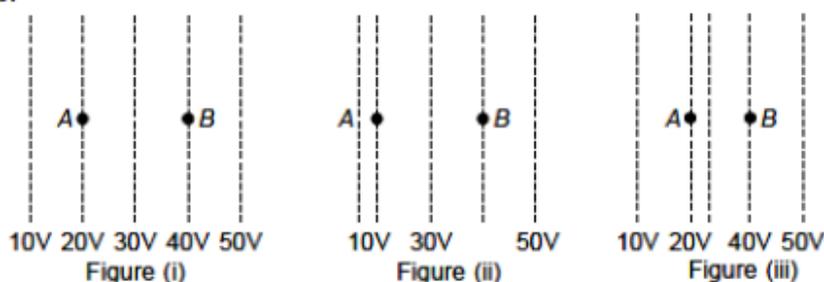


Electrostatic Potential and Capacitance

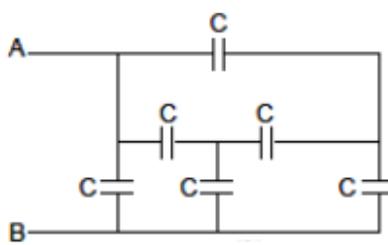
SECTION – A

Questions 1 to 10 carry 1 mark each.

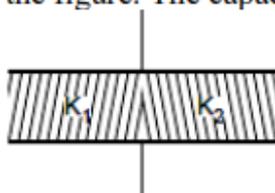
1. Figures show some equipotential lines distributed in space. A charged object is moved from point A to point B.



- (a) The work done in Fig. (i) is the greatest.
 (b) The work done in Fig. (ii) is least.
 (c) The work done is the same in Fig. (i), Fig.(ii) and Fig. (iii).
 (d) The work done in Fig. (iii) is greater than Fig. (ii) but equal to that in Fig. (i).
2. Find the equivalent capacitance of the system across the terminals A and B. All the capacitors have equal capacitances.



- (a) $2 C$ (b) $4 C$ (c) $3 C$ (d) $5 C$
3. The capacitors of capacitance $4 F$, $6 F$ and $12 F$ are connected first in series and then in parallel. What is the ratio of equivalent capacitance in the two cases?
 (a) $2 : 3$ (b) $11 : 1$ (c) $1 : 11$ (d) $1 : 3$
4. A parallel plate capacitor with air as medium between the plates has a capacitance of $10 \mu F$. The area of capacitor is divided into two equal halves and filled with two media having dielectric constant $k_1 = 2$ and $k_2 = 4$ as shown in the figure. The capacitance of the system will now be



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- (a) $10 \mu\text{F}$ (b) $20 \mu\text{F}$ (c) $30 \mu\text{F}$ (d) $40 \mu\text{F}$

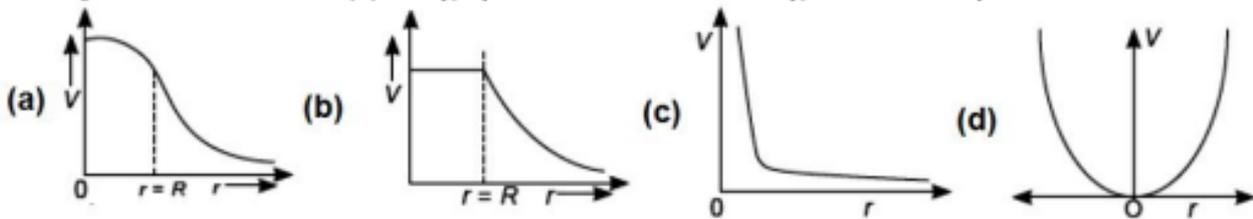
5. A point P lies at a distance x from the mid point of an electric dipole on its axis. The electric potential at point P is proportional to

- (a) $\frac{1}{x^2}$ (b) $\frac{1}{x^3}$ (c) $\frac{1}{x}$ (d) $\frac{1}{x^{1/2}}$

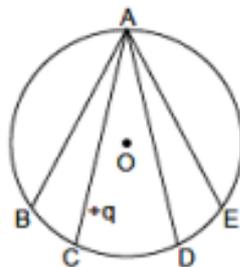
6. A charge Q is located at the centre of a circle of radius r . The work done in moving a test charge q_0 from point A to point B (at opposite ends of diameter AB) so as to complete a semicircle is $\left[k = \frac{1}{4\pi\epsilon_0} \right]$

- (a) $k \frac{q_0 Q}{r}$ (b) $\frac{Qq_0}{r^2}$ (c) $kq_0 Qr$ (d) Zero

7. Each of the graphs below represents the variation of electrostatic potential with distance in the region around a source charge, that is, either a point charge or a continuous charge distribution. Identify the most relevant $V(r)$ vs r graph due to a uniform charged insulated sphere.



