Class – 12 – Physics Chapter wise Mock test
Chapter – 02 – Electrostatic Potential and Capacitance

Maximum Marks: 70 **Time allowed: 3 hours**

General Instructions:

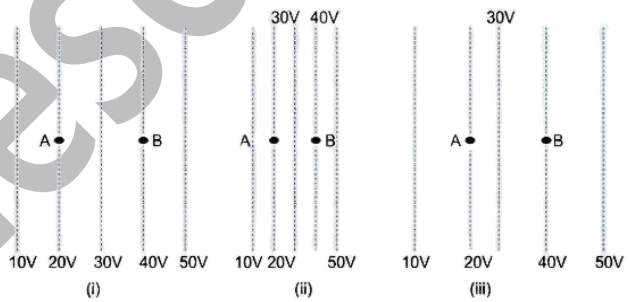
1. There are 33 questions in all. All questions are compulsory.
2. This question paper has five sections: Section A, Section B, Section C, Section D and Section E.
3. All the sections are compulsory.
4. **Section A** contains **sixteen questions, twelve MCQ and four Assertion Reasoning based of 1 mark each, Section B** contains **five questions of two marks each, Section C** contains seven questions of three marks each, **Section D** contains **two case study-based questions of four marks each** and **Section E** contains **three long answer questions of five marks each.**
5. There is no overall choice. However, an internal choice has been provided in one question in Section B, one question in Section C, one question in each CBQ in Section D and all three questions in Section E. You have to attempt only one of the choices in such questions.
6. Use of calculators is not allowed.

SECTION – A

1. Some charge is being given to a conductor. Then, its potential
(a) is maximum at surface.
(b) is maximum at centre.
(c) remains the same throughout the conductor.
(d) is maximum somewhere between surface and centre.

2. A positively charged particle is released from rest in an uniform electric field. The electric potential energy of the charge
(a) remains a constant because the electric field is uniform.
(b) increases because the charge moves along the electric field.
(c) decreases because the charge moves along the electric field.
(d) decreases because the charge moves opposite to the electric field.

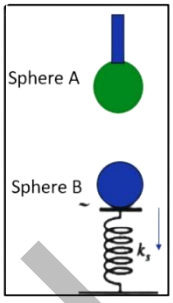
3. Figure shows some equipotential lines distributed in space. A charged object is moved from point A to point B.



(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. (1), Fig. (n) and Fig. (ii).
(d) The work done in Fig. (ii) is greater than Fig. (ii) but equal to that in Fig. (i).

4. A non-conducting sphere A, attached to an insulated handle is given a charge +q. It is brought near a non-conducting sphere B, having a charge +Q, placed on a platform attached to a spring and placed at a vertical distance R from sphere B.
The spring compresses by a distance d_1. Now, if sphere B is replaced by a similar conducting sphere and

sphere A is brought vertically at the same distance from B, without touching it, the spring compresses by a distance d_2.



Choose the correct option based on the above situation and diagram:

(a) $d_2 > d_1$

(b) $d_2 < d_1$

(c) $d_2 = d_1$

(d) insufficient information to compare d_2 and d_1.

5. Two parallel plate capacitors X and Y, have the same area of plates and same separation between plates. X has air and Y with dielectric of constant 2, between its plates. They are connected in series to a battery of 12 V. The ratio of electrostatic energy stored in X and Y is

(a) 4:1 (b) 1:4 (c) 2:1 (d) 1:2

6. A capacitor plates are charged by a battery with 'V' volts. After charging, battery is disconnected and a dielectric slab with dielectric constant 'K' is inserted between its plates, the potential across the plates of a capacitor will become

(a) zero (b) V/2 (c) V/K (d) KV

7. Three capacitors 2μF, 3μF and 6μF are joined in series with each other. The equivalent capacitance is

(a) 1/2 μF (b) 1 μF (c) 2 μF (d) 11 μF

8. Which of the following is NOT the property of equipotential surface?

(a) They do not cross each other.

(b) The rate of change of potential with distance on them is zero.

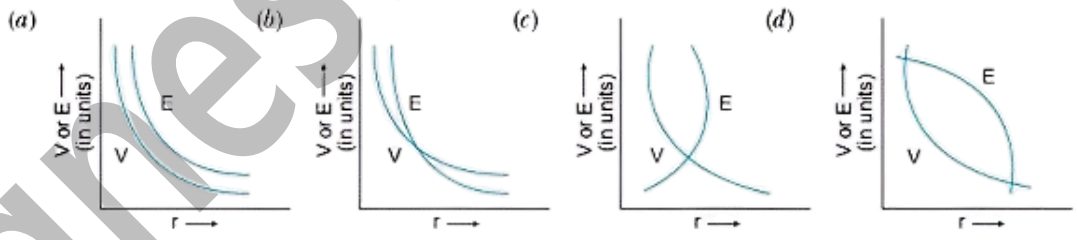
(c) For a uniform electric field they are concentric spheres.

