

# The Physics Cook Book - 2nd Edition

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# Contents



# Physics (Theory) - Electric Charges and Fields (CBSE)

Time allowed : 2 hours \_\_\_\_\_ Maximum Marks : 41

## Instructions

1. Please check that this question paper contains 3 printed pages.
2. Please check that this question paper contains 19 questions.
3. 10 minutes time has been allotted to read this question paper. The student will read the question paper only and will not write any answer on the answer script during this period.

## A. General Instructions :

1. All questions are compulsory.
2. There are 18 questions in total. Questions 1 to 6 carry one mark each, questions 7 to 11 carry two marks each, questions 12 to 16 carry three marks each and questions 17 to 18 carry five marks each.
3. Use of calculators is not permitted.
4. You may use the following values of physical constants wherever necessary:

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

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

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

$$\mu_o = 4\pi \times 10^{-7} TmA^{-1}$$

$$\epsilon_o = 8.854 \times 10^{-12} C^2N^{-1}m^{-2}$$

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

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

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

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

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

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

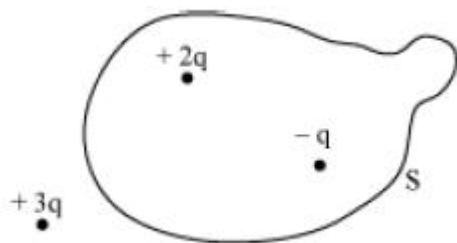
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## Section - A

**Q1:** Why is it necessary that the field lines from a point charge placed in the vicinity of a conductor must be normal to the surface of the conductor at every point ?

**Q2:** Is the force acting between two point electric charges  $q_1$  and  $q_2$  kept at some distance apart in air, attractive or repulsive when (i)  $q_1 q_2 > 0$  (ii)  $q_1 q_2 < 0$  ?

**Q3:** Figure shows three point charges  $+2q$ ,  $-q$  and  $+3q$ . Two charges  $+2q$  and  $-q$  are enclosed within a surface 'S'. What is the electric flux due to this configuration through the surface 'S'?



**Q4:** In which orientation, a dipole placed in a uniform electric field is in (i) stable, (ii) unstable equilibrium?

**Q5:** An electric dipole of dipole moment  $20 \times 10^{-6} \text{ C.m}$  is enclosed by a closed surface. What is the net flux coming out of the surface ?

**Q6:** An electrostatic field line cannot be discontinuous. Why ?

**For Questions 13 to 16, two statements are given - one labelled Assertion (A) and other labelled (R). Select the correct answer to these questions from the options as given below.**

(A) If both Assertion (A) and Reason (R) are true, and Reason (R) is the correct explanation of Assertion (A).

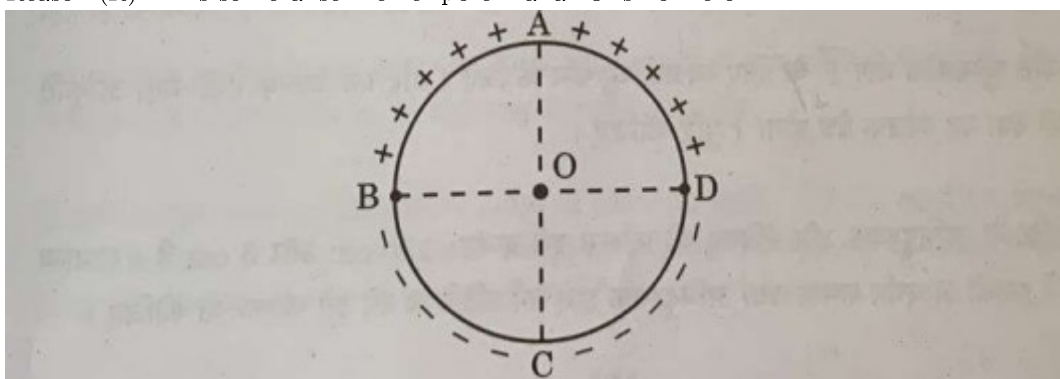
(B) If both Assertion (A) and Reason (R) are true, and Reason (R) is not the correct explanation of Assertion (A).

(C) If Assertion (A) is true but Reason (R) is false.

(D) If both Assertion (A) and Reason (R) are false.

**Q1:** Assertion (A) : Equal amount of positive and negative charges are distributed uniformly on two halves of a thin circular ring as shown in figure. The resultant electric field at the centre O of the ring is along OC.

Reason (R) : It is so because the net potential at O is not zero.



## Section B

**Q7:** Define Electric Flux. Write its S.I. Unit.

**Q8:** The sum of two point charges is  $7\mu\text{C}$ . They repel each other with a force of 1 N when kept 30 cm apart in free space. Calculate the value of each charge.

**Q9:** The electric field  $E$  due to a point charge at any point near it is defined as  $\lim_{q \rightarrow 0} \left( \frac{\mathbf{F}}{q} \right)$  where  $q$  is the test charge and  $\mathbf{F}$  is the force acting on it. What is the physical significance of  $\lim_{q \rightarrow 0}$  in this expression? Draw the electric field lines of a point charge  $Q$  when (i)  $Q > 0$  and (ii)  $Q < 0$ .

**Q10:** A spherical Gaussian surface encloses a charge of  $8.85 \times 10^{-10} C$ . (i) Calculate the electric flux passing through the surface. (ii) How would the flux change if the radius of the Gaussian surface is doubled and why?

**Q11:** Define 'electric line of force' and give its two important properties.

### Section - C

**Q12:** A positive point charge ( $+q$ ) is kept in the vicinity of an uncharged conducting plate. Sketch electric field lines originating from the point on to the surface of the plate. Derive the expression for the electric field at the surface of a charged conductor.

**Q13:** A thin conducting spherical shell of radius  $R$  has charge  $Q$  spread uniformly over its surface. Using Gauss's law, derive an expression for an electric field at a point outside the shell.

Draw a graph of electric field  $\mathbf{E}(r)$  with distance  $r$  from the centre of the shell for  $0 \leq r \leq \infty$ .

**Q14:** Define the term 'electric dipole moment', Is it scalar or vector?

Deduce an expression for the electric field at a point on the equatorial plane of an electric dipole of length  $2a$ .

**Q15:** State Gauss's theorem in electrostatics. Apply this theorem to derive an expression for electric field intensity at a point near an infinitely long straight charged wire.

**Q16:** An electric dipole is held in a uniform electric field. (i) Using suitable diagram, show that it does not undergo any translatory motion, and (ii) derive an expression for the torque acting on it and specify its direction.

**Q :** Four point charges of  $1 \mu C$ ,  $-2 \mu C$ ,  $1 \mu C$  and  $-2 \mu C$  are placed at the corners A, B, C and D respectively, of a square of side 30 cm. Find

### Section D

### Section E

**Q17:** (a) Using Gauss' law, derive an expression for the electric field intensity at any point outside a uniformly charged thin spherical shell of radius  $R$  and charge density  $\sigma C/m^2$ . Draw the field lines when the charge density of the sphere is (i) positive, (ii) negative.

(b) A uniformly charged conducting sphere of 2.5m in diameter has a surface charge density of  $100 mC/m^2$ . Calculate the (i) Charge on the sphere (ii) Total electric flux passing through the sphere.

**Q18:** Define the term dipole moment  $\vec{p}$  of an electric dipole indicating its direction. Write its SI unit. An electric dipole is placed in a uniform electric field  $\vec{E}$ . Deduce the expression for the torque acting on it. In a particular situation, it has its dipole moment aligned with the electric field. Is the equilibrium stable or unstable?