# Capacitor

## SOLUTIONS

### Exercise-I (Conceptual Questions)

**1.** C $\rightarrow$ Depends material & dimensions only

**2.** Q = CV

C $\rightarrow$ does not depend on Q and V

Q $\uparrow$ V $\uparrow$

**3.** Charge on capacitor = Charge of positive plate or negative plate. Net charge on capacitor = 0

**4.** $C = 4\pi\varepsilon_0 R$ and $V = \frac{4}{3}\pi R^3$

$A = 4\pi R^2$

$R = \left(\frac{3V}{A}\right)$

$\therefore \quad C = 12\pi\varepsilon_0\left(\frac{V}{A}\right)$

**5.** Current

**6.** Energy Source → Battery, Capacitor

**7.** $C = 4\pi\varepsilon_0 R\varepsilon_r \quad \left[\because\ 2\pi R = 2 \Rightarrow R = \frac{1}{\pi}\right]$

$C = \frac{4\pi\varepsilon_0\varepsilon_r}{\pi}$

$C \approx 2800$ pF

**8.** Energy supplied by the battery is

$U = CV^2 = Q^2/C = QV$

$= (10^{-6})(300)$

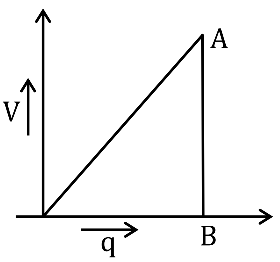
$= 3 \times 10^{-4}$J

**9.** It does not depend on the resistance

$\frac{1}{2}CV^2 = \frac{1}{2}\times 2\times 10^{-4}\times(200)^2 = 4J$

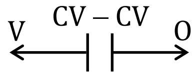
**10.** $V = \frac{Q}{C}$

**11.**



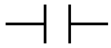

Area $= \frac{1}{2}qV$ = Energy stored in capacitor.

**12.**




Work = $CV^2 \Rightarrow U = \frac{1}{2}CV^2$

**13.**



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

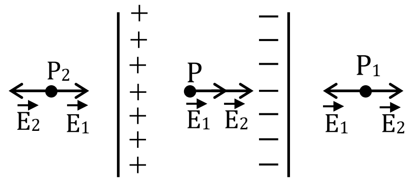
**14.** $C = \frac{\epsilon_0 A}{d}$

$Q = CV = \frac{\epsilon_0 AV}{d}$

$= \frac{8.85\times10^{-12}\times400\times10^{-4}\times200}{2\times10^{-3}}$

$= 3.54 \times 10^{-8}$ C

**15.**




at P, $E = \frac{q}{2A\varepsilon_0}$

at $P_1$ & $P_2$ E = 0

**16.** r = 20 mm for sphere

$A = \pi r^2 \qquad C' = 4\pi\epsilon_0 R$

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

$\frac{\epsilon_0 A}{d} = 4\pi\epsilon_0 R \Rightarrow d = \frac{\epsilon_0 r^2}{4\epsilon_0 R} = 1 \times 10^{-4}$ m

= 0.1 mm

**17.** Use $U = \frac{1}{2}\epsilon_0 E^2$

**18.** Q-same

$U' \propto \frac{1}{C} \qquad C' = KC$

$U' = \frac{CU_0}{C'} = \frac{U_0}{K}$

**19.** Q remains same.

$U = \frac{Q^2}{2C}$

$\therefore \qquad C' = KC = 6C$

& $U' = \frac{U}{K} = \frac{U}{6}$

**20.** $C=\dfrac{\epsilon_0 A}{d-t+\dfrac{t}{K}}$

**21.** Q = CV;
when a slab of dielectric medium is placed capacitance is increased
$Q \propto C$ so charge is also increased

