

## Electrostatic Potential and Capacitance — CBSE Pattern Test 1

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

### Test 1 — CBSE Pattern (90 minutes, 40 marks)

Class 12 Physics · Electrostatic Potential and Capacitance · Narayan Gurukul Academy (ClassApna)

General Instructions: (1) This paper has four sections — Section A ( $1 \times 10$ ), Section B ( $2 \times 4$ ), Section C ( $3 \times 4$ ) and Section D ( $5 \times 2$ ) — 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 SI unit of electric potential is the
  - volt
  - joule
  - coulomb
  - farad
- Electric potential is a
  - scalar quantity
  - vector quantity
  - tensor quantity
  - dimensionless quantity
- The SI unit of capacitance is the
  - farad
  - volt
  - coulomb
  - ohm
- The capacitance of a parallel-plate capacitor is
  - $\epsilon_0 A/d$
  - $\epsilon_0 d/A$
  - $\epsilon_0 A d$
  - $A/\epsilon_0 d$
- When a dielectric of dielectric constant  $K$  completely fills a capacitor, its capacitance becomes
  - $K$  times the original
  - $1/K$  times the original
  - unchanged
  - $K^2$  times the original
- When capacitors are connected in series, the equivalent capacitance is
  - less than the smallest capacitance
  - greater than the largest
  - the sum of all capacitances
  - always zero
- The energy stored in a charged capacitor is
  - $\frac{1}{2} CV^2$

- (B)  $CV^2$
- (C)  $CV$
- (D)  $\frac{1}{2}C^2V$

8. The energy density of an electric field  $E$  in vacuum is

- (A)  $\frac{1}{2}\epsilon_0 E^2$
- (B)  $\epsilon_0 E^2$
- (C)  $\frac{1}{2}E^2/\epsilon_0$
- (D)  $\epsilon_0 E$

9. Define electric potential.

10. Define capacitance.

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

11. Calculate the work done in moving a charge of 2 C through a potential difference of 12 V.

12. Two point charges  $+4 \mu\text{C}$  and  $-4 \mu\text{C}$  are separated by 0.2 m. Find the potential at the midpoint.

13. Two capacitors of  $2 \mu\text{F}$  and  $3 \mu\text{F}$  are connected (i) in series and (ii) in parallel. Find the equivalent capacitance.

14. A  $10 \mu\text{F}$  capacitor is charged to 50 V. Find the energy stored.

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

15. Derive the relation between electric field and electric potential.

16. Derive the expression for the capacitance of a parallel-plate capacitor, and explain how a dielectric increases it.

17. Derive the expression for the equivalent capacitance of three capacitors in series.

18. Derive the expression  $U = \frac{1}{2}CV^2$  for the energy stored in a capacitor.

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

19. Define capacitance. Derive the expression for the capacitance of a parallel-plate capacitor and explain how the insertion of a dielectric slab of dielectric constant  $K$  affects the capacitance and the stored energy.

20. State the formulae for capacitors in series and in parallel, derive the series formula for three capacitors, and apply them to find the total capacitance of a  $1 \mu\text{F}$  and  $2 \mu\text{F}$  pair in series connected in parallel with a  $3 \mu\text{F}$  capacitor.

### Answer Key (Marking Scheme)

Q1 — (A) volt. Q2 — (A) scalar quantity. Q3 — (A) farad. Q4 — (A)  $\epsilon_0 A/d$ .

Q5 — (A)  $K$  times the original. Q6 — (A) less than the smallest capacitance. Q7 — (A)  $\frac{1}{2}CV^2$ . Q8 — (A)  $\frac{1}{2}\epsilon_0 E^2$ .

Q9 — The work done in bringing a unit positive charge from infinity to that point.

Q10 — The charge stored per unit potential difference:  $C = Q/V$ .

Q11 —  $W = qV = 2 \times 12 = 24 \text{ J}$ .

Q12 — The potentials are equal and opposite, so  $V = 0$ .

Q13 — (i)  $1.2 \mu\text{F}$  (ii)  $5 \mu\text{F}$ .

Q14 —  $U = \frac{1}{2}CV^2 = \frac{1}{2} \times 10 \times 10^{-6} \times 50^2 = 1.25 \times 10^{-2} \text{ J}$ .

Q15 — Work done  $dW = -qE \cdot dr$  and  $dW = q dV$ , hence  $E = -dV/dr$ .

Q16 —  $E = \sigma/\epsilon_0 = Q/(\epsilon_0 A)$  and  $V = Ed = Qd/(\epsilon_0 A)$ , so  $C = Q/V = \epsilon_0 A/d$ ; a dielectric reduces  $V$  by  $K$ , giving  $C' = K\epsilon_0 A/d$ .

Q17 — For series, the charge is the same on each;  $1/C = 1/C_1 + 1/C_2 + 1/C_3$ , which is larger than each reciprocal, so  $C$  is smaller than the smallest.

Q18 — Work to add charge =  $\int (q/C) dq$  from 0 to  $Q = Q^2/2C = \frac{1}{2}CV^2$ .

Q19 —  $C = \epsilon_0 A/d$ ; a dielectric polarises and the induced field opposes the applied field, so  $V$  drops and  $C$  rises by  $K$ ; with the battery disconnected the energy falls by the factor  $K$  ( $U = Q^2/2C$ ).

Q20 — Series:  $1/C = \Sigma 1/C_i$ ; parallel:  $C = \Sigma C_i$ . Series pair:  $2/3 \mu\text{F}$ ; in parallel with  $3 \mu\text{F}$  gives  $\approx 3.67 \mu\text{F}$ .