(d) They can be imaginary spheres.

9. 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) $\frac{1}{x^4}$ (d) $\frac{1}{x^{1/2}}$

10. The variation potential V with r and electric field E with r for a point charge is correctly shown in the graphs.



11. A conducting sphere of radius R is given a charge Q. The electric potential and the electric field at the centre of the sphere respectively are

(a) zero and $\frac{Q}{4\pi\varepsilon_0 R^2}$ (b) $\frac{Q}{4\pi\varepsilon_0 R}$ and zero

(c) $\frac{Q}{4\pi\varepsilon_0 R}$ *and* $\frac{Q}{4\pi\varepsilon_0 R^2}$ (d) both are zero

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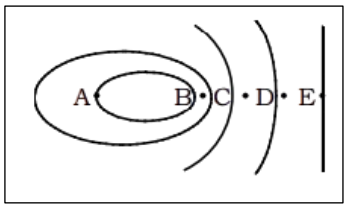
12. Four-point charges − Q, −q, 2q and 2Q are placed, one at each corner of the square. The relation between Q and q for which the potential at the centre of the square is zero is

(a) $Q = \frac{1}{2}q$ (b) Q = − q (c) $Q = -\frac{1}{2}q$ (d) Q = q

13. An electric dipole consisting of charges + q and −q separated by a distance L is in stable equilibrium in a uniform electric field $\vec{E}$. The electrostatic potential energy of the dipole is

(a) qLE (b) zero (c) −qLE (d) − 2 qEL

14. The diagram below shows the equipotential surfaces in a given region of space. The potential difference between any two consecutive surfaces is equal. There are five points marked in the space, namely A, B, C, D, and E as shown.



Assertion (A): The electric field strength is greatest at point A and reduces from A to E.
Reason (R): The potential difference in a region of space is equal to the negative electric field gradient in that region.

(a) Both Assertion and Reason are true, and Reason is the correct explanation for Assertion.
(b) Both Assertion and Reason are true, but Reason is not the correct explanation for Assertion.
(c) Assertion is true, and Reason is false.
(d) Both Assertion and Reason are false.

In the following questions (15- 16), a statement of Assertion (A) is followed by a statement of Reason (R). Choose the correct answer out of the following choices.

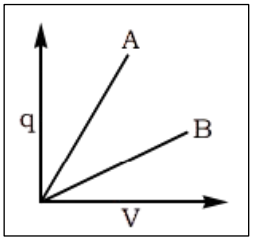
(a) Both A and R are true and R is the correct explanation of A.
(b) Both A and R are true but R is not the correct explanation of A.
(c) A is true but R is false.
(d) A is false and R is also false.

15. **Assertion(A):** In the absence of an externally applied electric field, the displacement per unit volume of a polar dielectric material is always zero.
Reason (R): In polar dielectrics, each molecule has a permanent dipole moment but these are randomly oriented in the absence of an externally applied electric field.

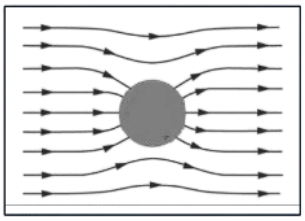
16. **Assertion (A)** Work done in moving a charge around a closed path, in an electric field is always zero.
Reason (R) Electrostatic force is a conservative force.

SECTION – B

17. The given graph shows the variation of charge on plates (q) versus the potential difference (V) between the plates of two capacitors C_1 and C_2.
Both the capacitors have the same plate area but the plate separation of C_1 is twice that of C_2. Which graph corresponds to C_1?



18. A hollow sphere made of material 'X' is placed in a region of electric field. The pattern of electric field lines around the sphere is observed to be like the figure shown below.

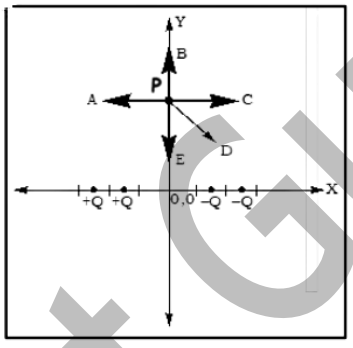


Plot the resistivity versus temperature graph for the material of the sphere.

