QUESTION BANK

Chapter:2 Electric Potential and Capacitance

SECTION A

(1 MARK QUESTIONS)

Q1. What is the net charge on a charged capacitor?

Q2. What is an equipotential surface. Give an example. (CBSE 2003)

Q3. What is the geometrical shape of equipotential surfaces due to a single isolated charge? (CBSE 2013)

Q4. Why are electric field lines are perpendicular at a point on an equipotential surface of a conductor? (CBSE 2015)

Q5. Define dielectric constant in terms of the capacitance of a capacitor.

Q6. What may be a possible reason of water having a much greater dielectric constant (=80) than say mica (=6)?

Q7.In what form is the energy stored in a charged capacitor?

MULTIPLE CHOICE QUESTIONS

Q8. If voltage applied on a capacitor is increased from V to 2V, choose the correct conclusion.

(a) Q remains the same, C is doubled

(b) Q is doubled, C doubled

(c) C remains same, Q doubled

(d) Both Q and C remain same

Q9. A parallel plate capacitor is charged. If the plates are pulled apart

(a) the capacitance increases

(b) the potential differences increase

(c) the total charge increases

(d) the charge & potential difference remain the same

Q10.Which of the following is an example of a molecule whose centre of mass of positive and negative charges coincide each other?

(a)CO_2 (b) CO (c) CH_3OH (d) NH_3

Q11.What is the angle between electric field and equipotential surface?

(a) 90^o always (b)0^o always (c)0^o to 90 (d)0^o to 180^o

Q12.If we carry a charge once around an equipotential path, then work done by the charge is:

(a) Infinity (b) Positive (c) Negative (d) Zero

2 MARKS QUESTIONS

Q13.Sketch equipotential surfaces for

(a) A negative point charge (CBSE 2001)

(b) Two equal and positive charges separated by a small distance. (CBSE 2015)

Q14.Deduce the expression for the potential energy of an electric dipole placed with its axis at an angle θ to the external field $\vec{E}$.Hence discuss the conditions of its stable and unstable equilibrium. (CBSE 2008,2019,2021 Compt.)

3 MARKS QUESTIONS

Q15. Obtain the expression for the resultant capacitance when three capacitors C_1 , C_2 and C_3 are connected (i) in series (ii) in parallel.

Q16. Define the capacitance of a capacitor. Obtain the expression for the capacitance of a parallel plate capacitor in vacuum in terms of plate area A and separation d between the plates.

5 MARKS QUESTIONS

Q17. (a) Define the SI unit of capacitance.

(b) Obtain the expression for the capacitance of a parallel plate capacitor.

Q18. (a) Define potential energy of a system of two charges.

(b)Two-point charges q_1 and q_2, separated by a distance r_{12} are kept in an external electric field. Derive an expression for the potential energy of the system of two charges in the field.

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SECTION-A Answer Key

1. Zero, because the two plates have equal & opposite charges.

2. A surface with a constant value of potential at all points on the surface. Example: Surface of a charged conductor.

3.For the point charge, the equipotential surfaces are concentric spherical shells with their centre at the point charge.

4. If it were not so, the presence of a component of the field along the surface would destroy its equipotential nature

5. The ratio of the capacitance of the capacitor completely filled with dielectric material to the capacitance of the same capacitor with vacuum between the platesis called dielectric constant.

6. Water molecules have permanent dipole moment.

7. Electrostatic potential energy

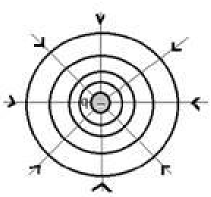
MCQ

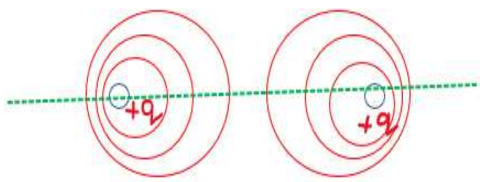
8. (c)   9. (b) V = Ed , V increases as distance increases

10. (a)   11. (a)   12. (d)

2 MARKS ANSWERS

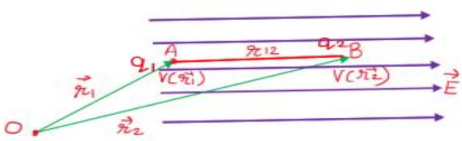
13.





