

Electrostatic Potential and Capacitance — CBSE Pattern Test 2

Class 12 Physics · 90 minutes · 40 marks · Sections A–D with answer key · Narayan Gurukul Academy

Test 2 — CBSE Pattern (90 minutes, 40 marks)

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General Instructions: (1) This paper has four sections — Section A (1×10), Section B (2×4), Section C (3×4) and Section D (5×2) — total 40 marks. Time allowed: 90 minutes.

(2) All questions are compulsory. No overall choice is given; internal choice, where allowed, is clearly marked.

(3) For MCQ questions choose the single correct option; for VSA answers write a single line.

(4) Take $g = 10 \text{ m/s}^2$. All symbols carry their usual meaning. Use of a calculator is not permitted.

Section A — MCQ & VSA ($10 \times 1 = 10$ marks)

- The electric potential at a distance r from a point charge Q is
 - $(1/4\pi\epsilon_0)(Q/r)$
 - $(1/4\pi\epsilon_0)(Q/r^2)$
 - $(1/4\pi\epsilon_0)(Qr)$
 - $(1/4\pi\epsilon_0)(Q^2/r)$
- The capacitance of a spherical conductor of radius R is
 - $4\pi\epsilon_0 R$
 - $4\pi\epsilon_0 R^2$
 - $4\pi\epsilon_0/R$
 - $\pi\epsilon_0 R$
- A dielectric is a material that
 - is an insulator and gets polarised in an electric field
 - conducts electricity
 - is always polar
 - has no effect in an electric field
- The dielectric constant of a medium is also called its
 - relative permittivity
 - conductivity
 - susceptibility
 - resistivity
- When capacitors are connected in parallel, the equivalent capacitance is
 - the sum of the individual capacitances
 - less than the smallest
 - the reciprocal of the sum
 - unchanged
- The energy stored in a charged capacitor resides in
 - the electric field between the plates
 - the plates' material
 - the connecting wires
 - the battery
- If the plates of an isolated charged capacitor are pulled apart, the energy stored
 - increases

- (B) decreases
 (C) remains the same
 (D) becomes zero
8. Capacitors are connected in parallel in order to
 (A) increase the total capacitance
 (B) decrease the total capacitance
 (C) increase the voltage rating only
 (D) store no charge
9. What is a dielectric?
10. Where is the energy of a charged capacitor stored?

Section B — Short Answer I ($4 \times 2 = 8$ marks)

11. A capacitor of capacitance $5 \mu\text{F}$ is charged to 100 V . Find the charge stored on each plate.
12. Three capacitors of $2 \mu\text{F}$ each are connected in series. Find the equivalent capacitance.
13. Define dielectric constant and give the relation between the permittivity ϵ and the dielectric constant K .
14. A parallel-plate capacitor has plates of area 0.02 m^2 separated by 1 mm . Find its capacitance in air ($\epsilon_0 = 8.85 \times 10^{-12} \text{ F/m}$).

Section C — Short Answer II ($4 \times 3 = 12$ marks)

15. Explain why the capacitance of a capacitor increases when a dielectric fills the space between its plates.
16. Derive the expression for the capacitance of a parallel-plate capacitor partly filled with a dielectric slab of thickness t and dielectric constant K .
17. Derive the expression for the energy stored per unit volume in an electric field, starting from $U = \frac{1}{2}CV^2$.
18. A parallel-plate capacitor has a capacitance of $2 \mu\text{F}$ and is charged to 200 V . Find the energy stored and state what happens to it when the plates are separated to double the distance with the battery still connected.

Section D — Long Answers ($2 \times 5 = 10$ marks)

19. Explain the polarisation of a dielectric. Distinguish between polar and non-polar molecules, and show that polarisation reduces the net electric field inside the dielectric by the factor K .
20. Define electric potential. Derive its expression for a point charge, obtain the relation $E = -dV/dr$, and hence find the potential at a point due to a system of charges.

Answer Key (Marking Scheme)

- Q1 — (A) $(1/4\pi\epsilon_0)(Q/r)$. Q2 — (A) $4\pi\epsilon_0 R$. Q3 — (A) is an insulator and gets polarised. Q4 — (A) relative permittivity.
 Q5 — (A) the sum of the individual capacitances. Q6 — (A) the electric field between the plates. Q7 — (A) increases. Q8 — (A) increase the total capacitance.
 Q9 — A non-conducting material that develops induced charges (polarisation) when placed in an electric field.
 Q10 — In the electric field between the plates.
 Q11 — $Q = CV = 5 \times 10^{-6} \times 100 = 5 \times 10^{-4} \text{ C}$.
 Q12 — $C = 2/3 \mu\text{F}$.
 Q13 — $K = \epsilon/\epsilon_0 = C(\text{with dielectric})/C(\text{vacuum})$; hence $\epsilon = K \epsilon_0$.
 Q14 — $C = \epsilon_0 A/d \approx 1.77 \times 10^{-10} \text{ F}$.

Q15 — The polarised dielectric sets up an electric field opposing the applied field; the potential difference falls, so $C = Q/V$ increases.

Q16 — Field in the dielectric is E/K over thickness t and E over $(d - t)$; summing the potential drop gives $C = \epsilon_0 A / (d - t + t/K)$.

Q17 — $U = \frac{1}{2}CV^2$ and, for $E = V/d$, $u = U/Ad = \frac{1}{2}\epsilon_0 E^2$.

Q18 — $U = \frac{1}{2}CV^2 = 0.04 \text{ J}$. If d doubles at constant V (battery connected), C halves so U halves to 0.02 J .

Q19 — Polar molecules have permanent dipole moments that align; non-polar molecules acquire induced dipoles. In both cases polarisation sets up a field reducing the net field to E/K .

Q20 — $V = W/q$; for a point charge $V = (1/4\pi\epsilon_0)(Q/r)$; $E = -dV/dr$; for a system, $V = \Sigma(1/4\pi\epsilon_0)(Q_i/r_i)$ (scalar sum).