**22.** Charge does not change. It remains constant.

**23.** $U=\dfrac{1}{2}CV^2$

$\because$ when a dielectric is inserted then $C\uparrow$ so $U\uparrow$

**24.** $U=\dfrac{Q^2}{2C}$ $\because C\uparrow \therefore U\downarrow$

**25.** $U=\dfrac{Q^2}{2C}$

$\because C=\dfrac{\epsilon_0 A}{d}$

If $d\downarrow C\uparrow U\downarrow$

**26.** $E=\dfrac{V}{d}$

$\because d\uparrow E\downarrow$

$\because Q = CV$ and $C=\dfrac{\epsilon_0 A}{d}$

$\because d\uparrow C\downarrow Q\downarrow$

**27.** Battery $\rightarrow$ removed
$Q \rightarrow$ constant

$V=\dfrac{Q}{C}$ if $d\uparrow C\downarrow V\uparrow$

**28.** No

**29.** $C=\dfrac{\epsilon_0 A}{d}$; $C_1=\dfrac{\epsilon_0 A}{2d}=\dfrac{C}{2}$

$C_2=\dfrac{5\epsilon_0 A}{2d}=\dfrac{5}{2}C$

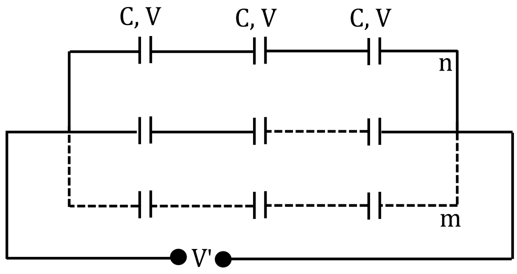
$C_{eq} = C_1 + C_2 = 3C$

$\dfrac{\Delta C}{C}\% = \dfrac{2C}{C}\times 100 = 200\%$

**30.** $C_{AB}=\dfrac{2}{3}+2=\dfrac{8}{3}\ \mu F$

**31.** $V_2 = V_3$
$Q_1 = Q_2 + Q_3$
$V = V_1 + V_2$

**32.** $C = 1\ \mu F$, $C' = 3\ \mu F$
$V = 500\ V$, $V' = 2000\ V$




Suppose m rows of given capacitors are connected in parallel and each row now contains n capacitors then potential difference across each capacitor $V=\dfrac{V'}{n}$ and equivalent capacitance of network $C'=\dfrac{mC}{n}$

on putting values,

$\Rightarrow \quad V=\dfrac{V'}{n} \quad \Rightarrow \quad 500=\dfrac{2000}{n}$

$n = 4 \quad \Rightarrow \quad C'=\dfrac{mC}{n}$

$3=\dfrac{m\times 1}{4} \quad \Rightarrow \quad m = 12$

$\therefore$ total capacitors = m × n = 48

**33.** Given circuit is balanced wheat stone bridge. Hence effective capacity is 6μF.

**34.** $\dfrac{V_1}{V_2}=\dfrac{C_2}{C_1}=\dfrac{10}{1}$

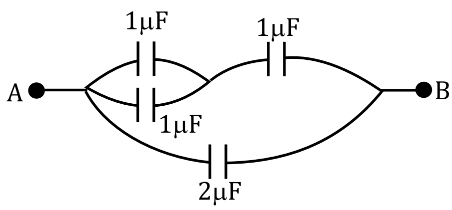
$V_1=\dfrac{500}{11}\times 10=\dfrac{5000}{11}$ volt

**35.** C and C are in parallel and in series with 2C. Therefore resultant of these three will be

$=\dfrac{(C+C)\times 2C}{C+C+2C}=C$

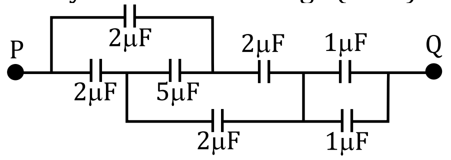
This equivalent system is in parallel with C.
It's equivalent capacitance = C + C = 2C
Now, 2C and 2C are in series and in parallel with 2C.
So, $C_{net}$ = C + 2C = 3C

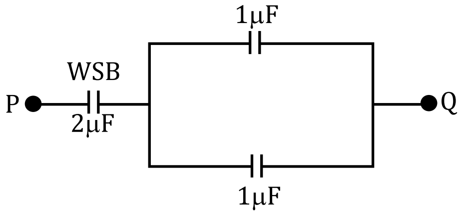
**36.**




Redraw the circuit $C_{AB}=\dfrac{8}{3}\ \mu F$

**37.** Identify Wheatstone bridge (WSB)




$C_{PQ} = 1\mu F$

**38.** Let Initial charge = q

then from charge conservation

$Q_1 + Q_2 = Q'_1 + Q'_2$

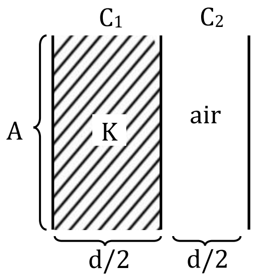
$q + q = C_1V + C_2V = V[C_1+C_2]$

$$V = \frac{2q}{C_1+C_2} = \frac{2q}{4\pi\epsilon_0(R_1+R_2)} = \frac{2kq}{(R_1+R_2)}$$

$$\Rightarrow q = \frac{V(R_1+R_2)}{2k}$$

**39.** As the potential of two spheres is same hence there will be no flow of charge.

**40.**




$$C = \frac{\epsilon_0 A}{d} \Rightarrow C_1 = \frac{\epsilon_0 KA}{d/2} = \frac{2\epsilon_0 KA}{d}$$

$$C_2 = \frac{\epsilon_0 A}{d/2} = 2\left(\frac{\epsilon_0 A}{d}\right)$$

$C_1$ & $C_2$ are in series combination

$$\text{Hence } \frac{1}{C_s} = \frac{1}{C_1} + \frac{1}{C_2} = \frac{d}{2\epsilon_0 A}\left(\frac{1}{K} + \frac{1}{1}\right)$$

$$\frac{1}{C_s} = \frac{d}{2\epsilon_0 A}\left(\frac{K+1}{K}\right)$$

$$C_s = \frac{2\epsilon_0 A}{d}\left(\frac{K}{K+1}\right) \Rightarrow C_s = \frac{2CK}{K+1}$$