14. Work done in moving the charge q_1 at the point A,

$W_1 = q_1V\ (\mathbf{r_1})$ Work done in moving the charge q_1 at the point B,



$W_2 = q_2V\ (\mathbf{r_2}) + \frac{1}{4\pi\epsilon_0}\frac{q_1q_2}{r_{12}}$

Total work done in assembling this configuration,

$W = W_1 + W_2$

$W = q_1V\ (\mathbf{r_1}) + q_2V\ (\mathbf{r_2}) + \frac{1}{4\pi\epsilon_0}\frac{q_1q_2}{r_{12}}$

3 MARKS ANSWERS

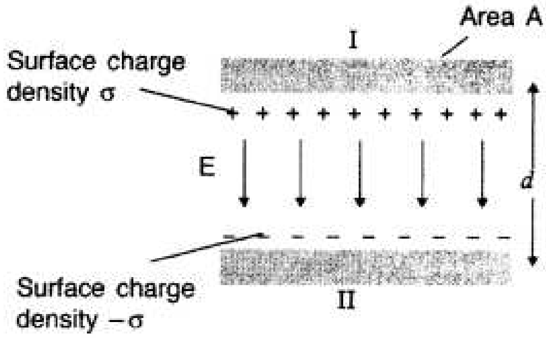
15. Derivation from ncert book

16. Derivation from ncert book

5 MARKS ANSWERS

17.When a charge of one coulomb produces a potential difference of one volt between the plates of capacitor, the capacitance is one farad.

Capacity of a parallel plate capacitor. A parallel plate capacitor consists of two large plane parallel conducting plates separated by a small distance. We first take the intervening medium between the plates to be vaccum. Let A be the area of each plate and d the separation between them. The two plates have charges Q and – Q. Since d is much smaller than the linear dimension of the plates ($d^2 << A$), we can use the result on electric field by an infinite plane sheet of uniform surface charge density. Plate 1 has surface charge density σ = Q/A and Plate 2 has a surface charge density -σ, the electric field in different region is:



Outer region I (region above the plate 1),

$$E = \frac{\sigma}{2\varepsilon_0} - \frac{\sigma}{2\varepsilon_0} = 0$$

Outer region II (region below the plate 2),

$$E = \frac{\sigma}{2\varepsilon_0} - \frac{\sigma}{2\varepsilon_0} = 0$$

In the inner region between the plates 1 and 2, the electric fields due to the two charged plates add up, giving

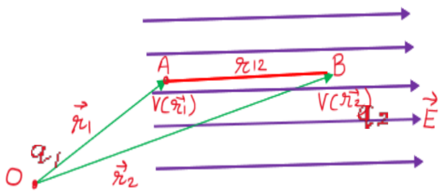
$$E = \frac{\sigma}{2\varepsilon_0} + \frac{\sigma}{2\varepsilon_0} = \frac{\sigma}{\varepsilon_0} = \frac{Q}{\varepsilon_0 A} \text{ or } V = Ed = \frac{1}{\varepsilon_0}\frac{Qd}{A}$$

The capacitance C of the parallel plate capacitor is then

$$C = \frac{Q}{V} = \frac{\varepsilon_0 A}{d}$$

18. a) The potential energy of a system of two charges is the amount of work done in assembling the charges at their locations by bringing them in, from infinity.

(b) Work done in moving the charge q_1 at the point A,



$W_1 = q_1V(\mathbf{r_1})$

Work done in moving the charge q_1 at the point B,

$W_2 = q_2V(\mathbf{r_2}) + \frac{1}{4\pi\epsilon_0}\frac{q_1q_2}{r_{12}}$

Electric energy of the system,

U = Total work done in assembling this configuration,

$U = W_1 + W_2$

$U = q_1V(\mathbf{r_1}) + q_2V(\mathbf{r_2}) + \frac{1}{4\pi\epsilon_0}\frac{q_1q_2}{r_{12}}$

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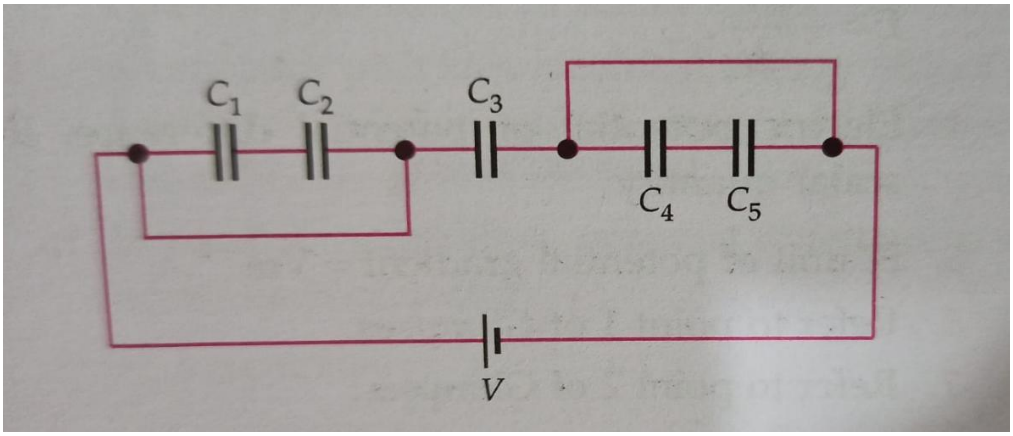
SECTION-B

1 MARK QUESTIONS

Q1. An air capacitor is given a charge of 2μC raising its potential to 200 V. If on inserting a dielectric medium, its potential falls to 50 V. What is the dielectric constant of the medium.

