



Attempt all questions before checking the answer key.
Use $k = 9 \times 10^9 \text{ N m}^2/\text{C}^2$ and $\epsilon_0 = 8.85 \times 10^{-12} \text{ F/m}$.
Neglect fringing in capacitors.

A. Very short answers - 1 mark each

1. Define electrostatic potential at a point.
2. What is the work done in moving a charge along an equipotential surface?
3. Can potential be zero at a point where the electric field is non-zero? Give an example.
4. Why is a conductor an equipotential body in electrostatic equilibrium?
5. Define one farad of capacitance.

B. Short answers / practice - 2 marks each

6. Find the potential at 0.20 m from a charge +4 nC in vacuum.
7. Draw equipotential surfaces for a point charge and a uniform electric field. Indicate the field direction.
8. Two capacitors of 3 μF and 6 μF are joined in series. Find equivalent capacitance; repeat for parallel connection.
9. Explain why electrostatic field is perpendicular to an equipotential surface.
10. A 5 μF capacitor is charged to 100 V. Find its charge and stored energy.
11. Can two equipotential surfaces intersect? Explain.
12. Find work needed to move +2 μC through a potential increase of 50 V.
13. A charge of 12 μC is stored at 6 V. Find capacitance.
14. What happens to capacitance when both plate area and separation double?
15. Find energy stored in a 2 μF capacitor at 20 V.
16. Find potential at the centre of a square of side a with charge q at each vertex.
17. Can a conductor have non-zero potential and zero internal field?
18. Explain why closely spaced equipotentials indicate a strong electric field.
19. A 6 μF and a 3 μF capacitor are in series across 18 V. Find their voltages.
20. Find the work done by the electric field on +1 μC moving from 100 V to 40 V.

C. Short answers - 3 marks each

21. Charges +2 μC and -2 μC are 0.20 m apart. Find potential at their midpoint and work needed to bring +1 μC there from infinity.

22. Three equal charges q occupy the vertices of an equilateral triangle of side a. Find the electrostatic potential energy and explain its sign.

23. A charged isolated parallel-plate capacitor is completely filled with dielectric of constant 4. Compare its capacitance, voltage and energy before and after insertion.

24. Repeat the dielectric comparison for a capacitor kept connected to an ideal battery. Explain the source of the energy change.

25. A 4 μF capacitor at 60 V is connected in parallel to an uncharged 2 μF capacitor. Find common voltage and the decrease in stored electrostatic energy.

D. Long answers - 5 marks each

26. Derive potential due to a point charge. Obtain the potential of a short electric dipole at a general point and discuss axial and equatorial cases.
27. Derive capacitance of a parallel-plate capacitor, first with vacuum and then with a dielectric completely filling the gap. State the assumptions.
28. Explain series and parallel combinations of capacitors and derive their equivalent capacitances. Find charge on each in a 2 μF -4 μF series pair across 12 V.
29. State the capacitor energy expressions without derivation. A 6 μF capacitor at 100 V is disconnected and its plate separation doubled; calculate final voltage and energies and account for the change.
30. Explain electrostatic shielding and charge distribution on a hollow conductor in equilibrium. Apply these ideas to a charged conductor with an empty cavity and no charge inside it.

ANSWER KEY - Numerical / short answers

- 2) Zero. 3) Yes; at the midpoint between equal opposite charges. 6) 180 V. 8) Series 2 μF ; parallel 9 μF . 10) 500 μC ; 0.025 J. 11) No, distinct potentials cannot occur at the same point. 12) External work = $1.0 \times 10^{-4} \text{ J}$. 13) 2 μF . 14) It is unchanged. 15) $4.0 \times 10^{-4} \text{ J}$. 16) $4\sqrt{2} \text{ kq/a}$. 17) Yes; a charged conductor in equilibrium does. 19) 6 V and 12 V respectively. 20) $+6.0 \times 10^{-5} \text{ J}$. 21) 0 V; 0 J. 22) $3kq^2/a$, positive for assembly of like charges. 23) C: 4 times; V and U: one-quarter. 24) C, Q and U: 4 times; V unchanged. 25) 40 V; loss = $2.4 \times 10^{-3} \text{ J}$. 28) Charge on each = 16 μC . 29) Final V = 200 V; initial U = 0.030 J, final U = 0.060 J; external work = 0.030 J.