8. In the electric field of a point charge q , a certain charge is carried from point A to B, C, D and E. Then the work done



- (a) is least along the path AB. (b) is least along the path AD.
 (c) is zero along all the paths AB, AC, AD and AE. (d) is least along AE.

In the following questions 9 and 10, a statement of assertion (A) is followed by a statement of reason (R). Mark the correct choice as:

- (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 but reason (R) is true.

9. **Assertion (A):** Work done in moving a charge around a closed path, in an electric field is always zero.

Reason (R): Electrostatic force is a conservative force.

10. **Assertion (A):** A parallel plate capacitor is connected across a battery. A dielectric slab of dielectric constant K is introduced between the plates. The energy stored becomes $1/K$ times.

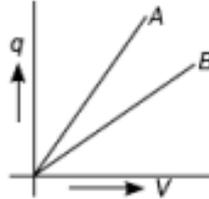
Reason (R): Energy does not depend on dielectric constant.

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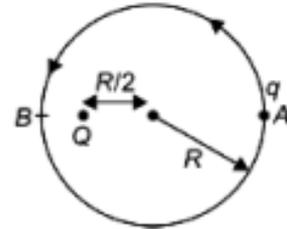
SECTION – B

Questions 11 to 14 carry 2 marks each.

11. Draw a plot showing the variation of (i) electric field (E) and (ii) electric potential (V) with distance r due to a point charge Q .
12. The given graph shows that variation of charge q versus potential difference V for two capacitors C_1 and C_2 . The two capacitors have same plate separation but the plate area of C_2 is double than that of C_1 . Which of the lines in the graph correspond to C_1 and C_2 and why?



13. There is a point charge Q at a distance $\frac{R}{2}$ from the centre of a circle of radius R . Another point charge q is to be moved from A to B , where A and B are two points on the circle diametrically opposite to each other. How much work is done by the electrostatic force exerted by Q on q ?

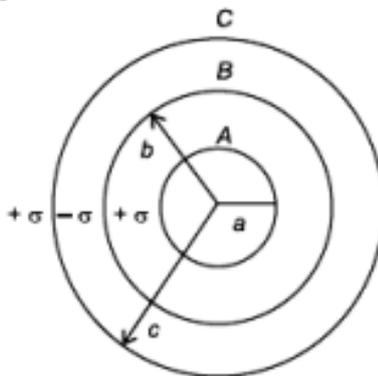


14. A charge Q is given to three capacitors C_1 , C_2 and C_3 connected in parallel. Determine the charge on each.

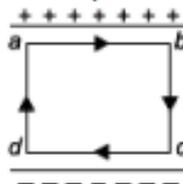
SECTION – C

Questions 15 to 17 carry 3 marks each.

15. Three concentric metallic shells A , B and C of radii a , b and c ($a < b < c$) have surface charge densities $+\sigma$, $-\sigma$ and $+\sigma$ respectively as shown in the figure. If shells A and C are at the same potential, then obtain the relation between the radii a , b , c .



16. (a) Obtain the expression for the energy stored per unit volume in a charged parallel plate capacitor.
(b) The electric field inside a parallel plate capacitor is E . Find the amount of work done in moving a charge q over a closed rectangular loop $a b c d a$.



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17. Two metal spheres A and B of radius r and $2r$, whose centres are separated by a distance of $6r$, are given charge Q each and are at potential V_1 and V_2 . Find the ratio of V_1/V_2 . These spheres are connected to each other with the help of a connecting wire keeping the separation unchanged, what is the amount of charge that will flow through the wire?

OR

Show by graph how q given to a capacitor varies with its potential difference.

Using the graph or otherwise, prove that the energy of a capacitor is $1/2 CV^2$. Calculate the energy density of the electrostatic field in a parallel plate capacitor.

