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DPP – 5 (Capacitor)

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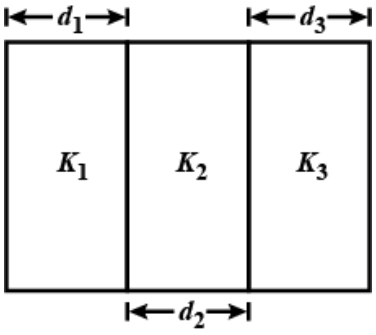
Q 1. The radii of a spherical capacitor are 0.5 m. and 0.6 m. If the empty space is completely filled by a medium of dielectric constant 6, then the capacity of the capacitor will be:
(a) 3.3×10^{-10}F (b) 2×10^{-9}F
(c) 2 F (d) 18 F

Q 2. An ebonite rod (K = 3), 6 mm thick is introduced between the plates of a parallel plate capacitor of plate area $4 \times 10^{-2}\ m^2$ and plate separation 0.01m. Find the capacitance.
(a) 59 pF (b) 40 pF
(c) 39 pF (d) 48 pF

Q 3. In a parallel plate capacitor of capacitance C, a metal sheet is inserted between the plates, parallel to them. If the thickness of the sheet is half of the separation between the plates. The capacitance will be
(a) $\frac{C}{2}$ (b) $\frac{3C}{4}$
(c) $4C$ (d) $2C$

Q 4. A parallel plate capacitor with air between the plates has a capacitance of 8 pF. What will be the capacitance if the distance between the plates is reduced by half, and the space between them is filled with a substance of dielectric constant 6?
(a) 26 pF (b) 36 pF
(c) 76 pF (d) 96 pF

Q 5. The expression for the capacity of the capacitor formed by compound dielectric placed between the plates of a parallel plate capacitor as shown in figure, will be (area of plate =A)



(a) $\frac{\varepsilon_o A}{\left(\frac{d_1}{k_1}+\frac{d_2}{k_2}+\frac{d_3}{k_3}\right)}$ (b) $\frac{\varepsilon_o A}{\left(\frac{d_1 d_2 d_3}{k_1 k_2 k_3}\right)}$

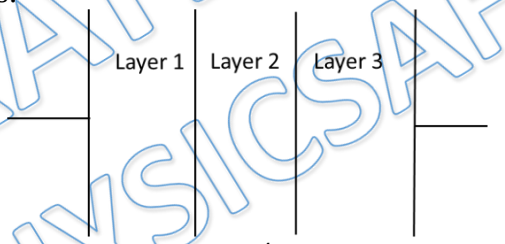
(c) $\frac{\varepsilon_o A(k_1 k_2 k_3)}{(d_1 d_2 d_3)}$ (d) $\varepsilon_o \left(\frac{Ak_1}{d_1} + \frac{Ak_2}{d_2} + \frac{Ak_3}{d_3}\right)$

Q 6. A capacitor with air as the dielectric is charged to a potential of 100 volts. If the space between the plates is now filled with a dielectric of dielectric constant 10, the potential difference between the plates will be
(a) 1000 volts (b) 100 volts
(c) 10 volts (d) zero

Q 7. Air filled capacitor is charged by a battery and after charging battery is removed. A slab of dielectric material is inserted in it to fill the space completely. The electric field in the capacitor is
(a) Increased (b) Decreased
(c) Remains constant (d) First increased then decreased

Q 8. While a capacitor remains connected to a battery and dielectric slab is applied between the plates, then
(a) Potential difference between the plates is changed
(b) Charge flows from the battery to the capacitor
(c) Electric field between the plates increases
(d) Energy store in the capacitor decreases

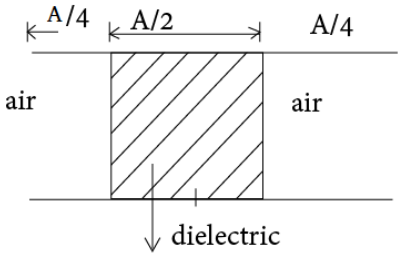
Q 9. The figure shows a charged capacitor having three layers of equal thickness and same area A that of a plate. Layer 1 is vacuum; layer II conductor and layer III is a dielectric of dielectric constant K The ratio of energy stored in region III to total energy stored in the capacitor is:



(a) $\frac{3}{k+1}$ (b) $\frac{4}{k+3}$
(c) $\frac{1}{k+1}$ (d) $\frac{4}{3k+1}$

Q 10. If the maximum circumference of a sphere is 2 m, then its capacitance in water would be:
(Dielectric constant of water = 81)
(a) 27.65 pF (b) 2385 pF
(c) 236.5 pF (d) 2865 pF

Q 11. Consider a parallel plate capacitator of capacity 10 μF filled with air. When the gap between the plates is filled partly with a dielectric of dielectric constant 4, as shown in figure, the new capacity of the capacitator is (A is the area of plates):

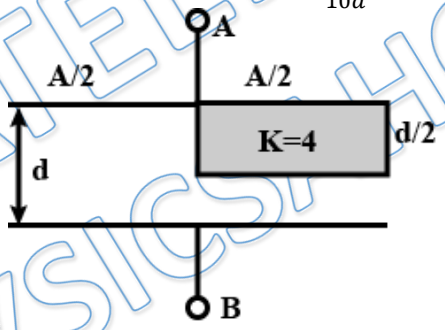


(a) 20 μF (b) 40 μF
(c) 2.5 μF (d) 25 μF

Q 12. Two parallel plate capacitors of capacitances C and 2C are connected in parallel and charged to a potential difference V. The battery is then disconnected, and the region between the plates of C is filled completely with a material of dielectric constant K. The common potential difference across the combination becomes:

(a) $\frac{2V}{K+2}$ (b) $\frac{V}{K+1}$
(c) $\frac{2+V}{K+2}$ (d) $\frac{3V}{K+2}$

Q 13. In the figure shown find the equivalent capacitance between terminals 'A' and 'B'. The letters have their usual meaning capacitance is $\frac{x\varepsilon_o A}{10d}$ then x is?



(a) 7 (b) 13
(c) 21 (d) 19

Q 14. The capacitance of a parallel plate capacitor in air is 2 μF. If a dielectric medium is placed between the plates then the potential difference reduces to $\frac{1}{6}$ of the original value. The dielectric constant of the medium is:
(a) 6 (b) 3
(c) 2.2 (d) 4.4

Q 15. A battery of 100 V is connected to series combination of two identical parallel-plate condensers. If dielectric of constant 4 is slipped between the plates of second condenser, then the potential difference on the condensers will respectively become:
(a) 80 V, 20 V (b) 75 V, 25 V
(c) 50 V, 80 V (d) 20 V, 80 V

Q 16. A parallel plate air capacitor of capacitance C is connected to a cell of emf V and then disconnected from it. A dielectric slab of dielectric constant K, which can just fill the air gap of the capacitor, is now inserted in it. Which of the following is incorrect?

(a) The change in energy stored is $\frac{1}{2}CV^2\left(\frac{1}{k}-1\right)$

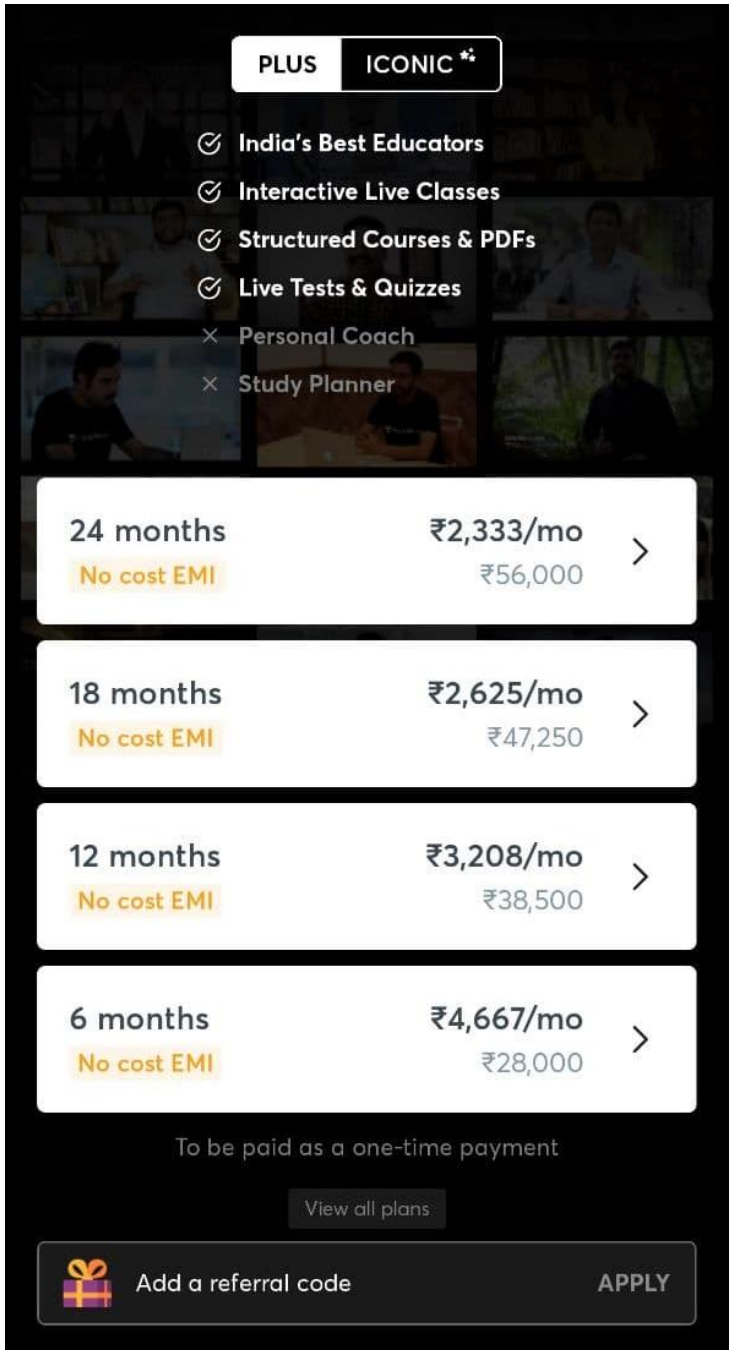
(b) The charge on the capacitor is not conserved