**41.** Q same $_{\rightarrow}$ $Q = C_1V_{AD} = C_1(V_1 - V_D)$

and $Q = C_2V_{DB} = C_2(V_D - V_2)$

$C_1(V_1 - V_D) = C_2(V_D - V_2)$

$C_1V_1 + C_2V_2 = (C_1 + C_2)V_D$

$$V_D = \frac{C_1V_1 + C_2V_2}{C_1 + C_2}$$

**42.** Since both capacitors are in series so charge on each capacitor will be same.

Applying KVL from A to B :-

$$V_A - V_B = \frac{Q}{C_1} - E + \frac{Q}{C_2}$$

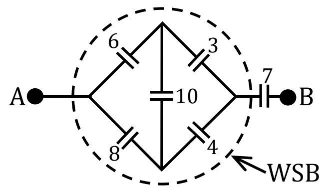
$$\text{or} \quad V_A - V_B + E = Q\left[\frac{1}{C_1} + \frac{1}{C_2}\right]$$

$$5 + 10 = Q\left[\frac{3}{2}\times 10^6\right]$$

$$Q = \frac{30}{3} = 10\ \mu C$$

$$V_1 = \frac{Q}{C_1} = \frac{10\times 10^{-6}}{1\times 10^{-6}} = 10V$$

**43.** Redraw circuit




$C_{net}$ of W.S.B.

$$= \frac{6\times 3}{6+3} + \frac{8\times 4}{8+4}$$

$$= 2 + \frac{32}{12} = \frac{14}{3}$$

This is in series with 7

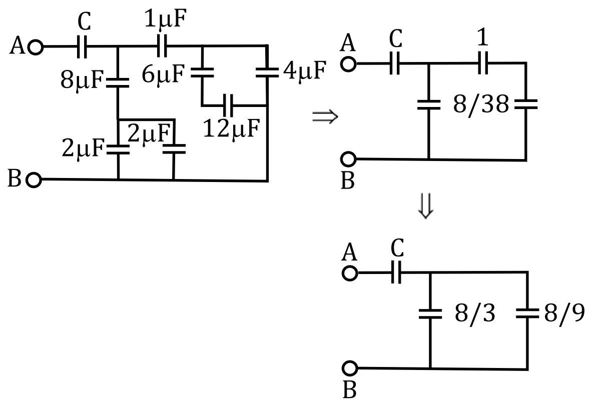
$$\text{So, } C_{eq.} = \frac{\frac{14}{3}\times 7}{\frac{14}{3}+7} = \frac{14}{5}$$

**44.** $C_{net}$ of $C_1$ and $C_2$, $C_{net} = \dfrac{C_1C_2}{C_1+C_2}$ $\{C_1 < C_2\}$

So, $C_{net}$ will be smaller than $C_1$

$C_{net} < C_1 < C_2$ so $\dfrac{C_1}{2} < C < C_1$

**45.**




$$C_{AB} = \frac{C\times\frac{32}{9}}{C+\frac{32}{9}} = 1 \Rightarrow C = \frac{32}{23}\mu F$$

**46.** When capacitor is fully charged. There will be no flow of current through capacitor.

So, $I = \dfrac{2.5}{2+0.5} = 1\text{ A}$

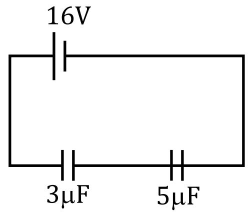
P.D. across upper branch = $2\Omega \times 1\text{A} = 2\text{V}$

and same voltage on lower branch

$V_C + V_{2\Omega} = 2\text{V}$

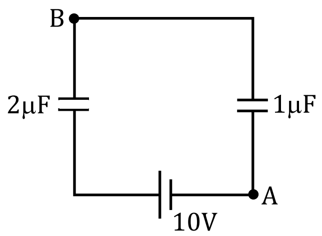
{but voltage on $2\Omega = 0$ as no current}

$V_C = 2\text{V}$, So $Q = 2\text{V} \times 5\mu\text{F} = 10\ \mu\text{C}$

**47.** 


$V_3 = \dfrac{5}{3+5} \times 16 = 10\text{V}$

**48.** Given circuit can be reduced as




Charge on capacitors = $\left(\dfrac{2}{3}\right)(10)\mu\text{C}$

Now $V_B - V_A = \left(\dfrac{20}{3}\right)(1) = \dfrac{20}{3}$

$\Rightarrow V_B = V_A + \dfrac{20}{3} = 10 + \dfrac{20}{3} = \dfrac{50}{3}\text{V}$

