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Electrostatic Potential and Capacitance — CBSE Class 12 Physics Chapter Test

FREE CHAPTER TEST · CLASS XII · PHYSICS (042) · PATTERN OF THE CBSE SAMPLE QUESTION PAPER 2026-27

TIME ALLOWED	MAXIMUM MARKS	QUESTIONS	NAME / ROLL NO.
1½ hours	37	17 (A 8 · B 3 · C 3 · D 1 · E 2)	

GENERAL INSTRUCTIONS

Read the following instructions very carefully and strictly follow them:

1. This question paper contains 17 questions. All questions are compulsory.
2. This question paper is divided into five sections: A, B, C, D and E.
3. Section A (Q1–8) contains 6 multiple choice questions and 2 assertion-reason based questions of 1 mark each.
4. Section B (Q9–11) contains short answer questions of 2 marks each.
5. Section C (Q12–14) contains short answer questions of 3 marks each.
6. Section D (Q15) contains case study based questions of 4 marks each, with four sub-parts of 1 mark.
7. Section E (Q16–17) contains long answer questions of 5 marks each.
8. There is no overall choice. However, an internal choice has been provided in 1 question in Section B, 1 question in Section C, 2 questions in Section E. Attempt only one of the alternatives in such questions.
9. Use of calculators is not allowed. You may use: $k = 1/4\pi\varepsilon_0 = 9 \times 10^9$ N m² C⁻², $\varepsilon_0 = 8.854 \times 10^{-12}$ C² N⁻¹ m⁻².
10. This chapter test follows the section structure, question types and marks per question of the CBSE Class XII Physics (042) Sample Question Paper 2026-27, at about half the length of the 70-mark board paper: 37 marks in 1½ hours.
11. The answer key and the marking scheme are at the end of this booklet. Attempt the paper in 1½ hours before you look at them.

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Chapter: Electrostatic Potential and Capacitance · **Topics:** Electrostatic potential and potential difference · Potential of a point charge, a dipole and a system of charges · Equipotential surfaces · Potential energy of a system of charges · Conductors, dielectrics and polarisation · Capacitors, combinations and energy stored

SECTION A

This section comprises 8 questions of 1 mark each: 6 multiple choice questions (MCQs) and 2 assertion-reason based questions.

1. A charge of 2 μC is moved between two points of an equipotential surface at a potential of 100 V. The work done is 1

(A) 200 μJ (B) zero

(C) 50 μJ (D) 2 mJ

2. The electrostatic potential at a distance of 6 cm from a point charge of 2 nC is 1

(A) 300 V (B) 30 V

(C) 3000 V (D) 333 V

3. Two capacitors of 6 μF each are connected in parallel, and this combination is connected in series with a 4 μF capacitor. The equivalent capacitance is 1

(A) 16 μF (B) 10 μF

(C) 2.4 μF (D) 3 μF

4. The capacitance of an air-filled parallel plate capacitor is C. The separation between its plates is doubled and the space is completely filled with a dielectric of dielectric constant 4. The new capacitance is 1

(A) $\frac{C}{2}$ (B) C

(C) 2C (D) 8C

5. The energy stored in a 5 μF capacitor charged to 100 V is 1

(A) 25 mJ (B) 50 mJ

(C) 0.5 mJ (D) 2.5 mJ

6. In a certain region of space the electrostatic potential has the same value at every point. The electric field in this region is 1

(A) uniform and non-zero (B) zero

(C) inversely proportional to the distance (D) inversely proportional to the square of the distance

7. **Assertion (A) :** The electrostatic potential everywhere inside a charged conductor is constant and equal to its value on the surface. 1

Reason (R) : The electric field inside a conductor is zero in electrostatics.

(A) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).

(B) Both Assertion (A) and Reason (R) are true, but Reason (R) is not the correct explanation of Assertion (A).

(C) Assertion (A) is true, but Reason (R) is false.

(D) Assertion (A) is false and Reason (R) is also false.

8. **Assertion (A) :** The capacitance of a parallel plate capacitor increases when a dielectric slab is placed between its plates. 1

Reason (R) : The dielectric constant of air is very nearly 1.

(A) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).

(B) Both Assertion (A) and Reason (R) are true, but Reason (R) is not the correct explanation of Assertion (A).

(C) Assertion (A) is true, but Reason (R) is false.

(D) Assertion (A) is false and Reason (R) is also false.

SECTION B

This section comprises 3 short answer questions of 2 marks each.

9. Point charges of 4 nC and −1 nC are placed 15 cm apart. Find the points on the line joining them where the electrostatic potential is zero (take the potential at infinity to be zero). 2

10. (a) Show that the energy stored in a capacitor of capacitance C charged to a potential difference V is $\frac{1}{2}CV^2$. 2

OR

(b) Point charges of 4 μC and −3 μC are placed at (−6 cm, 0, 0) and (6 cm, 0, 0) respectively. Find the electrostatic potential energy of the system.