(c) The potential difference between the plates decreases k times.

(d) The energy stored in the capacitor decreases k times

Answer Key

Q.1 b	**Q.2 a**	**Q.3 d**	**Q.4 d**	**Q.5 a**
Q.6 c	**Q.7 b**	**Q.8 b**	**Q.9 c**	**Q.10 d**
Q.11 d	**Q.12 d**	**Q.13 b**	**Q.14 a**	**Q.15 a**
Q. 16 b				



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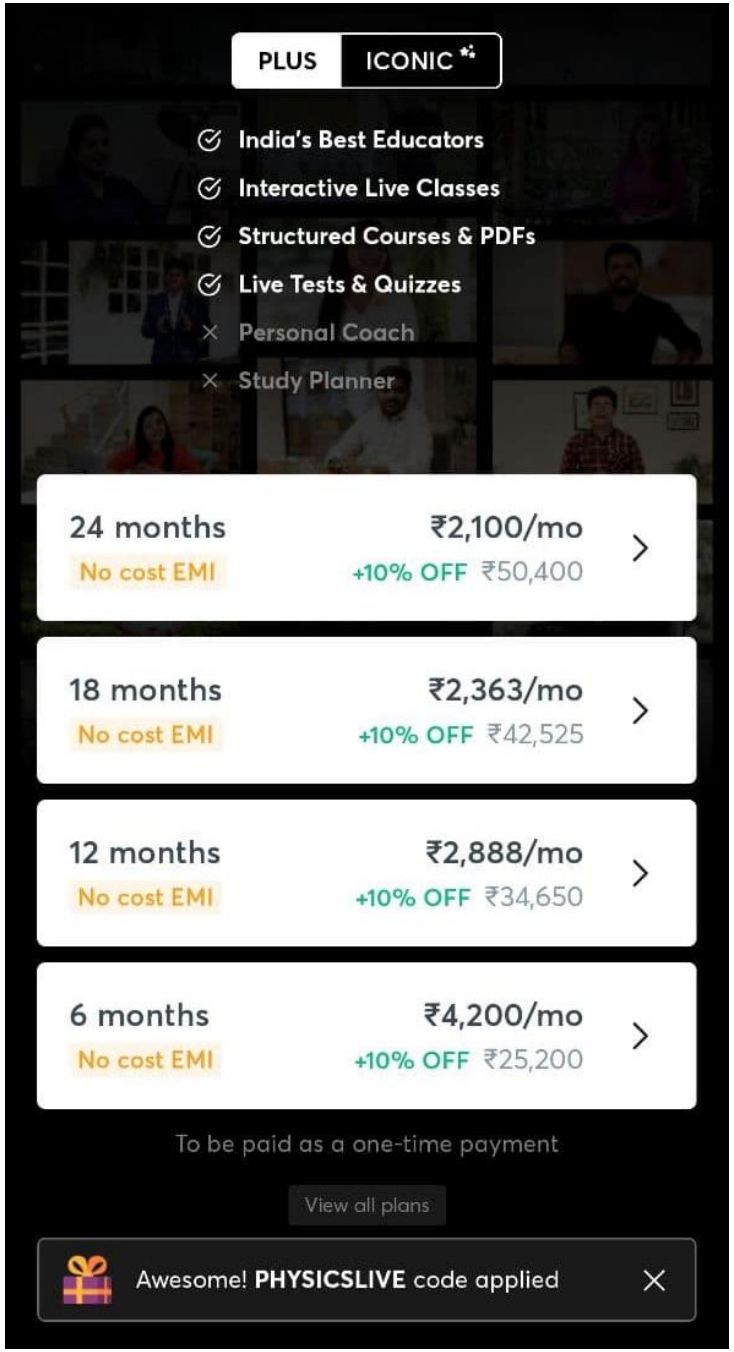