**49.** $C_2$ & $C_3$ are in parallel so $V_2 = V_3$

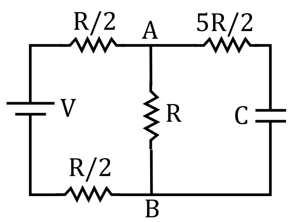
Let $C_1 = C$

$C_2 = C_3 = \dfrac{C_1}{2} = \dfrac{C}{2}$

Equivalent of $C_2$ & $C_3 = \dfrac{C}{2} + \dfrac{C}{2} = C$

So $V_1 = V_2 = V_3$

**50.** In steady state $V_C = V_{AB}$ = capacitor voltage = $V/2$




**51.** At $t \to \infty$ $V_{AB} = \dfrac{V}{2}, i_{AB} = \dfrac{V}{2R}$

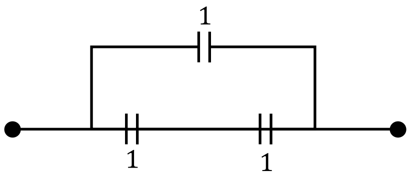
**52.** Bulb light up during charging

**53.** $C = \dfrac{\epsilon_0 A}{d} = 10\ \mu\text{F}$

$C_1 = \dfrac{k_1 \epsilon_0 A}{2d} = 10\ \mu\text{F}$

$C_2 = \dfrac{k_2 \epsilon_0 A}{2d} = 20\ \mu\text{F}$

$C_{eq} = C_1 + C_2 = 30\ \mu\text{F}$

**54.** 

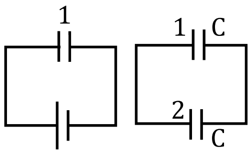

$C_{net} = 1.5\ \mu\text{F}$

**55.** Whenever there is transfer of charge some energy dissipates in the form of heat hence potential energy of system decreases.

If $V_1 \neq V_2$ then charge transfer takes place

$\Rightarrow \dfrac{kQ_1}{R_1} \neq \dfrac{kQ_2}{R_2}$

$Q_1R_2 \neq Q_2R_1$

**56.** 


energy stored (U) = $\dfrac{q^2}{2C}$

After connecting with another capacitor

$V_{\text{Common}} = \dfrac{q_1 + q_2}{C_1 + C_2} = \dfrac{q + 0}{C + C} = \dfrac{q}{2C}$

$\because$ Energy on each capacitor

$= \dfrac{1}{2} CV_{\text{Common}}^2 = \dfrac{1}{2} C\left(\dfrac{q}{2C}\right)^2 = \dfrac{1}{2}\dfrac{q^2}{4C} = \dfrac{U}{4}$

**57.** $\dfrac{1}{C_{eq}} = \dfrac{1}{3} + \dfrac{1}{10} + \dfrac{1}{15}$

$C_{eq} = 2\mu\text{F}$

$Q_{eq} = (2 \times 100)\ \mu\text{C} = 200\mu\text{C}$

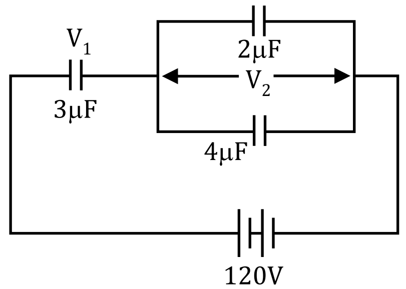
**58.** $V_A = \dfrac{C_B}{C_A + C_B} V_T = 6\text{V} \Rightarrow V_B = (10 - 6)\text{V} = 4\text{V}$

$\Rightarrow \dfrac{V_A}{V_B} = \dfrac{3}{2}$

**59.** $U_s = \frac{1}{2}kx^2 = 500\text{J}$ $\left[k = \frac{F}{x}\right]$

$U_C = \frac{1}{2}CV^2 = 500\text{ J} \Rightarrow \frac{U_s}{U_c} = \frac{1}{1}$

**60.**




$C_{eq} = \frac{6\times3}{6+3} = 2\mu F$

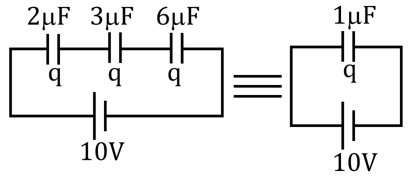
$\therefore$ Q = 120 × 2 μC = 240μC

$V_1 = \frac{240}{3} = 80\text{ V}$

$V_2 = 40\text{ V} \Rightarrow Q_2 = 40 \times 2 = 80\text{ C}$

$Q_3 = 40 \times 4 = 160\text{ C}$

**61.**




$\frac{1}{C} = \frac{1}{2} + \frac{1}{3} + \frac{1}{6} = \frac{6}{6} \Rightarrow C = 1\ \mu C$