Q2. A parallel plate capacitor with air between the plates has a capacitance of 8pF. What will be the capacitance if the distance between the plates by reduced by half and the space between them is filled with a substance of dielectric constant k =6.

Q3. What is the equivalent capacitance, C, of the five capacitors connected as shown in the figure



ASSERTION – REASON QUESTIONS

Directions: These questions consist of two statements, each printed as Assertion and Reason. While answering these questions, you are required to choose any one of the following four responses.

(a) Both Assertion and Reason are correct and the Reason is a correct explanation of the Assertion.

(b) Both Assertion and Reason are correct but Reason is not a correct explanation of the Assertion.

(c) Assertion is correct, Reason is incorrect

(d) Both Assertion and Reason are incorrect.

Q4 **Assertion:** A spherical equipotential surface is not possible for a point charge.

Reason: A spherical equipotential surface is not possible inside a spherical capacitor.

Q5.**Assertion:** The equatorial plane of a dipole is an equipotential surface.

Reason: The electric potential at any point on equatorial plane is zero.

Q6.**Assertion:** Electric potential and electric potential energy are different quantities.

Reason: For a system of positive test charge and point charge electric potential energy = electric potential.

Q7.**Assertion:** Two equipotential surfaces cannot intersect each other.

Reason: Two equipotential surfaces are parallel to each other.

Q8. Assertion : If the distance between parallel plates of a capacitor is halved and dielectric constant is three times, then the capacitance becomes 6 times.

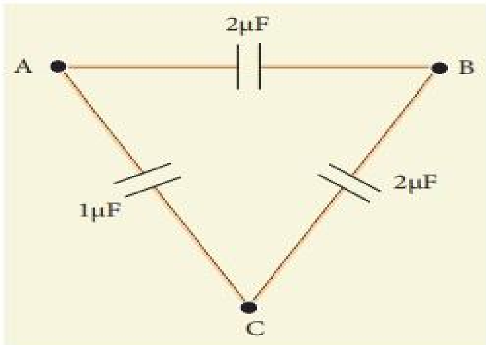
Reason : Capacity of the capacitor does not depend upon the nature of the material.

Q9**. Assertion** : A parallel plate capacitor is connected across battery through a key. A dielectric slab of dielectric constant K is introduced between the plates. The energy which is stored becomes K times.

Reason : The surface density of charge on the plate remains constant or unchanged.

MULTIPLE CHOICE QUESTIONS

Q10. Three capacitors are connected in triangle as shown in the figure. The equivalent capacitance between the points A and C is



(a) 1μF

(b) 2 μF

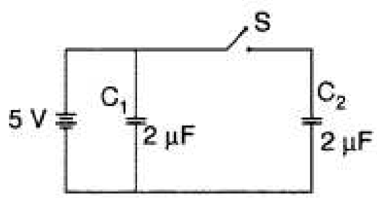
(c) 3 μF

(d)1/4μF

2 MARKS QUESTIONS

Q11.If two charged conductors are touched mutually and then separated, prove that the charges on them will be divided in the ratio of their capacitances.

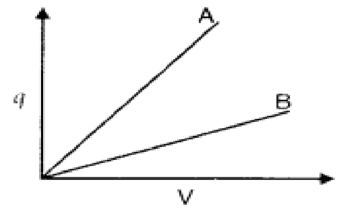
Q12. Figure shows two identical capacitors C_1 and C_2, each of 2 μF capacitance, connected to a battery of 5 V. Initially switch 'S' is left open and dielectric slabs of dielectric constant K = 5 are inserted to fill completely the space between the plates of the two capacitors.



(i) How will the charge and

(ii) potential difference between the plates of the capacitors be affected after the slabs are inserted?

Q13. The given graph shows variation of charge ‘q’ versus potential difference ‘V’ for two capacitors C_1 and C_2. Both the capacitors have same plate separation but plate area of C_2 is greater than that of C_1. Which line (A or B) corresponds to C_1 and why?



Q14. A metal plate is introduced between the plates of a charged parallel plate capacitor. What is its effect on the capacitance of the capacitor.

Q15. Two capacitors have a capacitance of 5μF when connected in parallel and 1.2μF when connected in series. Calculate their capacitances.