Written Solution

DPP 5 – Capacitor: Effect of Dielectric on Capacitor

By Physicsaholics Team

Solution: 1

$$C = K\left(\frac{4\pi\varepsilon_0 (a \cdot b)}{(b-a)}\right)$$

$$C = 6 \times \frac{4 \times 3.14 \times 8.85 \times 10^{-12} \times (0.5 \times 0.6)}{(0.6 - 0.5)}$$

$$C = 6 \times 33.3 \times 5 \times 10^{-12}$$

$$C = 6 \times 3.335 \times 10^{-10}\ F$$

$$\boxed{C = 2 \times 10^{-9}\ F}$$

Ans. b

Solution: 2

$$C = \frac{\epsilon_0 A}{d - t + \frac{t}{k}}$$

$$C = \frac{8.85 \times 10^{-12} \times 4 \times 10^{-2}}{0.01 - 0.006 + \frac{0.006}{3}}$$

$$C = \frac{8.85 \times 4 \times 10^{-2}}{0.004} \times 10^{-12}$$

$$C = \frac{8.85 \times 4 \times 10^{-2}}{0.006} \times 10^{-12}$$

$$C = \frac{8.85 \times 4 \times 10^{-2}}{6 \times 10^{-3}} \times 10^{-12}$$

$$\boxed{C = 59 \text{ pF}}$$ Ans

Ans. a

Solution: 3

for metal Plate; $k = \infty$

& thickness of Plate given; $t = d/2$

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

$$C' = \frac{\epsilon_0 A}{d - t + \frac{t}{k}} = \frac{\epsilon_0 A}{d - \frac{d}{2} + \frac{d/2}{\infty}} = \frac{\epsilon_0 A}{d - \frac{d}{2} + 0}$$

$$C' = \frac{\epsilon_0 A}{d/2}$$

$$C' = 2\,\frac{\epsilon_0 A}{d}$$

$$\boxed{C' = 2C}$$ Ans

Ans. d

Solution: 4

$$C = 8\ pF = \frac{\epsilon_0 A}{d}$$

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

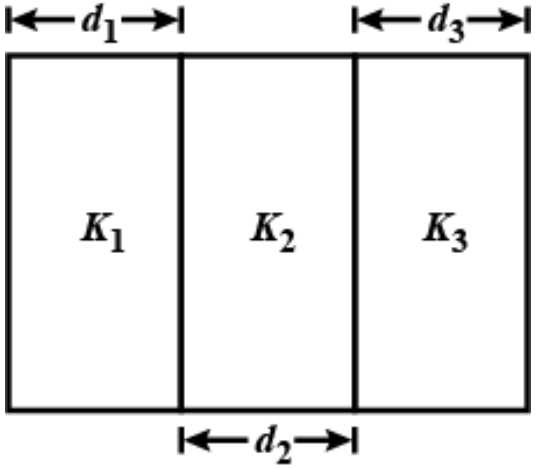
$$\frac{8\ pF}{C'} = \frac{\epsilon_0 A/d}{K \epsilon_0 A/d'}$$