$\Rightarrow q = 10^{-6} \times 10 = 10\ \mu C$

**62.** After connecting V become same

$\frac{E_a}{E_b} = \frac{b}{a}$

**63.** $C = \frac{4\pi\epsilon_0 R_1R_2}{R_2 - R_1}$

**64.** $C = \frac{4\pi\epsilon_0 b^2}{b-a}$

**65.** $\tau = RC$

**66.** Energy density $= \frac{1}{2}\epsilon_0\frac{V^2}{d^2}$

**67.** $V_{common} = \frac{C_1V_1 + C_2V_2}{C_1 + C_2}$ { $\because$ $V_2 = 0$)

$\Rightarrow$ $V_{common} = \frac{C_1V}{C_1 + C_2}$

**68.** Potential same at both spheres $V_1 = V_2$

$\therefore \frac{kQ_1}{R_1} = \frac{kQ_2}{R_2} \Rightarrow \frac{Q_1}{Q_2} = \frac{R_1}{R_2}$

surface charge density

$\therefore \frac{\sigma_1}{\sigma_2} = \frac{Q_1}{4\pi R_1^2} \times \frac{4\pi R_2^2}{Q_2}$

$= \frac{Q_1}{Q_2} \times \left(\frac{R_2}{R_1}\right)^2 = \left(\frac{R_1}{R_2}\right)\left(\frac{R_2}{R_1}\right)^2$

$= \frac{R_2}{R_1} = \frac{20}{10} = \frac{2}{1}$

**69.** $C_{eq} = 4\mu F$ (Wheat stone bridge)

**70.** By charge conservation

$V_{com} = \frac{6\times12 - 3\times12}{9} = 4\text{ Volt}$

**71.** $V_{com} = \frac{C_1V_1 + C_2V_2}{C_1 + C_2}$

$= \frac{0.2\times600 + 1\times0}{0.2+1}$

= 100 volt

**72.** $U = \frac{q^2}{2C} = \frac{q^2d}{2\epsilon_0 A}$

Volume = Ad

Energy Density $= \frac{U}{\text{Volume}} = \frac{q^2}{2\epsilon_0 A^2}$

**73.** $W = \frac{1}{2}CV_2^2 - \frac{1}{2}CV_1^2 = \frac{1}{2}C(900 - 225)$

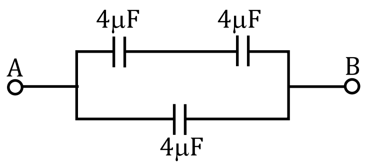
$C = \frac{2}{675}W$

Now in 2nd case

$\frac{1}{2}C\left[(60)^2 - (30)^2\right] = \frac{1}{2}C[3600 - 900]$

$= \frac{1}{2}.\frac{2}{675}W[2700] = 4W$

**74.**




$C_{AB} = (2 + 4)\ \mu F = 6\mu F$

**75.** $\frac{Q_1}{Q_2} = \frac{C_1V}{C_2V} = \frac{C_1V}{KC_1V}$ ($\because$ V = const.)

$\Rightarrow K = \frac{Q_2}{Q_1} = \frac{100}{40} = 2.5$

**76.** $C_{net} = \frac{C}{2}, V_{net} = 2V$

**77.** $C_{eq} = 2\mu F$

$Q_{eq} = 4\mu C$

Q on $1\mu F = 2\mu C$

Q on $2\mu F$ each $= 2\mu C$

**78.** E remain same because V = constant

**79.** $P = \frac{W}{t} = \frac{\frac{1}{2}CV^2}{t} = \frac{\frac{1}{2}\times 40\times 10^{-6}\times (3000)^2}{2\times 10^{-3}}$

$= 9 \times 10^4 = 90$ kW

**80.** $C_S = \frac{C_1C_2}{C_1+C_2}$

$C_P = C_1 + C_2$

**81.** $V \propto \frac{Q}{R}$ So $Q \propto R$ at constant V

So $\frac{q_1}{q_2} = \frac{R_1}{R_2}$

**82.** $V_{com.} = \frac{Q}{C_1+C_2} = \frac{Q}{4\pi \in_0 (R_1+R_2)}$

$= \frac{150\times 10^{-6}\times 9\times 10^9}{(10+20)\times 10^{-2}} = 4.5\times 10^6 V$

**83.** $\frac{1}{2}C_1V_1^2 = \frac{1}{2}C_2V_2^2$ [Assume no energy lost]

because total energy is transferred (given).

