CAPACITOR

1. Two equal capacitors are first connected in series and then in parallel. The ratio of the equivalent capacities in the two cases will be:

(1) 4 : 1 (2) 2 : 1
(3) 1 : 4 (4) 1 : 2

2. An electron with kinetic energy K_1 enters between parallel plates of a capacitor at an angle 'α' with the plates. It leaves the plates at angle 'β' with kinetic energy K_2. Then the ratio of kinetic energies $K_1 : K_2$ will be :

(1) $\frac{\sin^2\beta}{\cos^2\alpha}$ (2) $\frac{\cos^2\beta}{\cos^2\alpha}$

(3) $\frac{\cos\beta}{\cos\alpha}$ (4) $\frac{\cos\beta}{\sin\alpha}$

3. Consider the combination of 2 capacitors C_1 and C_2, with $C_2 > C_1$, when connected in parallel, the equivalent capacitance is $\frac{15}{4}$ time the equivalent capacitance of the same connected in series. Calculate the ratio of capacitors, $\frac{C_2}{C_1}$.

(1) $\frac{15}{11}$ (2) $\frac{111}{80}$

(3) $\frac{29}{15}$ (4) $\frac{15}{4}$

4. For changing the capacitance of a given parallel plate capacitor, a dielectric material of dielectric constant K is used, which has the same area as the plates of the capacitor. The thickness of the dielectric slab is $\frac{3}{4}$d, where 'd' is the separation between the plates of parallel plate capacitor. The new capacitance (C') in terms of original capacitance (C_0) is given by the following relation :

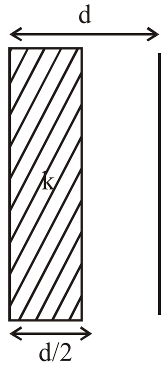
(1) $C' = \frac{3+K}{4K}C_0$

(2) $C' = \frac{4+K}{3}C_0$

(3) $C' = \frac{4K}{K+3}C_0$

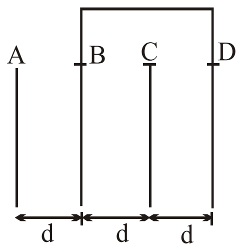
(4) $C' = \frac{4}{3+K}C_0$

5. In a parallel plate capacitor set up, the plate area of capacitor is 2 m^2 and the plates are separated by 1m. If the space between the plates are filled with a dielectric material of thickness 0.5 m and area $2m^2$ (see fig.) the capacitance of the set-up will be ______ ε_0. (Dielectric constant of the material = 3.2) (Round off to the Nearest Integer)



6. Four identical rectangular plates with length, l = 2 cm and breadth, b = $\frac{3}{2}$ cm are arranged as shown in figure. The equivalent capacitance between A and C is $\frac{x\varepsilon_0}{d}$. The value of x is ___.

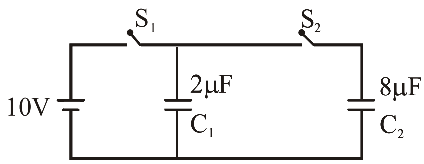
(Round off to the Nearest Integer)



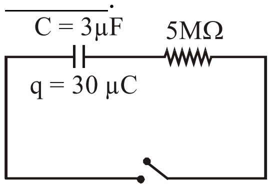
7. A parallel plate capacitor whose capacitance C is 14 pF is charged by a battery to a potential difference V = 12V between its plates. The charging battery is now disconnected and a porcelin plate with k = 7 is inserted between the plates, then the plate would oscillate back and forth between the plates with a constant mechanical energy of ______ pJ.

(Assume no friction)

8. A 2 μF capacitor C_1 is first charged to a potential difference of 10 V using a battery.Then the battery is removed and the capacitor is connected to an uncharged capacitor C_2 of 8μF. The charge in C_2 on equilibrium condition is_______μC. (Round off to the Nearest Integer)



9. The circuit shown in the figure consists of a charged capacitor of capacity 3 μF and a charge of 30 μC. At time t = 0, when the key is closed, the value of current flowing through the 5 MΩ resistor is 'x' μ-A. The value of 'x to the nearest integer is _______.