$$\frac{8\ pF}{C'} = \frac{d'}{Kd} = \frac{d/2}{6 \times d} = \frac{1}{12}$$

$$\boxed{C' = 96\ pF}$$ Ans

Ans. d

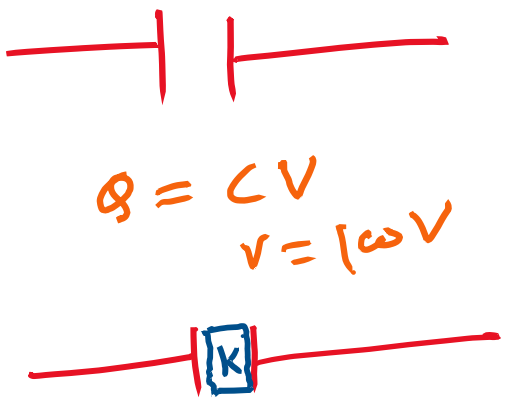
Solution: 5



$$C = \frac{\epsilon_0 A}{\frac{d_1}{K_1} + \frac{d_2}{K_2} + \frac{d_3}{K_3}}$$

Ans. a

Solution: 6



$Q = CV$

$V = 100\,V$

$Q_2 = C_2 V_2$

$CV = C_2 V_2$

$CV = (KC) V_2$

$$V_2 = \frac{V}{K}$$

$$V_2 = \frac{100}{10}$$

$$V_2 = 10 \text{ Volt}$$ Ans

Ans. c

Solution: 7

Let capacitor 'C' charged with batter V

so charge on capacitor

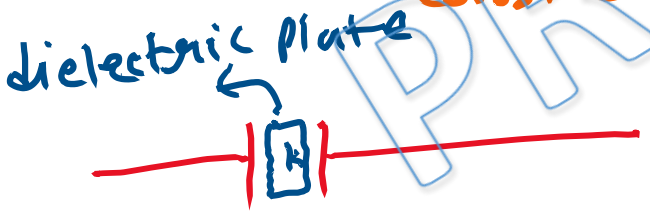
$q_0 = CV$

Now battery removed.

$E = \frac{V}{d}$

$q_0 = CV$

↳ charg will remain constant.



$C' = KC$

$q = C'V'$

$q = CV = C'V'$

$CV = (KC)V'$

$V' = \frac{V}{K}$

$\therefore E = \frac{V}{d}$

$E' = \frac{V'}{d}$

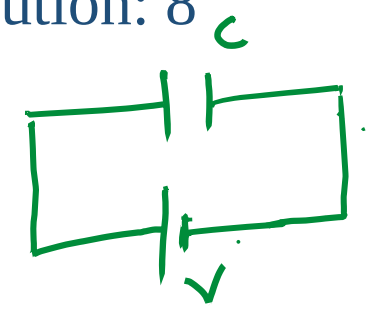
$E' = \frac{V}{Kd}$

$E' = \frac{E}{K}$ ∴

Electric field decreases K time.

Ans. b

Solution: 8



When capacitor is connected to battery; V = remains constant

is $\boxed{V = \text{constant}}$

$E = \frac{V}{d} = \text{constant}$

$\boxed{E = \text{constant}}$

$C' = KC$ (increases)

$U = \frac{1}{2} C V^2$

$U' = \frac{1}{2} (KC) V^2 = KU$ (increases)

$Q = CV$

$Q' = (KC)V$

$Q' = KQ$

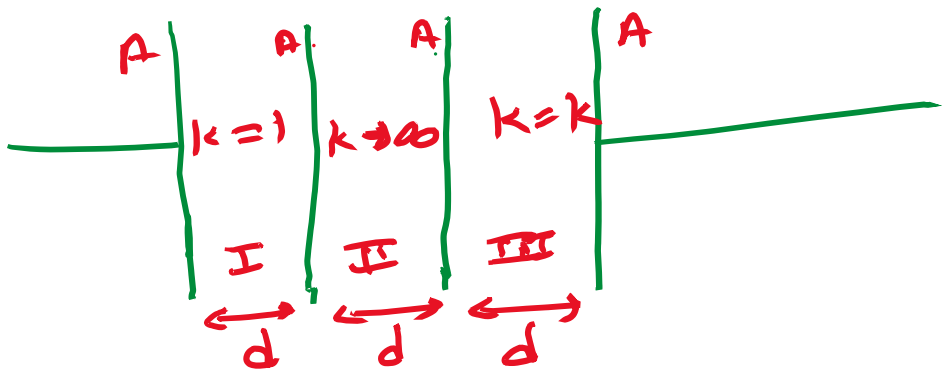
$\because K > 1$

so, $Q' > Q$ [charge increased]