Q16. Why does current in a steady state not flow in a capacitor connected across a battery? However momentary current does flow during charging or discharging of the capacitor. Explain.

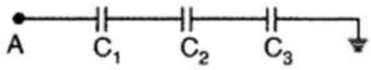
Q17. A capacitor is connected across a battery.

(i) Why does each plate receive a charge of exactly the same magnitude?

(ii) Is this true even if the plates are of different sizes?

3 MARKS QUESTIONS

Q18. Calculate the potential difference and the energy stored in the capacitor C_2 in the circuit shown i the figure. Given potential at A is 90 V, C_1 = 20 μF, C_2 = 30 μF and C_3 = 15 μF.



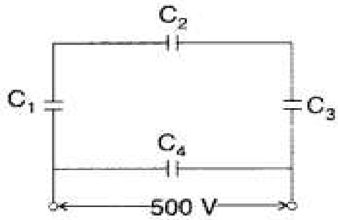
Q19. A capacitor of unknown capacitance is connected across a battery of V volts. The charge stored in it is 300 μC. When potential across the capacitor is reduced by 100 V, the charge stored in it becomes 100 V. Calculate the potential V and the unknown capacitance. What will be the charge stored in the capacitor if the voltage applied had increased by 100 V?

Q20. A parallel plate capacitor, of capacitance 20pF, is connected to a 100 V supply. After sometime the battery is disconnected, and the space, between the plates of the capacitor is filled with a dielectric, of dielectric constant 5. Calculate the energy stored in the capacitor

(i) before

(ii) after the dielectric has been put in between its plates.

Q21. A network of four capacitors each of 12μF capacitance is connected to a 500 V supply as shown in the figure.
Determine
(a) equivalent capacitance of the network and
(b) charge on each capacitor.

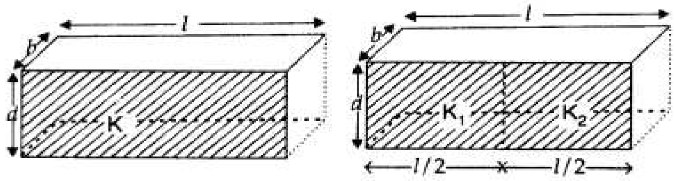


Q22. A parallel plate capacitor is charged by a battery to a potential difference V. It is disconnected from battery and then connected to another uncharged capacitor of the same capacitance. Calculate the ratio of the energy stored in the combination to the initial energy on the single capacitor.

5 MARKS QUESTIONS

Q23. a) Explain, using suitable diagrams, the difference in the behavior of a
(i) conductor and
(ii) dielectric in the presence of external electric field. Define the terms polarization of a dielectric and write its relation with susceptibility.

Q24. Two identical capacitors of plate dimensions l × b and plate separation d have di-electric slabs filled in between the space of the plates as shown in the figure.



Obtain the relation between the dielectric constants K, K_1 and K_2.

Q25. A parallel plate capacitor of capacitance C is charged to a potential V by a battery. Without disconnecting the battery, the distance between the plates is tripled and a dielectric medium of k = 10 is introduced between the plates is tripled and a dielectric medium of k = 10 is introduced between the plates of the capacitor. Explain giving reasons, how will the following be affected:
(i) capacitance of the capacitor
(ii) charge on the capacitance.

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SECTION B-ANSWER KEY

1. $k = v\_vac/v\_die = 200/30 = 4$

2. With air between the parallel plates,

$C_0 = \frac{\epsilon_0 A}{d} = 8PF$

With dielectric between the parallel plates

$$C = \frac{k\epsilon_0 A}{d\,/\,2} = 96PF$$

3. $C=C_3$ because the combination of C_1 and C_2 as well as C_4 and C_5 have been shorted.

4.(d) 5.(b) 6.(c) 7.(c) 8. (c) 9. (c)

MCQ

10. (b)

2 MARKS ANSWERS

11. Q ∝ C so the charge will be divided in proportion of their capacitances. Explanation: When two charged conductors are touched together then the charge on them will get divided as we know charge can flow. We also know Q= CV.

12. (i) When switch S is open and dielectric is introduced, charge on each capacitor will be $q_1 = C_1 V$, $q_2 = C_2 V$

$q_1 = 5CV = 5 \times 2 \times 5 = 50\ \mu C$, $q_2 = 50\ \mu C$

Charge on each capacitor will become 5 times

(ii) P.d. across C_1 is still 5V and across C_2,

$q = (5C)\ V$

$$V' = \frac{V}{5} = \frac{5}{5} = 1V$$

13. A represents C_2 and B represents C_1

Reason: From the graph the slope q/v= Capacitance is greater for A. Also according to given conditions the capacitance C∝A

so capacitance is larger for the C_2 because the area of its plates is large and d for the two capacitor is same. Hence, A represents C_2.