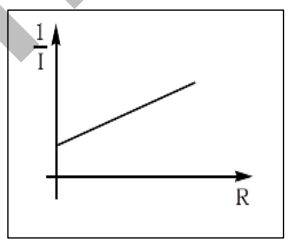
OR

Obtain an expression for electrostatic potential energy of a system of three charges q, 2q and −3q placed at the vertices of an equilateral triangle of side a.

19. Four charges +Q, +Q, −Q, and –Q are placed in an arrangement as shown. The direction of the net electric field at a point 'P' (on the diagram) is best indicated by which of the following vectors: A, B, C, D, or E?



20. Using a cell of electromotive force (e.m.f.) ε and internal resistance 'r', a student designs an electrical circuit to calculate current 'I' through a variable resistor 'R'. The student plots her findings on a graph as shown. What does the slope of the graph indicate?



21. A student wants to place three charges '−q', 'Q', and '−q' in such a way that the potential energy of the system is zero. The three charges are arranged in a straight line at an equal distance from each other. Calculate the ratio of 'Q' to 'q' for such an arrangement.

SECTION – C

22. A student starts working on a problem on Gauss' theorem to calculate the flux and hence the electric field at a given point due to a system of discreet charges. The teacher gives him certain instructions and the student responds to each instruction as per her understanding of the concept. State whether the student's response is *correct or incorrect*. Give a reason for your answer.

(a) **Examiner:** Draw a Gaussian surface for the given system of charges.

Student: *Draws a symmetric surface passing through the point at which the electric field is to be calculated.*

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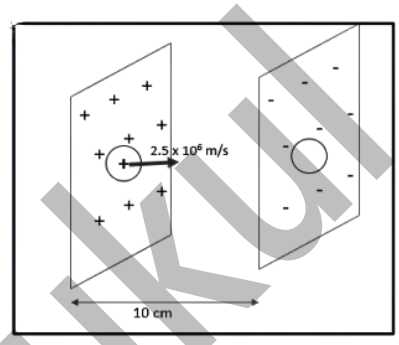
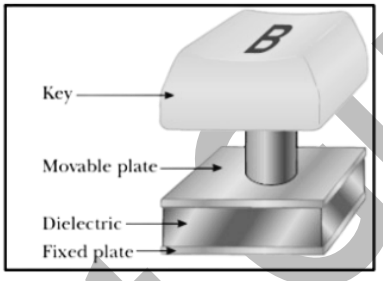
(b) **Examiner:** Suggest a way to double the flux through the given surface.
Student: *Doubles the surface area of the Gaussian surface.*

(c) **Examiner:** Calculate the electric flux of a point charge of 2 μC, placed 5 cm above the centre of a square plate of side 10 cm, through the given plate.
Student: *As the charge is not enclosed by the surface, the flux through the surface is zero.*

23. An alpha particle is made to move through two plates 10 cm apart.
The speed with which it enters the gap in the first plate is 2.5×10^6 m s^{-1}.
The particle exits the second plate with a velocity of 5×10^6 m s^{-1}.
(a) Calculate the potential difference between the plates.
(b) Calculate the electric field between the plates.
(c) Name a device where this principle is used.

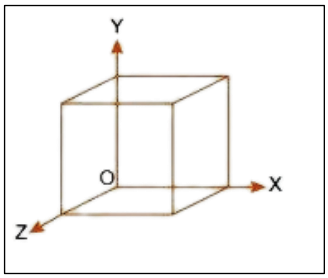


24. The computer's keyboards make use of capacitors at the base of their keys (as shown in the diagram).



Each key is connected to a movable plate, which represents one side of the capacitor. The fixed plate on the keyboard's bottom represents the capacitor's other side. External electronic circuits recognize each key in its capacitance when pressed.
(a) How would the capacitance of the capacitor so formed change, when the key is pressed?
(b) If the plate area is 2 cm^2 and the plate separation is 1 mm, calculate the charge density on the plate, if the potential difference between the plates is 3 V. The plates are separated by a dielectric of K = 5.
(c) Sketch a graph showing the variation of electric field E between the plates with distance 'd' from the first plate till the second plate.

25. A cube of side 20 cm is kept in a region as shown in the figure. An electric field $\vec{E}$ exists in the region such that the potential at a point is given by V = 10x + 5, where V is in volt and x is in m.
Find the
(i) electric field, and
(ii) total electric flux through the cube.