$\Rightarrow$ so, charge flowed from battery to capacitor

Ans. b

Solution: 9



∵ all three partitions are capacitors in series

so; Q = will be same on all

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

then; $C_1 = C$, $C_2 \to \infty$, $C_3 = kC$

$$U_1 = \frac{Q^2}{2C_1} = \frac{Q^2}{2C}$$

$$U_2 = \frac{Q^2}{2C_2} = 0, \quad U_3 = \frac{Q^2}{2C_3} = \frac{Q^2}{2kC}$$

$$U = U_1 + U_2 + U_3 = \frac{Q^2}{2C} + 0 + \frac{Q^2}{2kC}$$

$$U = \frac{Q^2}{C}\left(\frac{1}{2} + \frac{1}{2k}\right) = \frac{Q^2}{2kC}(k+1)$$

$$\frac{U_3}{U} = \frac{Q^2/2kC}{\frac{Q^2}{2kC}(k+1)} = \frac{2}{k+2}$$

$$\boxed{\frac{U_3}{U} = \frac{1}{k+1}} \text{ Ans}$$

Ans. c

Solution: 10

$$C = K(4\pi\epsilon_0 R)$$

given; $2\pi R = 2\ m$

$$\pi R = 1\ m$$

so; $C = K\epsilon_0[4\pi R]$

$$= 81 \times 8.85 \times 10^{-12} \times 4 \times 1$$

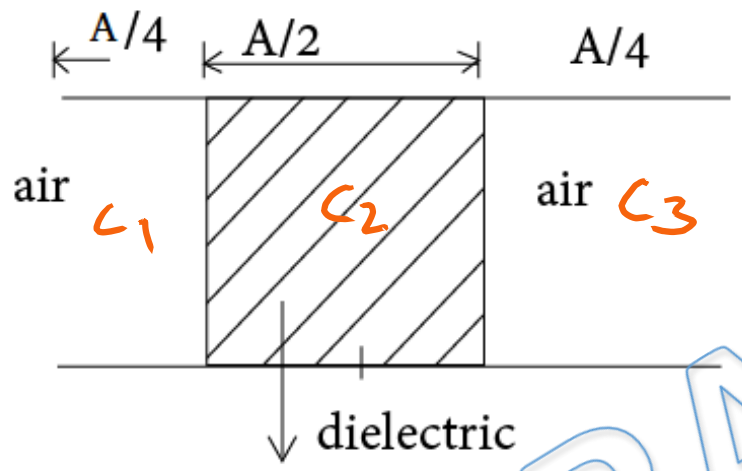
$$= 1432.7 \times 10^{-12}\ F$$

$$C \simeq 2865\ pF \quad \text{Ans}$$

Ans. d

Solution: 11

$C = \frac{\epsilon_0 A}{d} = 10\,\mu F$



C_1, C_2 & C_3 are in parallel

$C_1 = \frac{\epsilon_0 (A/4)}{d} = \frac{\epsilon_0 A}{4d} = C/4$

$C_2 = \frac{K\epsilon_0 (A/2)}{d} = \frac{4\epsilon_0 A}{2d} = \frac{2\epsilon_0 A}{d} = 2C$