11. A 400 pF capacitor is charged by a 150 V supply and disconnected. It is then connected across an uncharged 200 pF capacitor. How much electrostatic energy is lost in the process? 2

SECTION C

This section comprises 3 short answer questions of 3 marks each.

12. Derive an expression for the electrostatic potential due to an electric dipole at a point at distance r from its centre, the line joining the point to the centre making an angle θ with the dipole moment ($r \gg a$). What is the potential at any point on the equatorial plane? 3

13. (a) A parallel plate capacitor has plates of area 100 cm^2 separated by 2 mm of air. Find (i) its capacitance, (ii) the charge on each plate when it is connected to a 100 V supply and (iii) its capacitance when the space is completely filled with a material of dielectric constant 5. 3

OR

(b) Capacitors of 2 μF, 3 μF and 6 μF are connected in series to a 12 V battery. Find (i) the equivalent capacitance, (ii) the charge on each capacitor and (iii) the potential difference across each.

14. (i) Draw the equipotential surfaces for (I) a point charge and (II) a uniform electric field. 3

(ii) Why is the electric field always perpendicular to an equipotential surface?

(iii) A uniform electric field of 50 N C^{-1} points along the +x direction. Find the potential difference V(1 m) − V(4 m) between the points x = 1 m and x = 4 m.

SECTION D

This section comprises 1 case study based question of 4 marks, with four sub-parts of 1 mark each.

15. A defibrillator delivers a quick, strong electric shock to restart a heart. Its energy is stored in a capacitor: a 32 μF capacitor is charged to 5.0 kV and then discharged through the patient's chest in a few milliseconds. Capacitors are also used in camera flash units, where a small battery charges the capacitor slowly and the flash tube releases the stored energy in a very short time.

(I) The energy stored in the defibrillator's capacitor is

(A) 400 J (B) 800 J (C) 80 J (D) 160 J [1]

(II) The charge on the capacitor is

(A) 1.6×10^{-4} C (B) 0.016 C (C) 0.16 C (D) 16 C [1]

(III) If all the stored energy is delivered in 2.0 ms, the average power delivered is

(A) 2×10^{3} W (B) 8×10^{5} W (C) 4×10^{4} W (D) 2×10^{5} W [1]

(IV) If the capacitor were charged to twice the voltage, the stored energy would become

(A) half (B) the same (C) twice (D) four times [1]

SECTION E

This section comprises 2 long answer questions of 5 marks each.

16. (a) (i) A parallel plate capacitor has plates of area A separated by a distance d. A dielectric slab of thickness t (t < d) and dielectric constant K is placed between the plates, parallel to them. Derive an expression for its capacitance. 5

(ii) For such a capacitor with d = 3 mm, t = 2 mm and K = 4, find the ratio of its capacitance to its capacitance without the slab.

OR

(b) (i) Define electrostatic potential at a point. Derive the expression for the potential at a distance r from a point charge q.

(ii) A charge of 6 mC is placed at the origin. Find the work done in taking a small charge of −3 nC from the point P(0, 0, 2 cm) to the point Q(0, 3 cm, 0). Does the answer depend on the path? Why?

17. (a) (i) Derive the expression for the equivalent capacitance of three capacitors connected in series. 5

(ii) Show that the energy density of the electric field in vacuum is $\tfrac{1}{2}\varepsilon_0 E^2$.

(iii) Find the energy density in a region of air where the field is 3×10^{6} N C^{-1}.

OR

(b) (i) Explain the polarisation of a dielectric placed in an external electric field. Define the dielectric constant in terms of the fields.

(ii) A parallel plate capacitor is charged by a battery and the battery is then disconnected. A slab of dielectric constant K is now inserted to fill the space between the plates. How do (I) the charge, (II) the capacitance, (III) the potential difference, (IV) the electric field between the plates and (V) the stored energy change?

END OF THE QUESTION PAPER

ANSWER KEY — SECTION A

Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8
(B)	(A)	(D)	(C)	(A)	(B)	(A)	(B)

MARKING SCHEME AND WORKED SOLUTIONS

Marks for each step are shown in brackets, as in the CBSE marking scheme. Any correct alternative method earns full marks.

Q1. Answer (B). $W = q(V_B - V_A)$ and $V_B = V_A$ on an equipotential surface, so $W = 0$.

Q2. Answer (A). $V = kq/r = 9 \times 10^9 \times 2 \times 10^{-9}/0.06 = 300$ V.