26. A capacitor of 4 μF is charged by a battery of 12 V. The battery is disconnected and a dielectric slab of dielectric constant 8 is inserted in between the plates of the capacitor of fill the space completely. Find the change in the
(a) charge stored in the capacitor,
(b) potential difference between the places of the capacitor, and
(c) energy stored in the capacitor.

27. In a network, four capacitors C_1, C_2, C_3 and C_4 are connected as shown in the figure.

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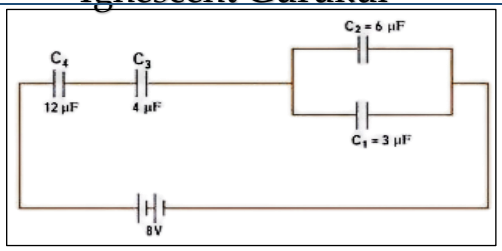
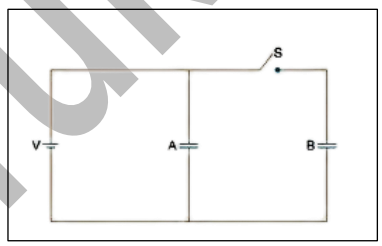


(a) Calculate the net capacitance in the circuit.
(b) If the charge on the capacitor C_1 is 6 μC,
(i) calculate the charge on the capacitors C_3 and C_4, and
(ii) net energy stored in the capacitors C_3 and C_4 connected in series.

Q. 19. You are given an air-filled parallel plate capacitor C_1. The space between its plates is now filled with slabs of dielectric constants K_1 and K_2 as shown in C_2. Find the capacitances of the capacitor C_2, if area of the plates is A and distance between the plates is d.

OR

Q. Two identical parallel plate capacitors A and B are connected to a battery of V volts with the switch S closed. The switch is now opened and the free space between the plates of the capacitors is filled with a dielectric of dielectric constant K. Find the ratio of the total electrostatic energy stored in both capacitors before and after the introduction of the dielectric.



SECTION – D

Case Study Based Questions

29. **Read the following paragraph and answer the questions that follow. [4]**

Faraday Cage: A Faraday cage or Faraday shield is an enclosure made of a conducting mate within a conductor cancel out with any external fields, so the electric field within the enclos These Faraday cages act as big hollow conductors you can put things in to shield them from Any electrical shocks the cage receives, pass harmlessly around the outside of the cage.

(i) Which of the following material can be used to make a Faraday cage?
(a) Plastic (b) Glass (c) Copper (d) Wood

(ii) Example of a real-world Faraday cage is
(a) car (b) plastic box (c) lightning rod (d) metal rod

(iii) What is the electrical force inside a Faraday cage when it is struck by lightning?
(a) The same as the lightning (b) Half that of the lightning
(c) Zero (d) A quarter of the lightning

(iv) An isolated point charge +q is placed inside the Faraday cage. Its surface must have charge equal to
(a) zero (b) +q (c) −4 (d) +29

OR

A point charge of 2 μC is placed at centre of Faraday cage in the shape of cube with surface of 9 cm edge. The number of electric field lines passing through the cube normally will be
(a) 1.9×10^5 Nm^2/C entering the surface (b) 1.9×10^5 Nm^2/C leaving the surface
(c) 2.0×10^5 Nm^2/C leaving the surface (d) 2.0×10^5 Nm^2/C entering the surface

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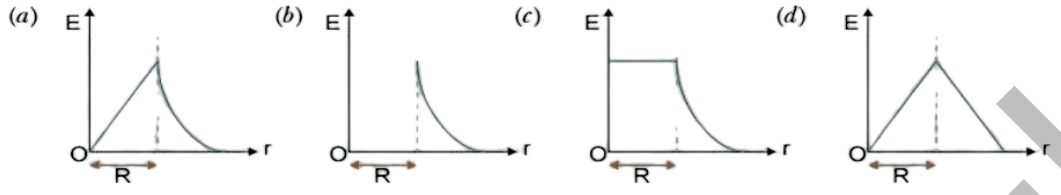
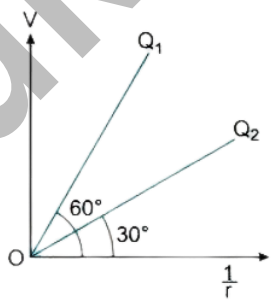
30. **Electrostatics:** Electrostatics deals with the study of forces, fields and potentials arising from static charges. Force and electric field, due to a point charge is basically determined by Coulomb's law. For symmetric charge configurations, Gauss's law, which is also based on Coulomb's law, helps us to find the electric field. A charge a system of charges like a dipole experiences a force/ torque in an electric field. Work is required to be done to provide a specific orientation to a dipole with respect to an electric field.

