** may match with one or more entries in **Col-II**.

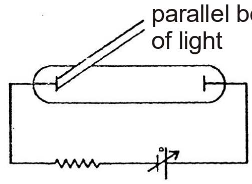
17. An electron in a hydrogen atom makes a transition $n_1 \rightarrow n_2$, where n_1, where n_1 and n_2 are the principal quantum numbers of the two states. Assume Bohr model to be valid.

Column I	Column II
(A) The electron emits an energy of 2.55 eV	(p) $n_1 = 2, n_2 = 1$
(B) Time period of the electron in the initial state is eight time that in the final state	(q) $n_1 = 4, n_2 = 2$
(C) Speed of electron become two times	(r) $n_1 = 5, n_2 = 3$
(D) Radius of orbit of electron becomes 4.77Å	
	(t) $n_1 = 8, n_2 = 4$

18. An electron in hydrogen atom moves from n = 1 to n = 2. Match the following

Column I	Column II
(A) Angular momentum	(p) One times
(B) Kinetic energy	(q) Two times
(C) Magnitude of potential energy	(r) Four times
(D) Total energy	(s) Half
	(t) One-fourth

19. In the shown experimental setup to study photoelectric effect, two conducting electrodes are enclosed in an evacuated glass-tube as shown. A parallel beam of monochromatic light, falls on photosensitive electrodes. The emf of battery shown is high enough such that all photoelectons ejected from left electrode will reach the right electrode. Under initial conditions photoelectrons are emitted. As changes are made in each situation of column I. Match the statements in column I with results in column II



Column I	Column II
(A) If frequency of incident light is increased keeping its intensity constant	(p) magnitude of stopping potential will increase
(B) If frequency of incident light is increased and its intensity is halved	(q) current through circuit may stop
(C) If work function of photo sensitive electrode is increased, keeping frequencyof incident light constant	(r) maximum kinetic energy of ejected photoelectrons will increase
(D) If intensity of incident light is increased	(s) saturation current will increase keeping its frequency constant

SECTION-E

Integer Answer Type

This section contains Integer type questions. The answer to each of the questions is an integer.

20. A metal surface has work function 1.1 eV. Photon of wavelength 6200 Å is absorbed by an electron which makes a collision with lattice before coming to surface. It is observed that if it comes out with kinetic energy 0.4 eV then percentage loss of kinetic energy during collision with lattice is 5x% (approximately). Then find x.

21. A gas containing hydrogen like ions with atomic no Z, emits photons in transition $n + 2 \rightarrow n$, where n = Z. These photons fall on a metallic plate and eject electrons having minimum de-Broglie wavelength λ of 2060Å. Find the value of 'Z' if the work function of metal is 4.2 eV.

22. When the voltage applied to an X-ray tube increased from V_1 = 15.5 kV to V_2 = 31 kV, the wavelength interval between the K_α line and the short wavelength cut-off of the continuous X-ray spectrum increases by a factor of 1.3. The atomic number of the element of the target is Z. Find Z–16. (Take: Rhe = 13.6 eV nm and R = 1 × 10^7/m)

23. A metal surface has work function 1.2 eV. Photon of wavelength 6200 Å is absorbed by an electron which makes a collision with lattice before coming to surface. If it is observed that it comes out with kinetic energy 0.4 eV then percentage loss of kinetic energy during collision with lattice is x% (approximately). Then find $\frac{x}{10}$.

24. Light of intensity I is incident on a fixed plane surface at an angle 30° with the surface. If 50% light is reflected and remaining light is absorbed then radiation pressure on the plate is $\frac{3I}{nc}$, then find n(speed of light is c)

25. Moseley plot for K_α – X-ray has $\sqrt{f}$ in the vertical axis and Z in the horizontal axis. If Moseley equation is given by $\sqrt{f} = a(Z-b)$. If constants 'a' is given by (approximately) 5 × 10^P $Hz^{1/2}$ then, find the value of 'P'.

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SECTION - A

Straight Objective Type

This section contains multiple choice questions. Each question has 4 choices (A), (B), (C) and (D) for its answer, out of which **ONLY ONE** is correct.