$\therefore \frac{1}{2} \times 900 \times 10^{-6} \times 100^2 = \frac{1}{2} \times 100 \times 10^{-6} \times V^2$

$\therefore V^2 = 90000 \Rightarrow V = 300$ Volt

## Exercise-II (Previous Year Questions)

**1.** Electric field, $E \propto \frac{1}{K}$ As $K_1 < K_2$ so $E_1 > E_2$

**2.** Once the capacitor is charged, its charge will be constant Q = CV. When dielectric slab is inserted

$C'_{New} = KC$

$E = \frac{Q^2}{2C} \Rightarrow E_{New} = \frac{1}{K} E_{initial}$

$V = \frac{Q}{C}$ so $V_{new} = \frac{1}{K} V$

**3.** $F = \frac{Q^2}{2\varepsilon_0 A}$

$\because$ Q = CV and $C = \frac{\varepsilon_0 A}{d} \Rightarrow \varepsilon_0 A = Cd$

So $F = \frac{C^2V^2}{2Cd} = \frac{CV^2}{2d}$

**4.** Initial energy stored in capacitor 2 μF

$U_i = \frac{1}{2}2(V)^2 = V^2$

Final voltage after switch 2 is ON

$V_f = \frac{C_1V_1}{C_1+C_2} = \frac{2V}{10} = 0.2$ V

Final energy in both the capacitors

$U_f = \frac{1}{2}(C_1+C_2)V_f^2 = \frac{1}{2}10\left(\frac{2V}{10}\right)^2 = 0.2\ V^2$

So energy dissipated $= \frac{V^2 - 0.2V^2}{V^2}\times 100 = 80\%$

**5.** $U_i = \frac{1}{2}CV^2$

$U_f = \frac{1}{2}[2C]\left[\frac{V}{2}\right]^2 = \frac{1}{2}U_i$

Decrease by a factor of 2

**6.** $F = QE = Q\frac{\sigma}{2\in_0} = \frac{Q^2}{2A\in_0}$

$\therefore$ Electrostatic force is independent of distance between plates

**7.** $U_{initial} = \frac{1}{2}CV^2$,

Loss $= \frac{C.C}{2(C+C)}(V-0)^2 = \frac{1}{4}CV^2$

% Loss $= \frac{\frac{1}{4}CV^2}{\frac{1}{2}CV^2}\times 100 = 50\%$

**8.** A B

R 2R

σ σ

Total charge = $\sigma \times 4\pi R^2 + \sigma \times 4\pi (2R)^2$

$= 20\ \sigma\pi R^2$

$\frac{Q_A}{Q_B} = \frac{1}{2}$

$Q_A = \frac{20}{3}\sigma\pi R^2$ and $Q_B = \frac{40}{3}\sigma\pi R^2$

$\sigma_A = \frac{Q_A}{\text{area}} = \frac{20}{3}\frac{\sigma\pi R^2}{4\pi R^2} = \frac{5\sigma}{3}$

$\sigma_B = \frac{40\sigma\pi R^2}{4\pi(2R)^2} = \frac{5\sigma}{6}$

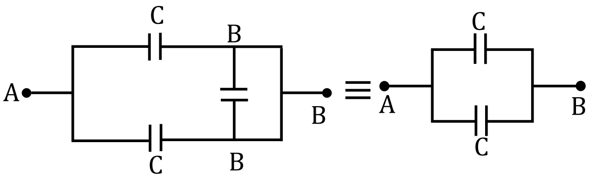
**9.** $C_m = \in_r C_o \Rightarrow \in_r = \frac{30}{6} = 5$

$\in = \in_0 \in_r = 8.85 \times 10^{-12} \times 5 = 0.44 \times 10^{-10}$

**10.** $C_0 = \frac{\in_0 A}{d}$

$C_K = \frac{\in_0 A}{d - t + \frac{t}{k}} = \frac{\in_0 A}{d - \frac{d}{2} + \frac{d}{8}} = \frac{8}{5}\frac{\in_0 A}{d} = \frac{8}{5}C_0$

**11.**




(one capacitor gets shorted)

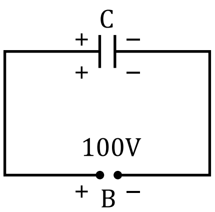
$\Rightarrow C_{eq} = C_1 + C_2$

$= C + C = 2C$

**12.** $E = \frac{1}{2}CV^2 = \frac{1}{2}\left(\frac{\varepsilon_0 A}{d}\right)(Ed)^2 = \frac{1}{2}\varepsilon_0 E^2 Ad$

**13.** Polar molecules have centres of positive and negative charges separated by some distance, so they have permanent dipole moment.