Let C be the capacitance of a capacitor

Given : $C_1 = C_2 = C_3 = C$ When connected in series: Cs=C/3=1μF So C=3μF

When connected in parallel: Cp=C+C+C=3+3+3= 9μF

14. By introducing the metal plate between the plates of charged capacitor, the capacitance of capacitor increases. As C=Aε_O /d-t(1-$\frac{1}{K}$). For metal plate K is infinite so Obviously, effective separation between plates is decreased from d to (d – t)

15. 5 = C1 + C2 ....(1st equation)

1.2 = C1C2/(C1 + C2) ....(2nd equation)

On solving we get C1 = 2mF and 3mF.

16. In the steady state, the displacement current and hence the conduction current, is zero as | |E→| | between the plates, is constant.

During charging and discharging, the displacement current and hence the conduction current is non zero as | |E→| | between the plates, is changing with time.

Current is non zero as | |E→| | between the plates, is changing with time.

17.a. The charge from one plate gets transferred to another plate through battery. The battery pumps the charge from one plate to another.

b. Yes size of plates does not matter.

3 MARKS ANSWERS

18. Given V_A= 90V, C_1 = 20μF, C_2 = 30μF and C_3= 15μF

Since these capacitors are connected in series, net capacitance will be

$$\frac{1}{c} = \frac{1}{20} + \frac{1}{30} + \frac{1}{15} = \frac{3}{20}$$

$$c = \frac{20}{3}\,\mu F$$

Carge on each capacitor q = CV =600μC

Potential difference across the capacitor C_2

$V_2 = \frac{q}{C_2} = \frac{600}{30} = 20v$

Energy stored in capacitor across C_2

E_2= 6000J

19. (i) Charge stored, Q = CV

300 μC = C × V ,

When potential is reduced by 100 V

$100\ \mu C = C(V - 100) = CV - 100\ C$

$100\ \mu C = 300\ \mu C - 100\ C$

$\Rightarrow 100\ C = 300\ \mu C - 100\ \mu C$

$\Rightarrow 100\ C = 200\ \mu C$

Therefore, capacitance $C = 2\mu F$

(ii) Charge stored when voltage applied is increased by 100 V

$Q' = 2\mu F \times (150 + 100) = 500\mu C$

20. $C = 20\mu F = 20 \times 10^{-6}$ F, V= 100 V , K= 5

Charge stored $Q= CV = 2000\mu C$

New value of capacitance $C' = 100\mu F$

Energy stored in a capacitor (E) $=\frac{Q^2}{2C}$

(i) Energy stored before dielectric is introduced

$E_1= 0.1$ J

(ii) Energy stored after dielectric is introduced (no change in the value of Q)

$E_2 = 0.02$J

21. $C_{123} = 4\mu F$ (being in series)

$C_{eq} = C_{123} + C_4 = 16\mu F$

(i) $Q_1 = C_4V= 6 \times 10^{-3}$

(ii) $Q_2 = C_{123}\ V= 2 \times 10^{-3}$ C

Charge on each of the capacitors $C_1, C_2, C_3 = 2 \times 10^{-3}$ C

22.Charge stored on the capacitor q=CV

When it is connected to the uncharged capacitor of same capacitance,

sharing of charge takes place between the two capacitor till the potential

of both the capacitor becomes $V/2$

Energy stored on the combination (U_2) $=\frac{1}{2}c\left(\frac{v}{2}\right)^2 + \frac{1}{z}c\left(\frac{v}{2}\right)^2 = \frac{cv^2}{4}$

Energy stored on single capacitor before connecting

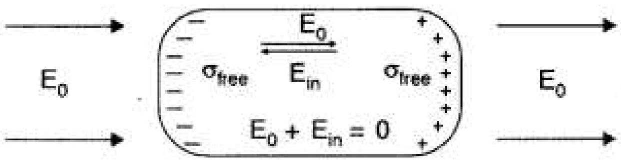
$U_1=\frac{1}{2}Cv^2$

Ratio of energy stored in the combination to that in the single capacitor

$$\frac{U_z}{v_1} = \frac{cv^{2}/_{4}}{cv^2\ /\ 2} = 1:2$$

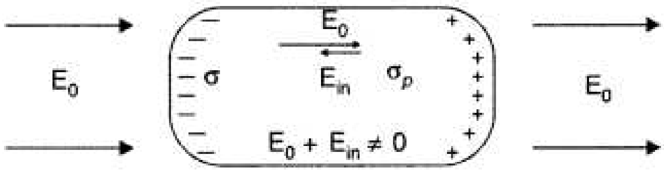
5 MARKS ANSWERS

22. (i) Behaviour of conductor in an external electric field :



Conductor

(ii) Behaviour of a dielectric in an external electrical field :



Dielectric

Explanation: In the presence of electric field, the free charge carriers in a conductor move the charge distribution and the conductor readjusts itself so that the net Electric field within the conductor becomes zero.