1. An α-particle in ground state with a kinetic energy of 2.1 eV makes head on collision with a hydrogen in ground state atom moving towards it with a kinetic energy 8.4 eV. The collision

(A) must be elastic

(B) may be perfectly inelastic (i.e. both the colliding objects stick together)

(C) may be elastic

(D) must be perfectly inelastic

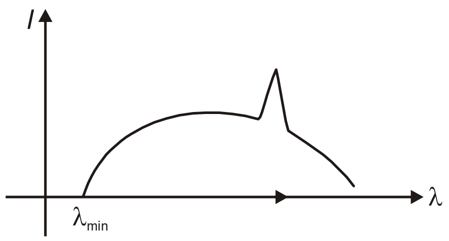
2. An electron in hypothetical hydrogen atom is in its 3rd excited state and makes transition from 3rd to 2nd excited, then to 1st excited state and then to ground state. If the amount of time spent by the electron in any state of quantum number n, is proportional to $\left(\frac{1}{n-1}\right)$, then the ratio of number of revolutions completed by the electron in 1st excited state to that in the 2nd excited state will be

(A) 2 (B) $\frac{27}{8}$

(C) $\frac{27}{4}$ (D) $\frac{27}{6}$

3. An x-ray tube has three main controls

(i) the target material (its atomic number Z)



(ii) the filament current (I_f) and

(iii) the acceleration voltage (V)

Figure shown a typical intensity distribution against wavelength. Which of the following is incorrect?

(A) The limit λ_{min} is proportional to V^{-1}

(B) The sharp peak shifts to the right as Z in increased

(C) the penetrating power of X ray increases if V is increased

(D) The intensity everywhere increases if filament current I_f is increased

4. In an X-ray set up accelerating potential difference is set at V volt and first a target metal having atomic number. Z_1 is used then target metal having atomic number Z_2 is used λ_{α_1} is wavelength of K_α X-ray from Z_1 target and λ_{α_2} is wavelength of K_α X-ray with Z_2 target (λ_{min} is the cut off wavelength)

(A) If $Z_1 > Z_2$ then $\left(\lambda_{\alpha_1} - \lambda_{min}\right) > \left(\lambda_{\alpha_2} - \lambda_{min}\right)$

(B) If $Z_1 < Z_2$ then $\left(\lambda_{\alpha_1} - \lambda_{min}\right) > \left(\lambda_{\alpha_2} - \lambda_{min}\right)$

(C) The difference $\left(\lambda_{\alpha_1} - \lambda_{min}\right)$ and $\left(\lambda_{\alpha_2} - \lambda_{min}\right)$ will be same for both the target metals.

(D) None of these

SECTION - B

Multiple Correct Answer Type

This section contains multiple choice questions. Each question has 4 choices (A), (B), (C) and (D) for its answer, out of which **ONE OR MORE** is/are correct.

5. Consider white light whose wavelength spread is from 400 nm to 700 nm. Its energy is uniformly distributed in this spectrum $\left(\text{i.e. } \frac{dE}{d\lambda} = \text{constant where } dE \text{ is the energy of the photons wavelengths between } \lambda \text{ and } \lambda + d\lambda\right)$.

The light is incident on a metal A of work function

1.55 eV. Saturation photo current is 6mA. Now the same light is incident on metal B of work function 2.48 eV. Choose the correct options [Take hc = 1240 eV nm. Assume photo efficiency remains same]

(A) Stopping potential for experiment with metal A is 0.22 V

(B) Stopping potential for experiment with metal B is 0.62 V

(C) Saturation photo current for metal B will be 2 mA

(D) Saturation photo current for metal B will be $\frac{18}{11}$ mA

SECTION - C

Linked Comprehension Type

This section contains paragraph. Based upon this paragraph, some multiple choice questions have to be answered. Each question has 4 choices (A), (B), (C) and (D) for its answer, out of which **ONLY ONE OR MORE** is/ are correct.

Paragraph for Question Nos. 6 and 7

A light of wavelength λ is incident on a metal sheet of work function $\phi = 2$ eV. The wavelength λ varies with time as $\lambda = 3000 + 40t$, where λ is in Å and t is in second. The power incident on metal sheet is constant at 100 W. This signal is switched on and off for time intervals of 2 minutes and 1 minute respectively. Each time the signal is swtched on, the λ start from initial value of 3000 Å. The metal plate is grounded and electron clouding is negligible. The efficiency of photoemission is 1% (hc = 12400 eVÅ).