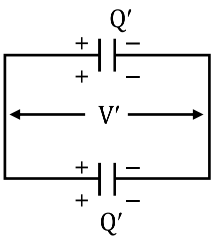
**14.**




$Q_i = CV$

$= 900 \times 10^{-12} \times 100$

$Q_i = 9 \times 10^{-8}$ C




$Q_f = 2Q'$

From conservation of charge

$2Q = Q_f = Q_i$

$Q' = \frac{Q_i}{2} = \frac{9 \times 10^{-8}}{2}$

$Q' = 4.5 \times 10^{-8}$ C

$E_{store} = 2 \times \frac{1}{2}\frac{(Q')^2}{C}$

$= \frac{(4.5 \times 10^{-8})^2}{900 \times 10^{-12}}$

$E_{store} = 2.25 \times 10^{-6}$ J

**15.** $C = \frac{A\varepsilon_0}{d}$

$C' = \frac{A/2\,\varepsilon_0}{2d} = \frac{A\varepsilon_0}{4d} = \frac{C}{4}$

**16.** $\frac{C_1 C_2}{C_1 + C_2} = 3$

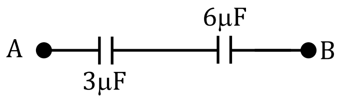
$C_1 + C_2 = 16$

$C_1 C_2 = 48$

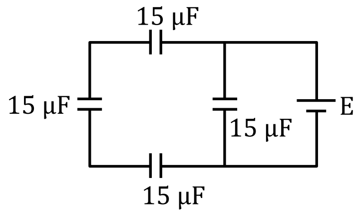
$C_1 = 12\mu F$

$C_2 = 4\mu F$

**17.** $C_{AB} = \frac{3 \times 6}{3 + 6} = 2\mu F$

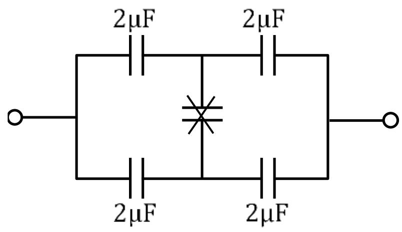


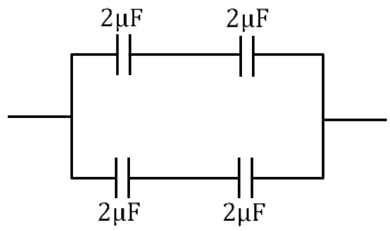

**18.**




$C_{eq} = 5 + 15 = 20\mu F$

**19.** Balanced wheat stone bridge




$C_{eq} = 2\mu F$

**20.** Battery connected so V = constant

Now $d\downarrow \Rightarrow C\uparrow$

A : $Q = CV \propto C \Rightarrow Q\uparrow$

B : $U = \frac{1}{2}CV^2 \propto C \Rightarrow U\uparrow$

C : $C = \frac{\epsilon_0 A}{d} \Rightarrow C\uparrow$

D : $\frac{Q}{V} = C \Rightarrow C\uparrow$

E : $(Q)(V) \propto C \Rightarrow QV\uparrow$

Therefore statements A, C and E are correct.

**21.** $U_{capacitor} = \frac{1}{2}CV^2$

$= \frac{1}{2} \times 12 \times 10^{-12} \times 50 \times 50$

$= 15 \times 10^{-9} J$

$= 15$ nJ

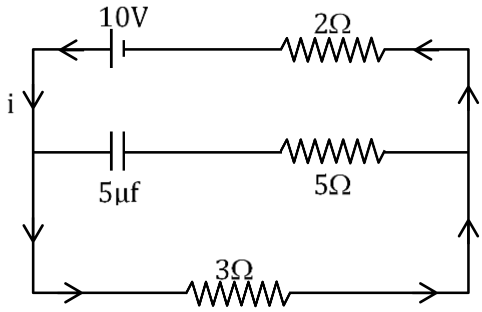
**22.** Capacitance depends only on

(1) Shape

(2) Size

(3) Medium

**23.**




There will be no current in middle branch containing capacitor.