$C_3 = \frac{\epsilon_0 (A/4)}{d} = \frac{\epsilon_0 A}{4d} = C/4$

$C_{eq} = \frac{C}{4} + 2C + \frac{C}{4}$

$= \frac{C}{2} + 2C$

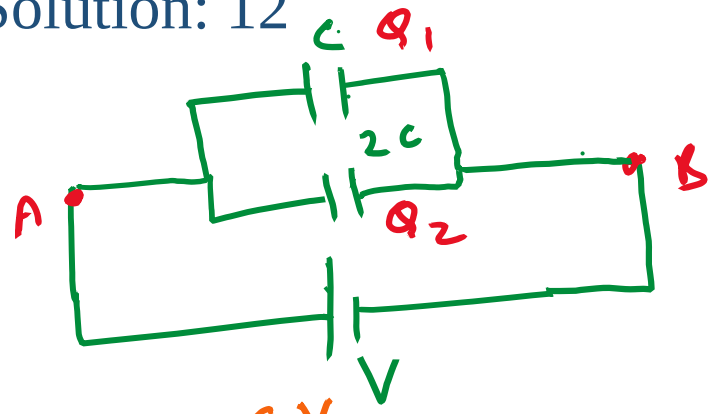
$C_{eq} = \frac{5C}{2}$

$C_{eq} = \frac{5}{2} \times 10$

$C_{eq} = 25\,\mu F$ Ans

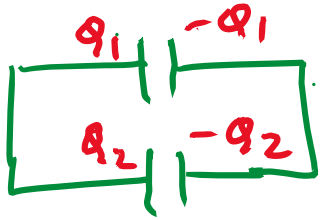
Ans. d

Solution: 12



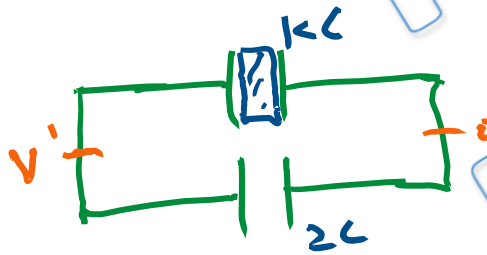
$Q_1 = CV$

$Q_2 = 2CV$



⇓

Now dielectric plate inserted



$$V' = \frac{C_1V_1 + C_2V_2}{C_1 + C_2} = \frac{Q_1 + Q_2}{C_1 + C_2}$$

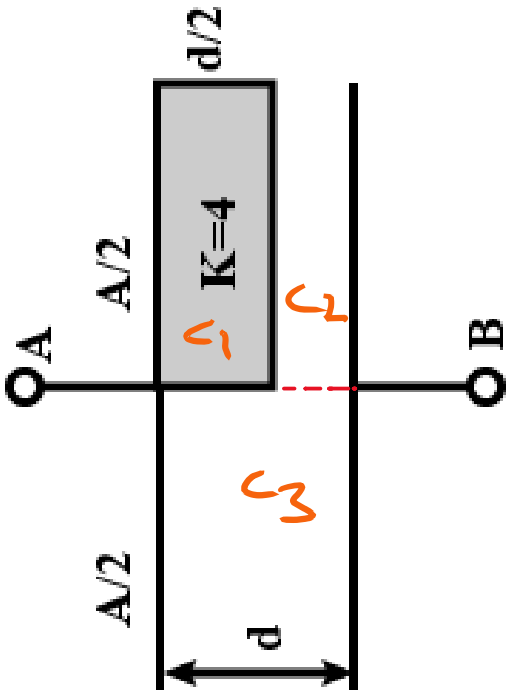
$$V' = \frac{CV + 2CV}{KC + 2C}$$

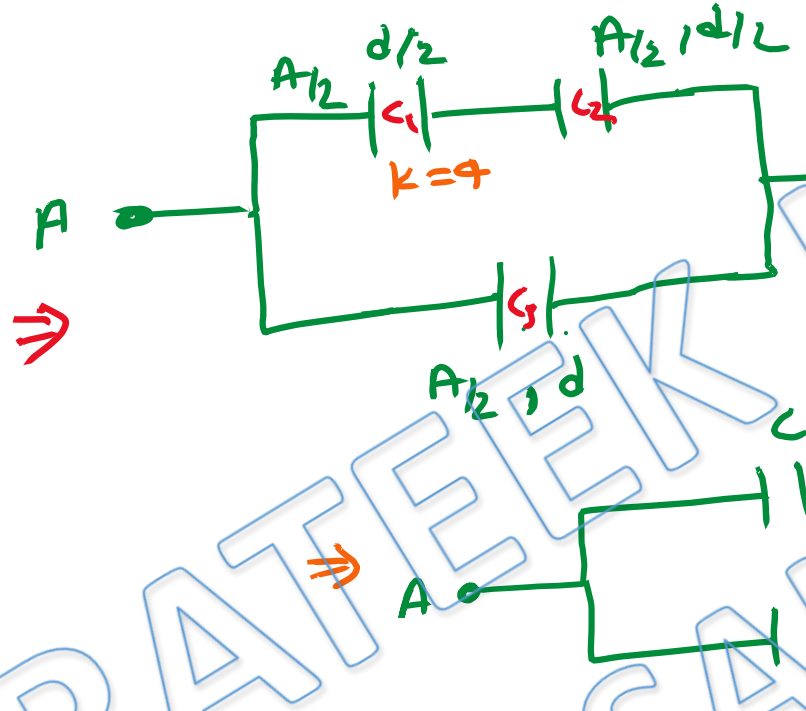
$$V' = \frac{3CV}{C(K+2)}$$

$$\boxed{V' = \frac{3V}{K+2}} \quad \text{Ans}$$

Ans. d

Solution: 13





$C_1 = \frac{4\epsilon_0 A/2}{d/2} = \frac{4\epsilon_0 A}{d}$

$C_2 = \frac{\epsilon_0 A/2}{d/2} = \frac{\epsilon_0 A}{d}$

$C_3 = \frac{\epsilon_0 A/2}{d} = \frac{\epsilon_0 A}{2d}$

$C' = \frac{C_1 C_2}{C_1 + C_2} = \frac{\frac{4\epsilon_0 A}{d} \cdot \frac{\epsilon_0 A}{d}}{\frac{4\epsilon_0 A}{d} + \frac{\epsilon_0 A}{d}}$

$$C' = \frac{4\epsilon_0 A}{5d}$$

$C_{eq} = C' + C_3$

$C_{eq} = \frac{4\epsilon_0 A}{5d} + \frac{\epsilon_0 A}{2d}$

$C_{eq} = \frac{\epsilon_0 A}{d}\left(\frac{4}{5} + \frac{1}{2}\right)$

$C_{eq} = \frac{\epsilon_0 A}{d}\left(\frac{13}{10}\right)$