In a dielectric, the external electric field induces a net dipole moment, by stretching / reorienting the molecules. The electric field, due to this induced dipole moment, opposes, but does not exactly cancel the external electric field.

Polarisation: Induced Dipole moment, per unit volume, is called the polarisation. For Linear isotropic dielectrics having a susceptibility x_c, we have polarisation (p) as: $p = X_cE$

23. In first case C_1=εoKx(lxb)/d……….(i)

In second case, these two apartments are in parallel, their net capacity would be the sum of two individual capacitances

$C_2 = C'_2 + C''_2$

$$= \frac{\varepsilon_0 K_1\left(\frac{l}{2}\times b\right)}{d} + \frac{\varepsilon_0 K_2\left(\frac{l}{2}\times b\right)}{d}$$

$$\Rightarrow C_2 = 2\varepsilon_0 \frac{(l\times b)}{d}(K_1 + K_2) \qquad \ldots(ii)$$

Since these are identical capacitors, comparing (i) and (ii), We have $C_1 = C_2$

$$\frac{\varepsilon_0 K(l \times b)}{d} = \varepsilon_0 \frac{(l \times b)}{d}\left(\frac{K_1 + K_2}{2}\right)$$

$$\therefore \quad \mathbf{K = \frac{K_1 + K_2}{2}}$$

24.Given : d' = 3d, K = 10, C = ?, Q' = ?, U'_d= ?

(i) For parallel plate capacitor

$$C = \frac{\epsilon_0 A}{d}$$

Let the new capacity be C'

$$C' = \frac{K \epsilon_0 A}{d'} = \frac{10 \times (\epsilon_0 A)}{3d}$$

$$[\because K = 10, d' = 3d]$$

$$\Rightarrow \quad \left(\frac{10}{3}\right)\left(\frac{\epsilon_0 A}{d}\right) = \frac{10}{3}C$$

$$\Rightarrow \quad \mathbf{C' = \frac{10}{3}C}$$

(ii) Since V remains the same as the battery is not disconnected,

$$Q' = C'V$$

$$Q' = \left(\frac{10}{3}C\right)V = \frac{10}{3}CV = \frac{10}{3}Q$$

$$\Rightarrow \quad \mathbf{Q' = \frac{10}{3}Q}$$

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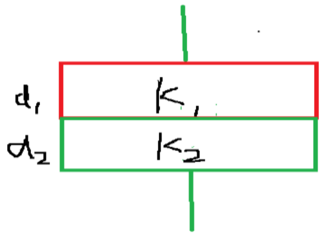
SECTION- C

1 MARK QUESTIONS

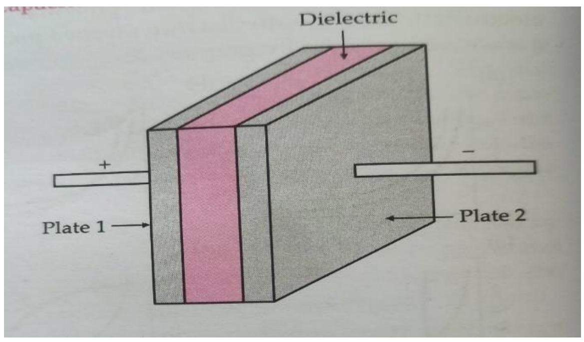
Q1. A parallel plate capacitor is made of two dielectric blocks in series. One of the blocks has thickness d_1 and dielectric constant K_1 and the other has thickness d_2 and dielectric constant K_2 as shown in figure. This arrangement can be thought as a dielectric slab of thickness d (= $d_1 + d_2$) and effective dielectric constant K. Then K is



(a) $\frac{k_1 d_1+k_2 d_2}{d_1+d_2}$ **(b)** $\frac{k,d,+k_2 d_2}{k_1+k_2}$

(c) $\frac{k_2k_1+(d_1+d_2)}{(k_1a,+k_2d_2)}$ **(d)** $\frac{2k_1k_2}{k_1^{+}k_2}$

Q2. **CASE BASED STUDY QUESTION**



An arrangement of two conductors separated by an insulating medium can be used to store electric charge and electric energy. Such a system is called a capacitor. The more charge a capacitor can store, the greater is its capacitance. Usually, a capacitor consists of two conductors having equal and opposite charge +Q and -Q. Hence, there is a potential difference V between them. By the capacitance of a capacitor, we mean the ratio of the charge Q to the potential difference V. By the charge on a capacitor we mean only the charge Q on the positive plate. Total charge of the capacitor is zero. The capacitance of a capacitor is a constant and depends on geometric factors, such as the shapes, sizes and relative positions of the two conductors, and the nature of the medium between them. The unit of capacitance is farad (F), but the more convenient units are μF and pF. A commonly used capacitor consists of two long strips or metal foils, separated by two long strips of dielectrics, rolled up into a small cylinder. Common dielectric materials are plastics (such as polyestors and polycarbonates) and aluminium oxide. Capacitors are widely used in radio, television, computer, and other electric circuits.