6. The time after which photoemission will stop in each cycle is

(A) 79 s (B) 80 s

(C) 81 s (D) 78 s

7. The total number of photoelectrons ejected in one hour is

(A) 3.71×10^{20} (B) 3.71×10^{21}

(C) 3.71×10^{22} (D) 3.71×10^{23}

Paragraph for Question Nos. 8 to 10

In a hypothetical positronium atom (attraction between positron and electron binds them) magnitude of linear momentum of each is quantized in the integral steps of $b_0h/2\pi$ (where b_0 is a +ve constant)

8. Energy of atom in nth orbit is proportional to

(A) n (B) n^2

(C) 1/n (D) $1/n^2$

9. Energy of atom in ground state will be

(A) $-\frac{b_0^2h^2}{16\pi^2m}$ (B) $-\frac{-b_0^2h^2}{2\pi^2m}$

(C) $-\frac{b_0^2h^2}{4\pi^2m}$ (D) $-\frac{b_0^2h^2}{9\pi^2m}$

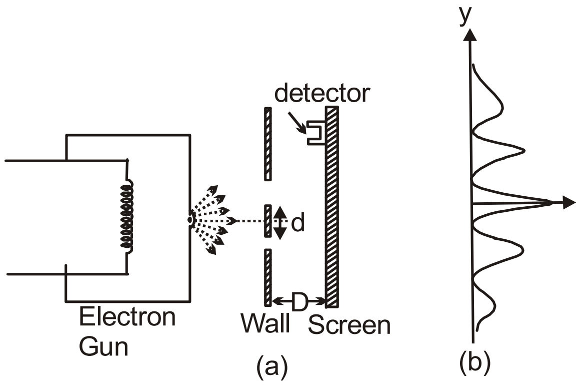
10. Magnetic moment of the electron in nth quantum state will be proportional to

(A) n (B) n^2

(C) 1/n (D) $1/n^2$

Paragraph for Question Nos. 11 to 13

Let us do the Young's double slit experiment with electron rather than light waves. We make an electron gun which consists of a tungsten wire heated by an electric current and surrounded by a metal box with a hole in it. If the wire is at negative potential with respect to the box, electron emitted by the wire (thermionic emission) will be accelerated towards the walls and same will pass through the hole. All the electrons coming out of this gun will have the same energy, qV. In front of gun there is a wall with two slits in it as shown Beyond the wall there is another plate which acts as a screen. The number of electrons arriving at the screen per unit area per unit time can be measured. When the graph of this is plotted with y coordinates on the screen, we obtain the graph as seen in YDSE experiment. This can be explained using de-Broglie's hypothesis which states that electrons also behave like waves



11. What is the wavelength of electrons in terms of other parameters ?.

(A) $\frac{h}{\sqrt{mqV}}$ (B) $\frac{2h}{\sqrt{mqV}}$

(C) $\frac{h}{\sqrt{2mqV}}$ (D) $\frac{h}{\sqrt{4mqV}}$

12. Which of following would increase fringe width, assuming that λ << slit width ?

(A) Increase temperature of wire

(B) Decrease D

(C) Increase d

(D) Decrease voltage V

13. Suppose we go on increasing the voltage from a very low value. Beyond a certain voltage, we obtain 3 maxima on the screen. What is the minimum voltage ?

(A) $\frac{h^2}{2mqd^2}$ (B) $\frac{5h^2}{2mqd^2}$

(C) $\frac{9h^2}{2mqd^2}$ (D) $\frac{7h^2}{2mqd^2}$

SECTION-E

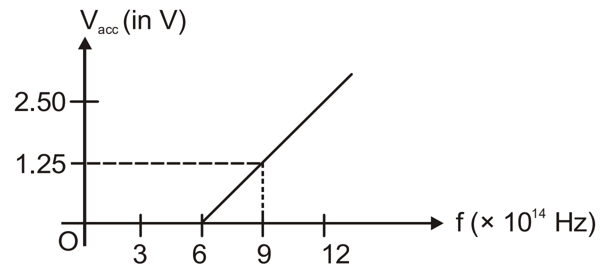
Integer Answer Type

This section contains Integer type questions. The answer to each of the questions is an integer.

