CBSE Pattern Test 1 — Electric Charges and Fields

Maximum Marks: 40 · Time Allowed: 90 minutes

General Instructions: All questions are compulsory. The paper has four sections. Section A : Q1–Q10 carry 1 mark each (choose the correct option). Section B : Q11–Q15 carry 2 marks each. Section C : Q16–Q20 carry 3 marks each. Section D : Q21 carries 5 marks. Internal choice is not offered within a question. Use $\varepsilon_0 = 8.85 \times 10^{-12}\ \mathrm{C^2N^{-1}m^{-2}}$ and $e = 1.6 \times 10^{-19}\ \mathrm{C}$ wherever required.

Section	Questions	Marks each	Total marks
A	Q1–Q10	1	10
B	Q11–Q15	2	10
C	Q16–Q20	3	15
D	Q21	5	5

Section A · Q1 – Q10 (1 mark each)

1. The SI unit of electric charge is

(A) C
(B) ampere
(C) joule
(D) volt

2. One coulomb of charge contains about

(A) $6.25 \times 10^{18} electrons$
(B) $1.6 \times 10^{19} electrons$
(C) $9.1 \times 10^{31} electrons$
(D) $6.25 \times 10^{16} electrons$

3. If the distance between two point charges is doubled, the Coulomb force between them becomes

(A) $F/4$
(B) $F/2$
(C) $2F$
(D) $4F$

4. Two point charges separated in air experience a force F. If a dielectric of constant $K = 8$ completely fills the space, the new force is

(A) $F/8$
(B) $8F$
(C) F
(D) $64F$

5. The SI unit of electric field intensity is

(A) N/C
(B) $N \cdot m$
(C) J/C
(D) C/N

6. The SI unit of electric flux is

(A) N/C
(B) $N \cdot m$
(C) $N\,m^2/C$
(D) C/N

7. Gauss's law states that the net electric flux through any closed surface is

(A) q_{enc}/ε_0
(B) $q_{enc}\,\varepsilon_0$
(C) q_{enc}/r^2
(D) zero

8. The electric field inside a uniformly charged thin spherical shell is

(A) zero
(B) kQ/r^2
(C) kQ/R^2
(D) infinite

9. Two electric field lines can never intersect because

(A) the field has a unique direction at any point
(B) the field is zero at the intersection
(C) field lines are always straight
(D) charges repel field lines

10. The electric field intensity of a point charge varies with distance r as

(A) $1/r^2$
(B) $1/r$
(C) r^2
(D) r

Section B · Q11 – Q15 (2 marks each)

11. Why must a test charge used to measure an electric field be very small in magnitude? *[2]*

12. Two charges $+2\,\mu$C and $+6\,\mu$C are placed 30 cm apart in air. Find the force between them. *[2]*

13. A point charge Q is placed at the centre of a cube. Show that the flux through one face of the cube is $Q/6\varepsilon_0$. *[2]*

14. From a charge Q_1 six electric field lines originate and into a charge Q_2 eighteen lines terminate. Determine the signs of the charges and the ratio $|Q_1|/|Q_2|$. *[2]*

15. Write the expressions for the electric field at a distance r from (a) an infinite line charge λ and (b) an infinite non-conducting sheet σ, with the units of each field. *[2]*

Section C · Q16 – Q20 (3 marks each)

16. Derive an expression for the electric field on the axis of a uniformly charged ring of radius R and charge Q at a distance x from its centre. Hence find the value of x for which the field is maximum. *[3]*

17. Using Gauss's law, derive the expression $E = \sigma/2\varepsilon_0$ for the electric field of an infinite non-conducting plane sheet of surface charge density σ. *[3]*

18. Using Gauss's law, derive the expression for the electric field of an infinitely long straight wire of linear charge density λ at a distance r. *[3]*

19. A non-uniform electric field $\mathbf{E} = 3.0x\,\hat{i} + 4.0\,\hat{j}$ N/C pierces a cube whose faces are at $x = 1$ m and $x = 3$ m, each of area $4\ \text{m}^2$. Calculate the net flux and the net charge enclosed. *[3]*

20. Show that the electric flux of a point charge Q through a spherical Gaussian surface of radius r is Q/ε_0 and is independent of r. *[3]*

Section D · Q21 (5 marks)

21. Using Gauss's law, derive expressions for the electric field of a uniformly charged thin spherical shell of radius R and charge Q for (i) $r < R$ and (ii) $r \geq R$. Discuss the discontinuity of the field at the surface. *[5]*

Answer Key — ${id}

Section A: 1–Coulomb, 2–6.25×10^{18}, 3–$F/4$, 4–$F/8$, 5–N/C, 6–$\text{N}\,m^2/C$, 7–q_{enc}/ε_0, 8–zero, 9–unique direction, 10–$1/r^2$

12. $1.2\,\text{N}$, repulsive

14. $Q_1(+),\ Q_2(-);\ |Q_1/Q_2| = 1/3$

19. Net flux $40\,\text{N}\,m^2/C$; $q_{enc} \approx 3.5 \times 10^{-10}\,\text{C}$

21. (i) $E = 0$ for $r < R$ (ii) $E = \frac{1}{4\pi\varepsilon_0}\frac{Q}{r^2}$ for $r \geq R$; jump of σ/ε_0 at the surface