BOARD QUESTION PAPER – 2024 (PHYSICS – 042)

ELECTROSTATICS

SET – 1 (Total 10 marks)

Q.1 Two charges + q each are kept '2a' distance apart. A third charge – 2q is placed midway between them. The potential energy of the system is – **1**

(A) $\frac{q^2}{8\pi\varepsilon_0 a}$ (B) $-\frac{6q^2}{8\pi\varepsilon_0 a}$

(C) $\frac{-7q^2}{8\pi\varepsilon_0 a}$ (D) $\frac{9q^2}{8\pi\varepsilon_0 a}$

Q.2 Two identical small conducting balls B_1 and B_2 are given –7 pC and + 4 pC charges respectively. They are brought in contact with a third identical ball B_3 and then separated. If the final charge on each ball is –2 pC, the initial charge on B_3 was **1**

(A) –2 pC (B) –3 pC

(C) –5 pC (D) –15 pC

Q.3 The electric field in a region is given by

$$\vec{E} = (10x + 4)\hat{i}$$

where x is in m and E is in N/C. Calculate the amount of work done in taking a unit charge from

(i) (5 m, 0) to (10 m, 0)

(ii) (5 m, 0) to (5 m, 10 m) **3**

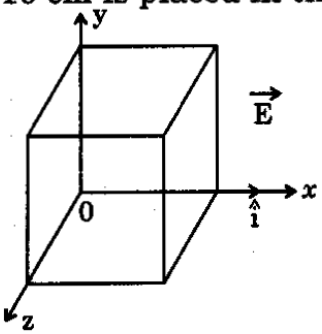
Q.4 (a) (i) A dielectric slab of dielectric constant 'K' and thickness 't' is inserted between plates of a parallel plate capacitor of plate separation d and plate area A. Obtain an expression for its capacitance.

(ii) Two capacitors of different capacitances are connected first (1) in series and then (2) in parallel across a dc source of 100 V. If the total energy stored in the combination in the two cases are 40 mJ and 250 mJ respectively, find the capacitance of the capacitors. **5**

OR

(b) (i) Using Gauss's law, show that the electric field $\vec{E}$ at a point due to a uniformly charged infinite plane sheet is given by $\vec{E} = \frac{\sigma}{2\varepsilon_0}\hat{n}$ where symbols have their usual meanings.

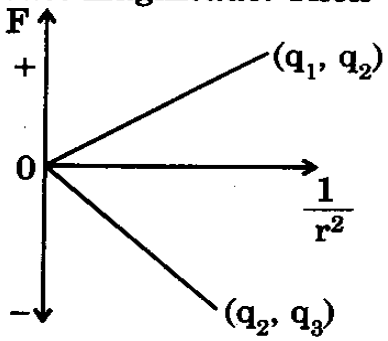
(ii) Electric field $\vec{E}$ in a region is given by
$\vec{E} = (5x^2 + 2)\hat{i}$
where E is in N/C and x is in meters.
A cube of side 10 cm is placed in the region as shown in figure.



Calculate (1) the electric flux through the cube, and (2) the net charge enclosed by the cube. 5

SET – 2

Q.1 The Coulomb force (F) versus $(1/r^2)$ graphs for two pairs of point charges (q_1 and q_2) and (q_2 and q_3) are shown in figure. The charge q_2 is positive and has least magnitude. Then 1



(A) $q_1 > q_2 > q_3$ (B) $q_1 > q_3 > q_2$

(C) $q_3 > q_2 > q_1$ (D) $q_3 > q_1 > q_2$

Q.2 A thin spherical conducting shell of radius R has a charge q. A point charge Q is placed at the centre of the shell. Find (i) The charge density on the outer surface of the shell and (ii) the potential at a distance of (R/2) from the centre of the shell. 3

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Q.1 An electric dipole of dipole moment $\vec{p}$ is kept in a uniform electric field $\vec{E}$. The amount of work done to rotate it from the position of stable equilibrium to that of unstable equilibrium will be **1**

(A) 2 pE
(B) –2 pE
(C) pE
(D) zero

Q.2 An infinite long straight wire having a charge density λ is kept along y'y axis in x-y plane. The Coulomb force on a point charge q at a point P (x, 0) will be **1**

(A) attractive and $\frac{q\lambda}{2\pi\varepsilon_0 x}$
(B) repulsive and $\frac{q\lambda}{2\pi\varepsilon_0 x}$
(C) attractive and $\frac{q\lambda}{\pi\varepsilon_0 x}$
(D) repulsive and $\frac{q\lambda}{\pi\varepsilon_0 x}$

Q.3 Two conducting spherical shells A and B of radii R and 2R are kept far apart and charged to the same charge density σ. They are connected by a wire. Obtain an expression for final potential of shell A. **3**

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Q.7. A charge Q is kept at the centre of a circle of radius r. A test charge q_0 is carried from a point X to the point Y on this circle such that arc XY subtends an angle of 60° at the centre of the circle. The amount of work done in this process will be 2020 Set - 2 *1*

(A) $\frac{1}{4\pi\varepsilon_0}\frac{Qq_0}{2r}$ (B) $\frac{1}{4\pi\varepsilon_0}\frac{\sqrt{3}Qq_0}{2r}$ (C) **Zero** (D) $\frac{1}{4\pi\varepsilon_0}\frac{\sqrt{3}Qq_0}{r}$

Q.8. An electric dipole consisting of charges + q and − q separated by a distance r, is kept symmetrically at the centre of an imaginary sphere of radius R (> r). Another point charge Q is also kept at the centre of the sphere. The net electric flux coming out of the sphere will be 2020 Set - 2 *1*

(A) $\frac{-(2q+Q)}{4\pi\varepsilon_0}$ (B) $\frac{Q}{\varepsilon_0}$ (C) $\frac{2q+Q}{\varepsilon_0}$ (D) $\frac{-Q}{\varepsilon_0}$

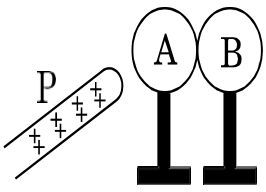
Q.9. Two large conducting spheres carrying charges Q_1 and Q_2 are kept with their centres r distance apart. The magnitude of electrostatic force between them is not exactly $\frac{1}{4\pi\varepsilon_0}\frac{Q_1Q_2}{r^2}$ because 2020 Set - 3 *1*

(A) these are not point charges.
(B) charge distribution on the spheres is not uniform.
(C) charges on spheres will shift towards the centres of their respective spheres.
(D) charges will shift towards the portions of the spheres which are closer and facing towards each other.

Q.10. A charged particle is placed between the two plates of a charged parallel plate capacitor. It experiences a force F. If one plate is removed, then the force on the particle will be *1*

(A) 2F (B) F 2020 Set - 3
(C) $\frac{F}{2}$ (D) Zero

Q.11. Two metallic spheres A and B kept on insulating stands are in contact with each other. A positively charged rod P is brought near the sphere A as shown in the figure. The two spheres are separated from each other, and the rod P is removed. What will be the nature of charges on spheres A and B ?



2020 Set – 1,2,3

Q.12. A metal sphere is kept on an insulating stand.

A negatively charged rod is brought near it, then the sphere is earthed as shown. On removing the earthing, and taking the negatively charged rod away, what will be the nature of charge on the sphere ? Give reason for your answer.