Q3. Answer (D). Parallel: $6 + 6 = 12$ μF. In series with 4 μF: $12 \times 4/(12 + 4) = 3$ μF.

Q4. Answer (C). $C = K\varepsilon_0 A/d$: $C' = 4\varepsilon_0 A/(2d) = 2C$.

Q5. Answer (A). $U = \tfrac{1}{2}CV^2 = \tfrac{1}{2} \times 5 \times 10^{-6} \times 100^2 = 2.5 \times 10^{-2}$ J = 25 mJ.

Q6. Answer (B). $E = -dV/dr$; if V is the same everywhere, every rate of change of V is zero, so $E = 0$.

Q7. Answer (A). With $E = 0$ inside, no work is done in moving a test charge anywhere inside or onto the surface, so V is the same everywhere: R explains A. Answer (A).

Q8. Answer (B). A is true: the slab is polarised, reduces the field and so the potential difference for the same charge, raising $C = Q/V$. R is true but does not explain A. Answer (B).

Q9. (2 marks) Answer: 12 cm and 20 cm from the 4 nC charge, towards the −1 nC charge.
Let the point be at distance x from 4 nC. Between the charges: $k(4)/x = k(1)/(0.15 - x)$, so $4(0.15 - x) = x$ and $x = 0.12$ m. [1]
Beyond the −1 nC charge: $4/x = 1/(x - 0.15)$, so $4x - 0.60 = x$ and $x = 0.20$ m. [1]
V = 0 at 12 cm and at 20 cm from the 4 nC charge, on the side of the −1 nC charge.

Q10. (2 marks) Answer: (a) $\tfrac{1}{2}CV^2$; (b) −0.9 J.
(a) When the capacitor holds charge q, its potential difference is q/C; carrying a further dq from one plate to the other needs work $dW = (q/C)\,dq$. [1]
Total work $W = \int_0^Q (q/C)\,dq = Q^2/2C$, stored as energy $U = Q^2/2C = \tfrac{1}{2}CV^2$ (with $Q = CV$). [1]
OR (b) $r = 12$ cm = 0.12 m. $U = kq_1q_2/r$ [1] $= 9 \times 10^9 \times 4 \times 10^{-6} \times (-3 \times 10^{-6})/0.12 = -0.9$ J. [1]

Q11. (2 marks) Answer: 1.5×10^{-6} J.
Initial energy $= \tfrac{1}{2} \times 400 \times 10^{-12} \times 150^2 = 4.5 \times 10^{-6}$ J. [½]
The charge $Q = 6.0 \times 10^{-8}$ C is shared; the common potential is $Q/(C_1 + C_2) = 6.0 \times 10^{-8}/(600 \times 10^{-12}) = 100$ V. [½]
Final energy $= \tfrac{1}{2} \times 600 \times 10^{-12} \times 100^2 = 3.0 \times 10^{-6}$ J. Energy lost $= 1.5 \times 10^{-6}$ J (as heat and radiation in the connecting wires). [1]

Q12. (3 marks) Answer: $V = p \cos\theta/(4\pi\varepsilon_0 r^2)$; zero on the equatorial plane.
With charges ±q at distance a from the centre, the distances to P are $r_1 \approx r - a\cos\theta$ (from +q) and $r_2 \approx r + a\cos\theta$ (from −q). [1]
$V = kq(1/r_1 - 1/r_2) = kq \times 2a\cos\theta/(r^2 - a^2\cos^2\theta)$ [1] $\approx kp\cos\theta/r^2$ for $r \gg a$, with $p = 2qa$. [½]
On the equatorial plane $\theta = 90°$, so $V = 0$. [½]

Q13. (3 marks) Answer: (a) ≈ 44.3 pF, ≈ 4.43 × 10^{-9} C, ≈ 221 pF; (b) 1 μF, 12 μC each, 6 V, 4 V, 2 V.
(a) (i) $C = \varepsilon_0 A/d = 8.854 \times 10^{-12} \times 1.0 \times 10^{-2}/(2 \times 10^{-3}) \approx 4.43 \times 10^{-11}$ F = 44.3 pF. [1]
(ii) $Q = CV \approx 4.43 \times 10^{-9}$ C. [1]
(iii) $C' = KC \approx 221$ pF (2.21×10^{-10} F). [1]
OR (b) (i) 1/C = 1/2 + 1/3 + 1/6 = 1, so C = 1 μF. [1]
(ii) In series each capacitor carries the same charge Q = CV = 12 μC. [1]
(iii) V = Q/C: 6 V, 4 V and 2 V (they add to 12 V). [1]