1.A parallel plate capacitor C has a charge Q . The actual charge on its plates are

(a) Q,Q (b) Q/2, Q/2 (c) Q ,-Q (d) Q/2, -Q/2

2.A parallel plate capacitor is charged. If the plates are pulled apart .

(a) the capacitance increases (b) the potential difference increases

(c) the total charge increases (d) the charge & potential difference remains the same

3.Three capacitors of 2 , 3 & 6 μF are connected in series to a 10 V source. The charge on the 3 μF capacitor is

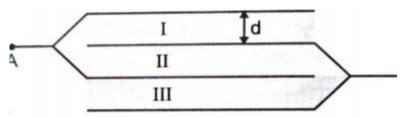
(a) 5μC (b) 10μC (c) 12μC (d) 15μC

4.If n capacitors each of capacitance C are connected in series, then the equivalent capacitance of the combination is

(a) NC (b) n^2C (c) C/n (d) C/n^2

2 MARKS QUESTIONS

Q3. A capacitor has some dielectric between its plates and the capacitor is connected to a DC source. The battery is now disconnected and then the dielectric is removed. State whether the capacitance, electric field, charge stored and the voltage will increase, decrease or remain constant.



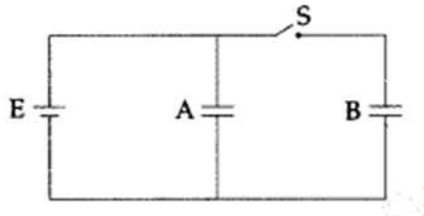
Q4.What is the capacitance of arrangement of 4 plates of area A at distance d in air in fig.

Q5. A parallel plate capacitor has square plates of side 5 cm and separated by a distance of 1 mm. (a) Calculate the capacitance of this capacitor. (b) If a 10 V battery is connected to the capacitor, what is the charge stored in any one of the plates? (The value of $\varepsilon_o = 8.85 \times 10^{-12}$ $Nm^2 C^{-2}$)

3 MARKS QUESTIONS

Q6. A 200 μF parallel plate capacitor having plate separation of 5 mm is charged by a 100 V dc source. It remains connected to the source. Using an insulated handle, the distance between the plates is doubled and a dielectric slab of thickness 5 mm and dielectric constant 10 is introduced between the plates. Explain with reason, how the (i) capacitance, (ii) electric field between the plates, (iii) energy density of the capacitor will change ?

Q7.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.



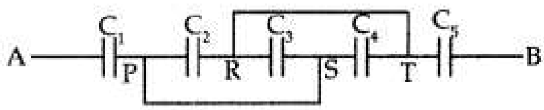
Find the ratio of the total electrostatic energy stored in both capacitors before and after the introduction of the dielectric.

5 MARKS QUESTIONS

Q8. A capacitor of unknown capacitance is connected across a battery of V volt. A charge of 120 μC is stored in it. When the potential across the capacitor is reduced by 40 V, the charge stored in the capacitor becomes 40 μC. Calculate V and the unknown capacitance. What would have been the charge in the capacitor if the voltage were increased by 40 V?

Q9. A capacitor of unknown capacitance is connected across a battery of V volt. A charge of 240 pC is stored in it. When the potential across the capacitor is reduced by 80 V, the charge stored in the capacitor becomes 80 pC. Calculate V and the unknown capacitance. What would have been the charge in the capacitor if the voltage were increased by 80 V?

Q10. Find equivalent capacitance between A and B in the combination given below. Each capacitor is of 2 μF capacitance.



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SECTION-C ANSWER KEY

1. (c) Here the system can be considered as two capacitors C_1 and C_2 connected in series.

CASE BASED STUDY QUESTION

2. 1.(c) 2. (b) 3. (b) 4.(c)

2 MARKS ANSWERS

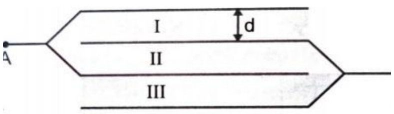
3. The capacitance of the parallel plate capacitor, filled with dielectric medium of dielectric constant K is given by $C=K\,\epsilon_0 A/d$

The capacitance of the parallel plate capacitor decreases with the removal of dielectric medium as for air or vacuum K = 1 and for dielectric K > 1.

