Octahedron institute, chandan nagar

office no 2, 1st floor chandan complex

Class 12 - Physics

DUAL NATURE OF MATTER

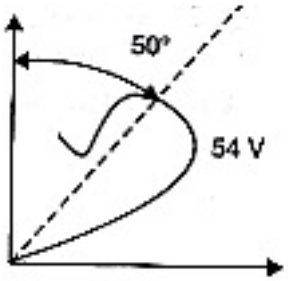
Maximum Marks: 95 **Time Allowed: 2 hours**

General Instructions:

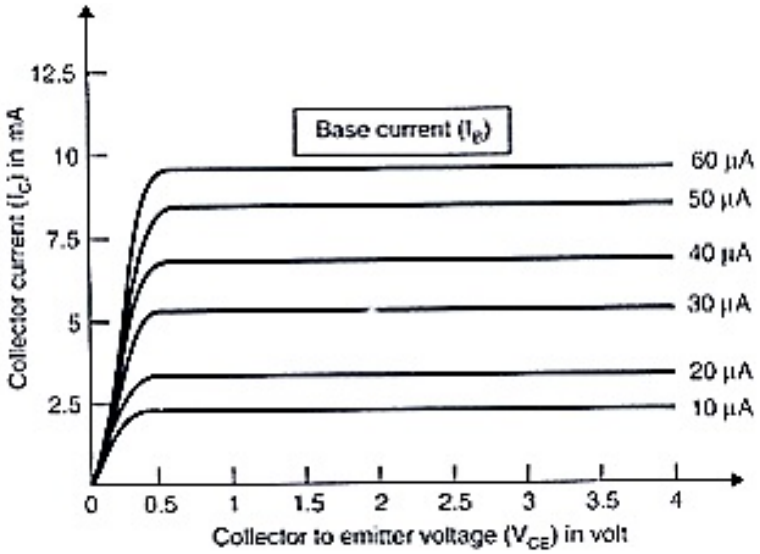
ANSWER ALL QUESTIONS

Section A

1. How will the photoelectric current change on decreasing the wavelength of incident radiation for a given photosensitive material? **2**
2. The threshold frequency for a certain metal is $3.3 \times 10^{14} Hz$. If light of frequency $8.2 \times 10^{-14} Hz$ is incident on the metal predict the cut-off voltage for the photoelectric emission. **2**
3. A 100 W sodium lamp radius energy uniformly in all directions. The lamp is located at the centre of a large sphere that absorbs all the sodium light which is incident on it. The wavelength of the sodium light is 589 nm. **2**
   a. What is the energy per photon associated with the sodium light?
   b. At what rate are the photons delivered to the sphere?
4. In an experiment on photoelectric effect, the slope of the cut-off voltage versus frequency of incident light is found to be $4.12 \times 10^{-15} Vs$. Calculate the value of Planck's constant. **2**
5. Why should gases be insulators at ordinary pressures and start conducting at very low pressures? **2**
6. What is the difference between thermionic emission and photoelectric emission? **2**
7. The work function for a certain metal is 4.2 eV. Will this metal give photoelectric emission for incident radiation of wavelength 330 nm? **2**
8. Why are alkali metals most suited for photoelectric emission? **2**
9. Name the experiment for which the following graph, showing the variation of intensity of scattered electrons with the angle of scattering, was obtained. Also, name the important hypothesis that was confirmed by this experiment. **2**



10. Plot a graph showing the variation of photoelectric current with anode potential for two light beam of same wavelength but different intensity. **2**
11. Find the(a) maximum frequency, and (b) minimum wavelength of X-rays produced by 30 kV electrons. **2**
12. Quarks inside protons and neutrons are thought to carry fractional charges $\left[\left(+\frac{2}{3}\right)e\left(-\frac{1}{3}e\right)\right]$ [(+ 2/3) e (-1/3 e)]. Why do they not show up in Millikan's oil drop experiment? **2**
13. Show graphically how the stopping potential for a given photosensitive surface varies with the frequency of the incident radiation. **2**
14. The work function of caesium metal is 2.14 eV. When light of frequency $6 \times 10^{14} Hz$ is incident on the metal surface, photoemission of electrons occurs. What is the **2**
    a. maximum kinetic energy of the emitted electrons,
    b. stopping potential, and
    c. maximum speed of the emitted photoelectrons?
15. Mention the significance of Davission and Germer's experiment. An α- particle and a proton are accelerated from rest through the same potential difference V. Find the ratio of de-Broglie wavelengths associated with them. **3**
16. From the output characteristics shown in figure calculate the values of current amplification factor of the transistor when V_{CE} is 2V. **3**