Q14. (3 marks) Answer: (iii) 150 V.
(i) (I) Concentric spheres centred on the charge, closer together near it. (II) Equally spaced parallel planes perpendicular to the field. [1]
(ii) Along an equipotential surface no work is done in moving a charge (ΔV = 0); if E had a component along the surface, work would be done. So E has no component along the surface: it is perpendicular to it. [1]
(iii) V(1) − V(4) = E × (4 − 1) = 50 × 3 = 150 V (the potential falls along the field). [1]

Q15. (4 marks) Answer: (I) A; (II) C; (III) D; (IV) D.
(I) (A) $U = \frac{1}{2}CV^2 = \frac{1}{2} \times 32 \times 10^{-6} \times (5.0 \times 10^3)^2 = 400$ J. [1]
(II) (C) $Q = CV = 32 \times 10^{-6} \times 5.0 \times 10^3 = 0.16$ C. [1]
(III) (D) $P = U/t = 400/(2.0 \times 10^{-3}) = 2 \times 10^5$ W. [1]
(IV) (D) $U \propto V^2$, so doubling V makes U four times. [1]

Q16. (5 marks) Answer: (a) $C = \varepsilon_0 A/(d - t + t/K)$; ratio 2; (b) $V = q/4\pi\varepsilon_0 r$; 2.7 J, independent of the path.
(a) (i) With charge ±Q on the plates, $\sigma = Q/A$. In the air gaps (total thickness d − t) the field is $E_0 = \sigma/\varepsilon_0$; inside the slab it is reduced to E_0/K. [1½]
$V = E_0(d - t) + (E_0/K)t = (Q/\varepsilon_0 A)(d - t + t/K)$. [1]
$C = Q/V = \varepsilon_0 A/(d - t + t/K)$. [½]
(ii) Without the slab $C_0 = \varepsilon_0 A/d = \varepsilon_0 A/(3\text{ mm})$. With it, $C = \varepsilon_0 A/(1 + 0.5)\text{ mm} = \varepsilon_0 A/(1.5\text{ mm})$. Ratio $C/C_0 = 3/1.5 = 2$. [2]
OR (b) (i) The potential at a point is the work done per unit charge by an external agent in bringing a small test charge from infinity to that point (without acceleration). [1]
The force on a unit positive charge at distance x is kq/x^2; the work done against it from ∞ to r is $V = -\int_{\infty}^{r} (kq/x^2)\,dx = kq/r = q/(4\pi\varepsilon_0 r)$. [2]
(ii) $V_P = 9 \times 10^9 \times 6 \times 10^{-3}/0.02 = 2.7 \times 10^9$ V; $V_Q = 9 \times 10^9 \times 6 \times 10^{-3}/0.03 = 1.8 \times 10^9$ V. [1]
$W = q(V_Q - V_P) = (-3 \times 10^{-9})(1.8 \times 10^9 - 2.7 \times 10^9) = 2.7$ J. No: the electrostatic force is conservative, so the work depends only on the end points. [1]

Q17. (5 marks) Answer: (a) $1/C = \Sigma 1/C_i$; $u = \frac{1}{2}\varepsilon_0 E^2$; ≈ 39.8 J m^{-3}; (b) Q same, C × K, V/K, E/K, U/K.
(a) (i) In series each capacitor carries the same charge Q, and the potential differences add: $V = V_1 + V_2 + V_3 = Q/C_1 + Q/C_2 + Q/C_3$. [1] With V = Q/C: $1/C = 1/C_1 + 1/C_2 + 1/C_3$. [1]
(ii) For a parallel plate capacitor $U = \frac{1}{2}CV^2 = \frac{1}{2}(\varepsilon_0 A/d)(Ed)^2 = \frac{1}{2}\varepsilon_0 E^2 \times Ad$; Ad is the volume between the plates, so $u = U/Ad = \frac{1}{2}\varepsilon_0 E^2$. [2]
(iii) $u = \frac{1}{2} \times 8.854 \times 10^{-12} \times (3 \times 10^6)^2 \approx 39.8$ J m^{-3}. [1]
OR (b) (i) The field displaces the charges in non-polar molecules (induced dipoles) and aligns the permanent dipoles of polar molecules; the dielectric develops a dipole moment, with bound surface charges that set up a field opposite to the applied field, reducing it. [1½] Dielectric constant $K = E_0/E$, the ratio of the applied field to the reduced field inside the dielectric. [½]
(ii) (I) Q: unchanged (isolated). (II) C: becomes KC. (III) V: becomes V/K. (IV) E: becomes E/K. (V) $U = Q^2/2C$: becomes U/K. [3, ½ each, 1 for U]

All questions are original and © Master Testing Agency. Free to download and use for personal practice; not for resale. Every answer in this paper was checked independently by computer: potentials summed from kq/r, zero-potential points found by scanning, capacitor networks solved by charge conservation, the slab capacitor layer by layer.