If we disconnect the battery from capacitor, then the charge stored will remain the same due to conservation of charge.

The potential difference across the plates of the capacitor is given by $V = q/C$ Since q is constant and C decreases which in turn increases V and therefore E increases as $E = V/d$.

4.



$C_p = 3C = 3\,A\varepsilon_O/d$

5. The capacitance of this capacitor is 221.2×10^{-13} F. The charge stored in any one of the plates 221.2 pC.

3 MARKS ANSWERS

6. Dielectric slab of thickness 5mm is equivalent to an air capacitor of thickness = $\frac{5}{10}$mm

Effective separation between the plates with air in between is = 5.5 mm

Effective new capacitance = 200 μF X $\frac{5}{5\cdot5}$ = 182 μF

(ii)Effective new electric field = $\frac{100}{5\cdot5\times10^{-3}}$ =18182 V/m

New energy stored / original energy stored = 10/11

7.Given : $C_A = C_B = C$, Dielectric costant = K

Energy stored = $\frac{1}{2}Cv^2$ (i)

Net capacitance with switch S closed = C+C= 2C

E_1= Energy stored = CV^2 (ii)

After switch S is opened, capacitance of each capacitor = KC

Energy stored in capacitor A = $\frac{1}{2}kcv^2$ (iii)

For capacitor B,

Energy stored = $\frac{Cv^2}{2k}$ (iv)

From equations (iii) & (iv)

E_2 = Total energy stored = $\frac{1}{2}cv^2\left(\frac{k^2+1}{k}\right)$

Required Ratio = $\frac{E_1}{E_2} = \frac{2k}{k^2+1}$

5-MARKS ANSWERS

8. Answer:

Given : $q_1 = 360\ \mu C = 360 \times 10^{-6}\ \mu C$, $q_2 = 120\ \mu C = 120 \times 10^{-6}\ C$

$C = \frac{q_1}{V_1}$. Also $C = \frac{q_2}{V_2}$ and $C = \frac{q_3}{V_3}$

[∵ Capacitor is the same

$$\because \quad \frac{q_1}{V_1} = \frac{q_2}{V_2}$$

$$\Rightarrow \quad \frac{(360 \times 10^{-6})}{V} = \frac{(120 \times 10^{-6})}{(V - 120)}$$

On solving, **V = 180 V**

$$C = \frac{360 \times 10^{-6}}{180}$$

= **2μF** is the unknown capacitance.

Now the voltage has been increased by 120 V, then V = 180 + 120 = 300 V

$$C = \frac{q_3}{300} = 2\mu F$$

$$q_3 = 300 \times \mu C$$

q_3 = 600 μC would be charge on the capacitor if voltage were incresed by 120 V.

[Ans : V = 60 V, c = 2 pF, Q3 = 200 μC].

9.

Given : $q_1 = 360\ \mu C = 360 \times 10^{-6}\ \mu C$, $q_2 = 120\ \mu C$
$= 120 \times 10^{-6}$ C

$C = \frac{q_1}{V_1}$. Also $C = \frac{q_2}{V_2}$ and $C = \frac{q_3}{V_3}$

[$\because$ Capacitor is the same

$\because \quad \frac{q_1}{V_1} = \frac{q_2}{V_2}$

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Now the voltage has been increased by 120 V, then V = 180 + 120 = 300 V

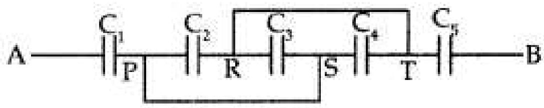
$C = \frac{q_3}{300} = 2\mu F$

$q_3 = 300 \times \mu C$

$q_3 = 600\ \mu C$ would be charge on the capacitor if voltage were incresed by 120 V.
[Answer : V = 120 V, c = 2 μF, Q = 400 μC]

10.

Given : $C_1 = C_2 = C_3 = C_4 = C_5 = 2\mu F$
$= 2 \times 10^{-6}$ F



(*i*) Capacitors C_2, C_3 and C_4 are in parallel

$\therefore \quad C_{234} = C_2 + C_3 + C_4 = 2 + 2 + 2$

$\therefore \quad C_{234} = 6\mu F$

Capacitors C_1, C_{234} and C_5 are in series

$\therefore \ \frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_{234}} + \frac{1}{C_5} = \frac{1}{2} + \frac{1}{6} + \frac{1}{2} = \frac{7}{6}\mu F$

$C_{equivalent} = \frac{6}{7}\mu F = \frac{6}{7} 10^{-6}$ F

(*ii*) Charge drawn from the source

$Q = C_{eq} V = \frac{6}{7} \times 7\ \mu C = 6\ \mu C$

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