$$C_{eq} = \frac{13\epsilon_0 A}{10d}$$

So; $n = 13$

Ans

Ans. b

Solution: 14

Before dielectric Plate;

$C_1 = 2\ \mu F$

$V_1 = V$

after dielectric Plate

$C_2 = kC_1 = 2k\ \mu F$

$V_2 = \frac{V}{6}$

$\because \quad q_1 = q_2$

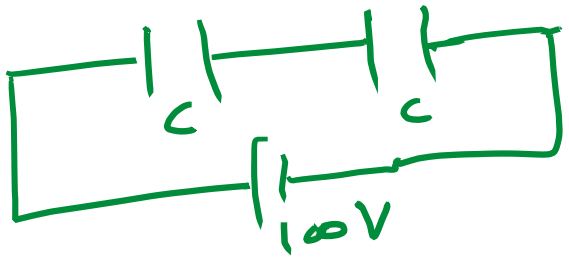
$(2\ \mu F)\, V = (2k\ \mu F) \cdot \frac{V}{6}$

$V = \frac{kV}{6}$

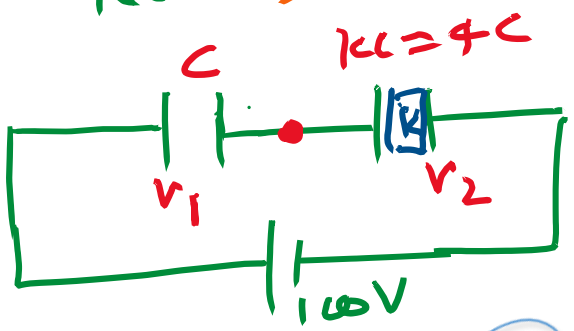
$\boxed{k = 6}$ Ans

Ans. a

Solution: 15



Now ⇒



$V_1 + V_2 = 100\ V$

$q_1 = q_2$ [in series]

$C \times V_1 = 4C \times V_2$

$V_1 = 4V_2$

$4V_2 + V_2 = 100\ V$

$5V_2 = 100\ V$

$V_2 = 20$ Volt

so; $V_1 = 80$ Volt Ans

Ans. a

Solution: 16

Initially:

$C_1 = C$

$q_1 = CV$

$V_1 = V$

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

After dielectric plate inserted:

$\because C_2 = kC$

$q_2 = q_1 = CV$ [$\because$ battery is disconnected so; q = conserved]

so; $(kC)V_2 = CV$

$\Rightarrow \boxed{V_2 = \frac{V}{k}}$ ✓

$U_2 = \frac{1}{2}C_2V_2^2 = \frac{1}{2}kC\left(\frac{V}{k}\right)^2$

$U_2 = \left(\frac{1}{2}CV^2\right)\frac{1}{k}$

$\boxed{U_2 = \frac{U}{k}}$ ✓

Change in Stored Energy:

$\Delta U = U_2 - U_1 = \left(\frac{1}{2}CV^2\right)\frac{1}{k} - \frac{1}{2}CV^2$

$\boxed{\Delta U = \frac{1}{2}CV^2\left(\frac{1}{k} - 1\right)}$ ✓ Ans

Ans. b

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