17. The following graph shown the variation of stopping potential $V_0$with the frequency ν of the incident radiation for two photosensitive metals P and Q. **3**
    i. Explain which metal has smaller threshold wavelengths.
    ii. Explain, giving reason, which metal emits photoelectrons having smaller kinetic energy.
    iii. If the distance between the light source and metal P is doubled, how will the stopping potential change?
18. A nucleus of mass M initially at rest splits into two fragments of masses m/3 and 2m/3. Find the ratio of de-Broglie wavelength of the two fragments. **3**
19. An electron and alpha particle have the same deBroglie wavelength associated with them. How are their kinetic energies related to each other? **3**
20. Find the de-Broglie wavelengths of (a) a 46-g golf ball with a velocity of 30 m.s, and (b) an electron with a velocity of 10^7 m/s. **3**
21. The wavelength of a probe is roughly a measure of the size of a structure that it can probe in some detail. The quark structure of protons and neutrons appears at the minute length scale of 10^{-15} m or less. This structure was first probed in early 1970's using high energy electron beams produced by a linear accelerator at Stanford, USA. Guess what might have been the order of energy of these electron beams. (Rest mass energy of electron = 0.511 MeV) **3**
22. For what kinetic energy of a proton, will the associated de-Broglie wavelength be 16.5 nm? **3**
23. Compute the typical de-Broglie wavelength of an electron in a metal at 27°C and **3**

compare it with the mean separation between two electrons in a metal which is given to be about $2 \times 10^{-10} m$.

24. Sketch the graphs showing the variation of stopping potential with frequency of incident radiations for two photosensitive materials A and B having threshold frequencies $\nu_0' > \nu_0$ respectively: **3**
    i. Which of the two metals, A or B has higher work function?
    ii. What information do you get from the slope of the graphs?
    iii. What does the value of intercept of graph 'A' on the potential axis represent?
25. Monochromatic light of wavelength 632.8 nm is produced by a helium neon laser. The power emitted is 9.42 mW. **3**
    a. Find the energy and momentum of each photon in the light beam.
    b. How many photons per second, on the average, arrive at a target irradiated by this beam? (assume the beam to have uniform cross-section which is less than the target area), and
    c. How fast does a hydrogen atom have to travel in order to have the same momentum as that of the photon?
26. An electron and a proton are accelerated through the same potential. Which one of the two has (i) greater value of de-Broglie wavelength associated with it and (ii) less momentum? **3**
27. Explain.Given $m_n = 1.675 \times 10^{-27} kg$(b) Obtain the de-Broglie wavelength associated with thermal neutrons at room temperature (27°C). Hence explain why a fast neutron beam needs to be thermalised with the environment before it can be used for neutron diffraction experiments. **3**
28. Calculate de-Broglie wavelength in nm associated with a ball of mass 66 g moving with a velocity $2.5 \times 10^5 ms^{-1}$. Given $h = 6.6 \times 10^{-34} Js$. **3**
29. A proton and an alpha particle are accelerated through the same potential. Which one of the two has (i) greater value of de-Broglie wavelength associated with it, and (ii) less kinetic energy? **3**
30. The wavelength of light in the visible region is about 390 nm for violet colour, about 550 nm (average wavelength) for yellow-green colour and about 760 nm for red colour.What are the energies of photons in (eV) at the **3**
    i. violet and

ii. average wavelength, yellow-green colour, and

iii. red end of the visible spectrum? (Take h $6.63 \times 10^{-34} Js$ and 1eV $= 1.6 \times 10^{19} J$)

31. The fission properties of $^{239}_{94}Pu$ are very similar to those of $^{235}_{92}U$. The average energy released per fission is 180 MeV. How much energy, in MeV, is released if all the atoms in 1 kg of pure $^{239}_{94}Pu$ undergo fission? **3**

32. The work function for the following metals is given: Na : 2.75 eV K : 2.30 eV M_0 4.17 eV Ni : 5.15 eV, Which of these metals will not give photoelectric emission for a radiation of wavelength $3300 \overset{o}{A}$ from a He-Cd laser placed 1m away from the photocell? What happens if the laser is brought nearer and placed 50 cm away? **3**

33. Radiations of frequency 10^{15}Hz are incident on two photosensitive surfaces A and B. Following observations are recorded:Surface A : No photoemission takes place.Surface B : Photoemission takes place but photoelectrons have zero energy. Explain the above observations on the basis of Einsteins photoelectric equation.How will the observation with surface B change when the wavelength of incident radiations is decreased? **3**

34. For a CE-transistor amplifier, the audio signal voltage across the collector resistance of $2K\Omega$ is 2V. If the current amplification factor of the transistor is 100, Calculate: **5**

(i) input signal voltage

(ii) base current. Given that the value of the base resistance is $1K\Omega$.

35. Why are de-Broglie waves associated with a moving football not visible?The wavelength λ, of a photon and the de-Broglie wavelength of an electron have the same value. Show that the energy of the photon is $\frac{2\lambda mc}{h}$ times the kinetic energy of the electron, where m, c and h have their usual meanings for electron. **5**