SECTION – D

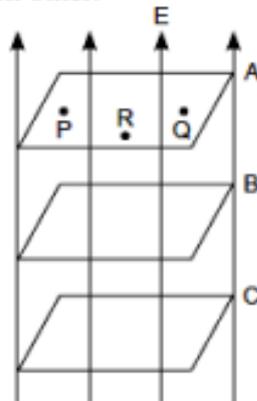
Questions 18 carry 5 marks.

18. Derive the expression for the energy stored in a parallel plate capacitor of capacitance C with air as medium between its plates having charges Q and $\frac{1}{2}\epsilon_0 E^2 Ad$ where A is the area of each plate and d is the separation between the plates.
How will the energy stored in a fully charged capacitor change when the separation between the plates is doubled and a dielectric medium of dielectric constant 4 is introduced between the plates?

SECTION – E (Case Study Based Questions)

Questions 19 to 20 carry 4 marks each.

19. Consider three surfaces A , B and C are placed perpendicular to the electric field 'E'. These surfaces are at equal distance from each other.



- (i) If a charge $+q$ is moved from 'P' to point 'Q' via a point 'R' on the surface A then how much work is done in this case?
(a) qE (b) qV (c) qF (d) Zero
- (ii) What will happen if the electric field become parallel to these surfaces in (i)?
(a) Work done will be zero. (b) Force due to electric field will be zero.
(c) Some work will be done (d) None of the above
- (iii) Consider these surfaces are not at equal distances, then what will it represent?
(a) Electric field is zero. (b) Electric field is constant.
(c) Electric field is not constant. (d) Potential difference between P and Q is positive.
- (iv) What will happen if surfaces 'B' and 'C' intersect in the same field?
(a) There will be two directions of electric fields which is not possible in equipotential surfaces.
(b) There will be two directions of electric fields, indicating equipotential surfaces.
(c) It will not affect direction of electric field.
(d) None of the above.

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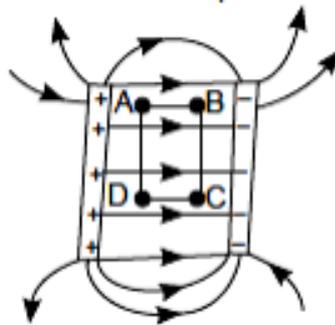
OR

(iv) Nature of equipotential surface for a point charge is

- (a) ellipsoid with charge at foci.
- (b) sphere with charge at the centre of the sphere.
- (c) sphere with charge on the surface of the sphere.
- (d) plane with charge on the surface.

20. Electric field between oppositely charged parallel conducting plates: When two plane parallel conducting plates, having the size and spacing as shown in the figure, are given equal and opposite charges, the field between and around them is approximately as shown, while most of the charge accumulates at the opposite faces of the plates and the field is essentially uniform in the space between them, there is a small quantity of charge on the outer surfaces of the plates and a certain spreading or “fringing of the field at the edges of the plates.

As the plates are made larger and the distance between them diminished, the fringing becomes relatively less. This kind of arrangement is called capacitor.



Now if two plates are separated by a distance ' $3d$ ', and are maintained at a potential difference ' V ', then answer the following questions.

(i) Capacitance of a parallel plate capacitor depends on

- (a) electric charge stored.
- (b) electric field between the plates.
- (c) potential difference applied.
- (d) electrical permittivity of the medium between the plates.

(ii) If two protons are placed at points A and B respectively, then which one will experience more force?

- (a) Proton at point A
- (b) Proton at point B
- (c) Proton at points A and B both experiences same force.
- (d) None of the above

(iii) When both the protons are released then which one will gain more K.E. just before striking the negative ($-ve$) plate?

- (a) Proton released from point A
- (b) Proton released from point B
- (c) Proton released from points A and B will gain equal kinetic energy.
- (d) No one will gain kinetic energy.

(iv) If one proton is moved from (I) A to B, (II) B to C, and (III) along ABCD, then work done in cases I, II and III respectively are

- (a) eED , Zero, $-eED$
- (b) eED , Zero, Zero
- (c) $-eED$, $+eED$, Zero
- (d) eED , $-eED$, Zero

OR

(iv) Which property of electric field is shown by part (iii) and part (iv)

- (a) Non-conservative nature
- (b) Conservative nature
- (c) Dissipative nature
- (d) None of the above