(i) Consider a uniformly charged thin conducting shell of radius R. Which of the following graph showing the variation of $|\vec{E}|$ with distance r from the centre, for points $0 \leq r \leq 3r$.



(ii) The figure shows the variation of potential V with 1/r for two point charges Q_1 and Q_2. where V is the potential at a distance r due to a point charge. The ratio, $\frac{Q_1}{Q_2}$ will be



(a) 1:3
(b) 3:1
(c) 2:1
(d) 1:2

(iii) An electric dipole of dipole moment of 6 x 10^{-7} C-m is kept in a uniform electric field of 10^4 N/C such that the dipole moment and the electric field are parallel. The potential energy of the dipole will be

(a) 2×10^3 J (b) -2×10^3 J (c) -6×10^{-3} J (d) 6×10^{-3} J

(iv) A dipole is placed parallel to electric field. If W is the work done in rotating the dipole from 0° to 60°, then work done in rotating it from 0° to 180° is

(a) 2 W (b) 3 W (c) 4 W (d) W/2

OR

The electric potential Vat any point *x, y, z* (all in metres) in space is given by $V = 4x^2$ volt. The electric field at the point (1 m, 0, 2 m) in volt/metre is

(a) 8 along negative x-axis (b) 8 along positive x-axis
(c) 16 along negative x-axis (d) 16 along positive z-axis

SECTION – E

31. **Electrostatic precipitators**: Electrostatic precipitators are devices used to remove particles, such as dust and ash, from a flowing gas using the force of an induced electrostatic charge. It consists of two sets of electrodes: positive and negative. The negative electrodes are in the form of a wire mesh, and the positive electrodes are plates. These electrodes are vertically placed and alternate to each other. High Direct Current (DC) voltage is fed to the discharge electrodes, generating a negative electric field around them. The gas-borne particles such as ash are ionised by the corona effect. When the polluted gas passes through the electric field, the particles become charged and are attracted to oppositely charged collector plates, where they adhere until they are removed.

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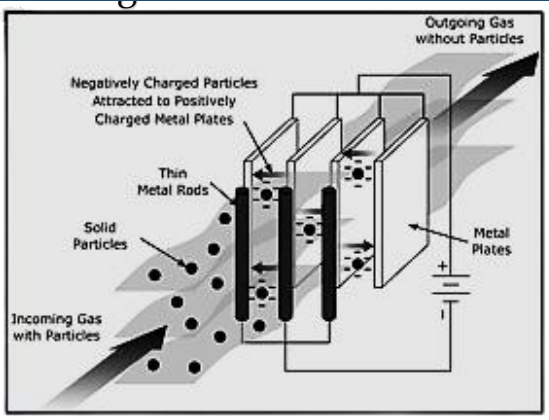


Answer the following questions.

(a) Name *any two* electrostatic processes involved in the working of an electrostatic precipitator.

(b) If the medium between the mesh and the plates is filled with a dielectric medium of dielectric constant K = 10, what will happen to the efficiency of working of the device?

(c) What is the strength of the electric field between two parallel conducting plates separated by 2 cm and having a potential difference (voltage) between them of 1.50×10^4 V?

(d) Name any other device used in day-to-day life, based on the principle of the electrostatic precipitator.

32. Derive an expression for the electric potential at a point due to an electric dipole. Mention the contrasting features of electric potential of a dipole at a point as compared to that due to a single charge.

OR

Briefly explain the principle of a capacitor. Derive an expression for the capacitance of a parallel plate capacitor, whose plates are separated by a dielectric medium.

33. Derive an expression for equivalent capacitance of three capacitors when connected in series and (ii) in parallel.

OR

(i) Compare the individual dipole moment and the specimen dipole moment for H_2O molecule and O_2 molecule when placed in

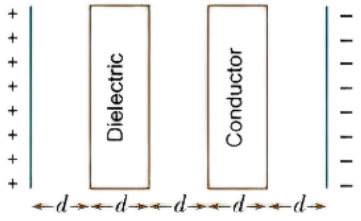
(a) Absence of external electric field

(b) Presence of external eclectic field. Justify your answer.

(ii) Given two parallel conducting plates of area A and charge densities + σ and − σ. A dielectric slab of constant K and a conducting slab of thickness d each are inserted in between them as shown.

(a) Find the potential difference between the plates.

(b) Plot E versus x graph, taking x = 0 at positive plate and x = 5d at negative plate.



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