

Physics (Theory)

[Time allowed: 3 hours]

[Maximum marks:70]

General Instructions:

(i) **All** questions are compulsory.

(ii) There are **30** questions in total.

Questions **1** to **8** carry **one** mark each.

Questions **9** to **18** carry **two** marks each.

Question **19** to **27** carry **three** marks each.

Question **28** to **30** carry **five** marks each.

(iii) There is no overall choice. However, an internal choice has been provided in **one** question of **two** marks; **one** question of **three** marks and all **three** questions of **five** marks each. You have to attempt only one of the choices in such questions.

(iv) Use of calculators is **not** permitted.

(v) You may use the following values of physical constants wherever necessary:

$$c = 3 \times 10^8 \text{ ms}^{-1}$$

$$h = 6.626 \times 10^{-34} \text{ Js}$$

$$e = 1.602 \times 10^{-19} \text{ C}$$

$$\mu_0 = 4\pi \times 10^{-7} \text{ Tm A}^{-1}$$

$$\frac{1}{4\pi\epsilon_0} = 9 \times 10^9 \text{ Nm}^2\text{C}^{-2}$$

$$\text{Mass of electron } m_e = 9.1 \times 10^{-31} \text{ kg}$$

$$\text{Mass of neutron } m_n \cong 1.675 \times 10^{-27} \text{ kg}$$

$$\text{Boltzmann's constant } k = 1.381 \times 10^{-23} \text{ JK}^{-1}$$

$$\text{Avogadro's number } N_A = 6.022 \times 10^{23} \text{ mol}^{-1}$$

$$\text{Radius of earth} = 6400 \text{ km}$$

1. A hollow metal sphere of radius 10 cm is charged such that the potential on its surface is 5 V. What is the potential at the centre of the sphere?

Solution:

We know

$$E = -\frac{dv}{dr} \text{ and for hollow shell electric field at center} = 0$$

$$\Rightarrow -\frac{dv}{dr} = 0 \Rightarrow dv = 0$$

Hence $V_c = 5V$

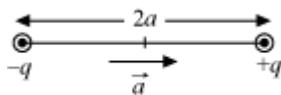
2. How are X-rays produced?

Solution:

X-rays are produced when inside a vacuum tube high energy electrons emitted by the cathode collides with the anode (usually made of tungsten, copper, etc.)

3. Define electric dipole moment. Write its S.I. unit.

Solution:



Electric dipole moment is the product of the magnitude of the either charge and the distance between the charges (this distance is also called the displacement vector). It is a vector quantity with direction pointing from the negative charge to the positive charge. SI unit of electric dipole moment is coulomb meter (Cm).

4. Where on the surface of Earth is the angle of dip zero?

Solution:

At equator the angle of dip of a magnetic compass is zero.

5. Define the term 'stopping potential' in relation to photo-electric effect.

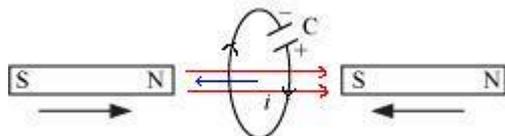
Solution:

If we increase the negative potential of the collector, the photoelectric current decreases rapidly. At a certain critical value of the negative potential of the collector, the photoelectric current becomes zero. This potential is called stopping potential or cut-off potential and it depends on the frequency of the incident radiation, but independent of its intensity.

6. Two bar magnets are quickly moved towards a metallic loop connected across a capacitor 'C' as shown in the figure. Predict the polarity of the capacitor.



Solution:



Red lines represent the magnetic lines due to the magnets. Blue line represents the magnetic line due to the current induced in the loop.

Polarity of the capacitor: lower plate is positive; upper plate is negative.

7. Write any two characteristic properties of nuclear force.

Solution:

Characteristic properties of nuclear force are

- (i) It does not depend on the electric charge.
- (ii) It is the strongest force in nature.
- (iii) It is a very short range force.
- (iv) The nuclear force is only felt among hadrons. At much smaller separations between nucleons the force is very powerfully repulsive, which keeps the nucleons at a certain average separation. Beyond about 1.7 femtometer (fm) separation, the force drops to negligibly small values.

[Note: Writing any two properties will be sufficient]

8. What happens to the width of depletion layer of a p-n junction when it is (i) forward biased, (ii) reverse biased?

Solution:

- (i) In forward bias, the width of the depletion layer decreases.
- (ii) In reverse bias, the width of the depletion layer increases.