CBSE Pattern Test 2 — 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 permittivity of free space is

(A) $8.85 \times 10^{-12}\ \mathrm{C^2N^{-1}m^{-2}}$
(B) $8.85 \times 10^{-12}\ \mathrm{C\,m^{-1}}$
(C) $9 \times 10^{9}\ \mathrm{N}\,m^2/C^2$
(D) 1

2. Electric charge is said to be quantised because it

(A) always exists as an integer multiple of e
(B) can be continuously varied
(C) depends on the speed of the body
(D) is always zero

3. A glass rod rubbed with silk acquires opposite charge on both bodies. This is an example of

(A) conservation of charge
(B) creation of charge
(C) destruction of charge
(D) quantisation of charge

4. If a charge q is placed in an electric field $\mathbf{E}$, the force on it is

(A) $q\mathbf{E}$
(B) $q/\mathbf{E}$
(C) $\mathbf{E}/q$
(D) zero

5. Electric field lines start at

(A) positive charges and end at negative charges
(B) negative charges and end at positive charges
(C) any charge and end at infinity
(D) only at infinity

6. The net flux through a closed surface enclosing a charge q is

(A) q/ε_0
(B) $q\varepsilon_0$
(C) zero
(D) $q/(4\pi r^2\varepsilon_0)$

7. The field of an infinitely long line charge varies with distance r as

(A) $1/r$
(B) $1/r^2$
(C) $1/r^3$
(D) constant

8. The electric field on the axis of a charged ring is maximum at

(A) $x = R/\sqrt{2}$
(B) $x = R/2$
(C) $x = 2R$
(D) the centre

9. The dielectric constant of vacuum is

(A) 1
(B) 0
(C) 8.85
(D) $1/4\pi$

10. Inside a uniformly charged non-conducting solid sphere the electric field

(A) increases linearly with r
(B) is constant
(C) varies as 1/r²
(D) is zero everywhere

Section B · Q11 – Q15 (2 marks each)

11. Define electric flux through a surface. Write its SI unit. *[2]*

12. Two charges of $8\ \mu$C and $5\ \mu$C placed in vacuum exert a force of 0.09 N on each other. Find the distance between them. *[2]*

13. State and explain the two properties of electric charge known as quantisation and conservation. *[2]*

14. Explain why the electric field inside a charged conductor in electrostatic equilibrium is zero. *[2]*

15. Write the SI units of linear, surface and volume charge densities. *[2]*

Section C · Q16 – Q20 (3 marks each)

16. An electron enters symmetrically with speed v_0 a uniform electric field E between two parallel plates of length l. Derive the expression $\tan\theta = eEl/(mv_0^2)$ for the angle of deviation. *[3]*

17. Using Gauss's law, derive expressions for the electric field inside and outside a uniformly charged non-conducting solid sphere of radius R and charge Q. Sketch E versus r. *[3]*

18. Charges q and $4q$ are separated by a distance d. Show that the electric field is zero at $x = d/3$ from the charge q on the line joining them. *[3]*

19. Consider the non-uniform field $\mathbf{E} = 2x\,\hat{i} + 3\,\hat{j}$ N/C piercing a cube whose faces are at $x = 1$ m and $x = 4$ m, side 2 m. Find the flux through the right, left and top faces and the net charge enclosed. *[3]*

20. Why is the number of field lines leaving a charge proportional to its magnitude? Explain why field lines of a static charge never form closed loops. *[3]*

Section D · Q21 (5 marks)

21. Derive an expression for the electric field at a point on the axis of a uniformly charged ring of radius R and charge Q. Find the position of maximum field and show that $E_{max} = Q/(6\sqrt{3}\,\pi\varepsilon_0 R^2)$. *[5]*

Answer Key — ${id}

Section A: 1–8.85×10^{-12}, 2–multiple of e, 3–conservation, 4–$q\mathbf{E}$, 5–positive to negative, 6–q/ε_0, 7–$1/r$, 8–$R/\sqrt{2}$, 9–1, 10–linear increase with r

12. $2\ \text{m}$

19. Right $32\ \text{N}\,m^2/C$, left -8, top $+12$; net over all faces $24\ \text{N}\,m^2/C$, $q_{enc} \approx 2.1 \times 10^{-10}\ \text{C}$

21. Maximum at $x = R/\sqrt{2}$; $E_{max} = Q/(6\sqrt{3}\,\pi\varepsilon_0 R^2)$