14. A μ meson particle moves in a circular orbit around a nucleus of charge +3e. Assuming Bohr's model is applicable to this system. The wavelength of radiation emitted in picometer is 11 K, when μ-meson jumps from 3rd orbit to 1st orbit. [μ meson is a particle, whose charge is equal to that of an electron and mass = 208 times that of an electron]. Find the value of K

15. The peak emission from a black body at a certain temperature occurs at a wavelength of 6200Å. On increasing its temperature, the total radiation emitted is increased 16 times. These radiations are allowed to fall on a metal surface. Photoelectrons emitted by the peak radiation at higher temperature can be brought to rest by applying a potential equivalent to the excitation potential corresponding to the transition for the level n = 4 to n = 2 in the Bohr's hydrogen atom. The work function of the metal is given by $\frac{\alpha}{100}$ eV where α is the numerical constant. Find the value of α

16. Figure shows the stopping potential versus the light frequency for a metal cathode used in photoelectric-effect experiment. Suppose this cathode is now illuminated with 6.63 μW of 300 nm light and that the efficiency of converting photons to photoelectrons is 10%.



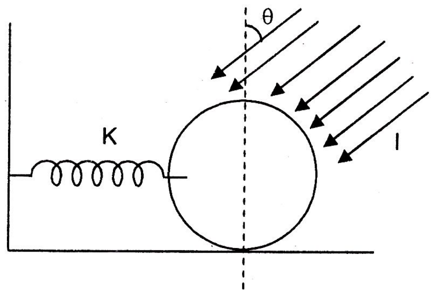
The power (in nano watt) of emitted photoelectron beam assuming that on an average, each photoelectron emitted has energy $\frac{5K_{max}}{6}$ is x. Assume that anode potential is sufficiently positive. Find x.

17. Atoms of a hydrogen like gas are in a particular excited energy level. When these atoms de-excite they emit photons of different energies. Maximum and minimum energies of emitted photons are E_{max} = 52.24 eV and E_{min} = 1.24 eV respectively. Calculate the principal quantum number of initially excited level. (Ionisation energy of hydrogen atom = 13.6 eV)

18. Electrons in a hydrogen like atom (Z = 3) make transitions from the fourth excited state to the third excited state and from the third excited state to the second excited state. The resulting radiations are incident on a metal plate to eject photoelectrons. The stopping potential for photoelectrons ejected by shorter wavelength is 3.996 V. If the stopping potential for the photoelectrons ejected by the longer wavelength is $N\times10^{-1}$ V, then find N (Take energy of the hydrogen atom in ground state as –13.6 eV)

19. A sphere of radius R is kept on smooth horizontal surface. It is connected with ideal spring of constant k as shown in figure. A parallel light beam having intensity I is falling at an angle θ =30° with vertical on the sphere. Then find the compression in the spring (in CGS unit) in equilibrium position, assuming the surface at the sphere absorbs 100% of the light incident on it.

[Take $\frac{IR^2}{Kc}=\frac{1}{10\pi}$ SI unit, where c is speed of light in vacuum]



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ANSWERS

LEVEL-1

1. (D)	2. (A)	3. (D)	4. (A)	5. (C)	6. (C)
7. (B)	8. (B)	9. (A)	10. (A,B,C)	11. (B,D)	12. (B,D)
13. (A,B,C)	14. (A)	15. (B)	16. (C)	17. (A-q, B-p,q,s,t C-p,q,s,t D-r,s)	
18. (A-q, B-t, C-t, D-t)	19. (A-p,r B-p,r C-q, D-s)		20. (11)	21. (2)	22. (9)
23. (5)	24. (4)	25. (7)			

LEVEL-2

1. (A)	2. (C)	3. (B)	4. (B)	5. (B,D)	6. (B)
7. (B)	8. (B)	9. (C)	10. (C)	11. (C)	12. (D)
13. (A)	14. (5)	15. (145)	16. (218)	17. (5)	18. (8)
19. (5)					

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