$i = \frac{V}{R} = \frac{10}{2+3} = 2A$

## Exercise-III (Analytical Questions)

**1.** $\because$ battery is connected

$\therefore$ V = constant

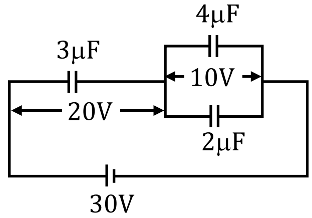
$U = \frac{1}{2}CV^2$, $Q = CV$

$U \propto C$, $Q \propto C$

**4.** $U = \frac{1}{2}\epsilon_0 E^2 (Ad)$

$U \propto E^2$

**5.**




$\because V \propto \frac{1}{C}$

$Q_{Battery} = C_{eff} V = 2 \times 20\ \mu C$

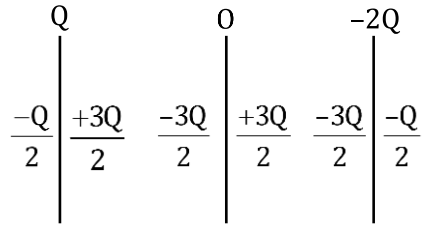
$Q_{battery} = 60\ \mu C$

$Q_{3\mu F} = 60\mu C$

$Q_{4\mu F} = 40\mu C$

$Q_{2\mu F} = 20\mu C$

**6.**




**7.** $U_{self} = \frac{KQ^2}{2R}$ Energy density $= \frac{1}{2}\varepsilon_0 E^2$

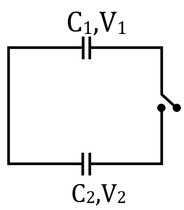
$F = \frac{Q^2}{2A\varepsilon_0}$ $W_{field} = U_i - U_f = \frac{kQ^2}{R} - 0$

$W_{field} = \frac{kQ^2}{R}$

**8.** Force between two point charges is independent of the presence of other charges.

**9.** $C = 4\pi\varepsilon_0 R \Rightarrow 1 = \frac{1}{9\times10^9}R \Rightarrow R = 9 \times 10^9$ m

**10.**




$V = \frac{C_1V_1 + C_2V_2}{C_2 + C_2}$

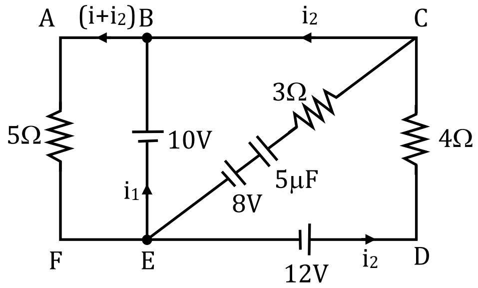
When two capacitors are connected then energy of system decreases. (but Not always)

**11.** A high capacity capacitor charged to high voltage has very high charges, that may discharge to ground through human body, when touched with bare hands.

**12.** $U = \frac{Q^2}{2C}$ and $C = \frac{\varepsilon_0 A}{d}$ $d\uparrow C\downarrow U\uparrow$

**13.** At facing surface same magnitude and opposite nature charges are there.

**14.**




When a steady state is reached, no current passes through the capacitor or the branch CE.

Considering the loop ABEFA,

$5 \times (i_1 + i_2) = 10$ or $i_1 + i_2 = 2A$ ...(i)

Considering the loop BCDEB

$4i_2 = 12 - 10 = 2 \Rightarrow i_2 = 0.5$ A

So $i_1 = 2 - 0.5 = 1.5$ A

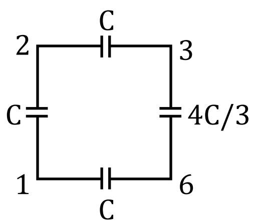
To find the charge on capacitors, we must know potential difference across the plates.

Consider the loop CEDC :

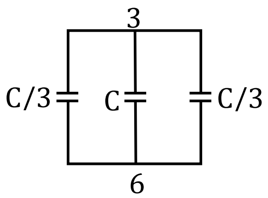
$-12 + 4i_2 + 3 \times 0 - V_C + 8 = 0 \Rightarrow V_C = -2V$.

So, charge on capacitor $Q = CV = 10$ μC

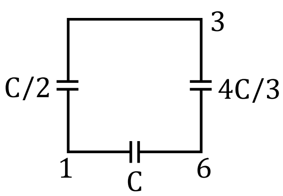
**16.** (1)




(2)




(3)

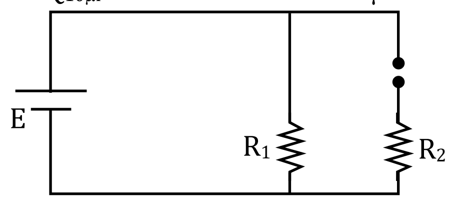



**18.** In steady state current through battery

$$I = \frac{50}{23+3+17+7} = 1A$$

$\Rightarrow Q_{10\mu F} = CV = 10 \times 20 = 200\mu C$

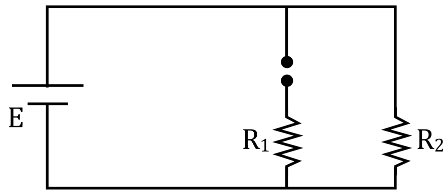
**19.**




At t = 0

$I_1 = \frac{E}{R_1} = \frac{25}{5} = 5A$

$I_2 = 0$




At t = ∞

$I_1 = 0$

$I_2 = \frac{E}{R_2} = \frac{25}{10} = 2.5$ A