10. A parallel plate capacitor has plate area 100 m^2 and plate separation of 10 m. The space between the plates is filled up to a thickness 5 m with a material of dielectric constant of 10. The resultant capacitance of the system is 'x' pF.
The value of $\varepsilon_0 = 8.85 \times 10^{-12}$ F.m^{-1}.
The value of 'x' to the nearest integer is_____.

11. A parallel plate capacitor with plate area 'A' and distance of separation 'd' is filled with a dielectric. What is the capacity of the capacitor when permittivity of the dielectric varies as :

$$\varepsilon(x) = \varepsilon_0 + kx, \text{ for } \left(0 < x \le \frac{d}{2}\right)$$

$$\varepsilon(x) = \varepsilon_0 + k(d - x), \text{ for } \left(\frac{d}{2} \le x \le d\right)$$

(1) $\left(\varepsilon_0 + \frac{kd}{2}\right)^{2/kA}$

(2) $\dfrac{kA}{2\ln\left(\dfrac{2\varepsilon_0 + kd}{2\varepsilon_0}\right)}$

(3) 0

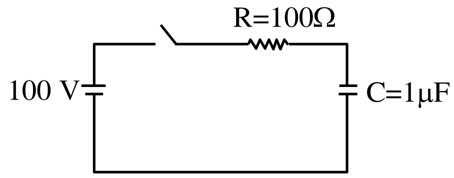
(4) $\dfrac{kA}{2}\ln\left(\dfrac{2\varepsilon_0}{2\varepsilon_0 - kd}\right)$

12. If q_f is the free charge on the capacitor plates and q_b is the bound charge on the dielectric slab of dielectric constant k placed between the capacitor plates, then bound charge q_b can be expressed as :

(1) $q_b = q_f\left(1 - \frac{1}{\sqrt{k}}\right)$ (2) $q_b = q_f\left(1 - \frac{1}{k}\right)$

(3) $q_b = q_f\left(1 + \frac{1}{\sqrt{k}}\right)$ (4) $q_b = q_f\left(1 + \frac{1}{k}\right)$

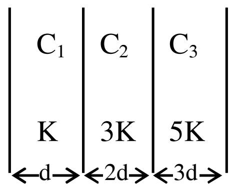
13.



A capacitor of capacitance C=1 μF is suddenly connected to a battery of 100 volt through a resistance R = 100 Ω. The time taken for the capacitor to be charged to get 50 V is :
[Take ln 2 = 0.69]

(1) 1.44×10^{-4} s (2) 3.33×10^{-4} s
(3) 0.69×10^{-4} s (4) 0.30×10^{-4} s

14. In the reported figure, a capacitor is formed by placing a compound dielectric between the plates of parallel plate capacitor. The expression for the capacity of the said capacitor will be :
(Given area of plate = A)



(1) $\frac{15}{34}\frac{K\varepsilon_0 A}{d}$ (2) $\frac{15}{6}\frac{K\varepsilon_0 A}{d}$

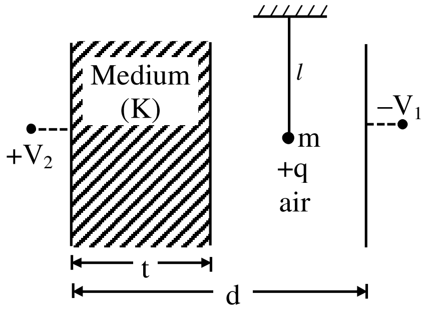
(3) $\frac{25}{6}\frac{K\varepsilon_0 A}{d}$ (4) $\frac{9}{6}\frac{K\varepsilon_0 A}{d}$

15. Two capacitors of capacities 2C and C are joined in parallel and charged up to potential V. The battery is removed and the capacitor of capacity C is filled completely with a medium of dielectric constant K. The potential difference across the capacitors will now be :

(1) $\frac{V}{K+2}$ (2) $\frac{V}{K}$

(3) $\frac{3V}{K+2}$ (4) $\frac{3V}{K}$

16. A simple pendulum of mass 'm', length 'l' and charge '+q' suspended in the electric field produced by two conducting parallel plates as shown. The value of deflection of pendulum in equilibrium position will be:



(1) $\tan^{-1}\left[\frac{q}{mg}\times\frac{C_1(V_2-V_1)}{(C_1+C_2)(d-t)}\right]$

(2) $\tan^{-1}\left[\frac{q}{mg}\times\frac{C_2(V_2-V_1)}{(C_1+C_2)(d-t)}\right]$

(3) $\tan^{-1}\left[\frac{q}{mg}\times\frac{C_2(V_1+V_2)}{(C_1+C_2)(d-t)}\right]$

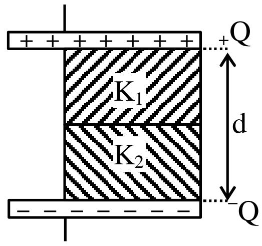
(4) $\tan^{-1}\left[\frac{q}{mg}\times\frac{C_1(V_1+V_2)}{(C_1+C_2)(d-t)}\right]$

17. The material filled between the plates of a parallel plate capacitor has resistivity 200 Ωm. The value of capacitance of the capacitor is 2 pF. If a potential difference of 40 V is applied across the plates of the capacitor, then the value of leakage current flowing out of the capacitor is : (given the value of relative permitivity of material is 50)

(1) 9.0 μA (2) 9.0 mA

(3) 0.9 mA (4) 0.9 μA

18. A parallel - plate capacitor with plate area A has separation d between the plates. Two dielectric slabs of dielectric constant K_1 and K_2 of same area A/2 and thickness d/2 are inserted in the space between the plates. The capacitance of the capacitor will be given by :



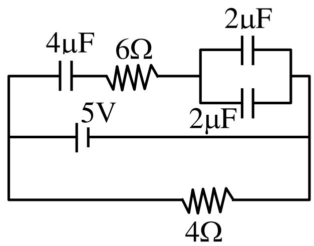
(1) $\frac{\varepsilon_0 A}{d}\left(\frac{1}{2}+\frac{K_1K_2}{K_1+K_2}\right)$

(2) $\frac{\varepsilon_0 A}{d}\left(\frac{1}{2}+\frac{K_1K_2}{2(K_1+K_2)}\right)$

(3) $\frac{\varepsilon_0 A}{d}\left(\frac{1}{2}+\frac{K_1+K_2}{K_1K_2}\right)$

(4) $\frac{\varepsilon_0 A}{d}\left(\frac{1}{2}+\frac{2(K_1+K_2)}{K_1K_2}\right)$

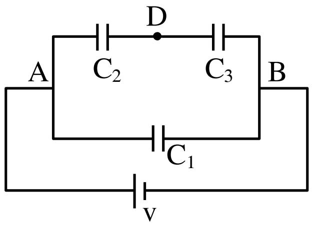
19. Calculate the amount of charge on capacitor of 4 μF. The internal resistance of battery is 1Ω :



(1) 8 μC (2) zero

(3) 16 μC (4) 4 μC

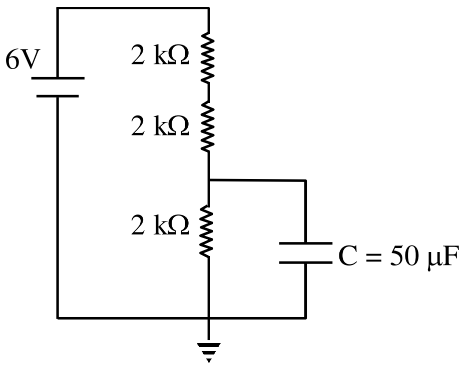
20. Three capacitors $C_1 = 2\mu F$, $C_2 = 6\ \mu F$ and $C_3 = 12\ \mu F$ are connected as shown in figure. Find the ratio of the charges on capacitors C_1, C_2 and C_3 respectively :



(1) 2 : 1 : 1 (2) 2 : 3 : 3

(3) 1 : 2 : 2 (4) 3 : 4 : 4

21. A capacitor of 50 μF is connected in a circuit as shown in figure. The charge on the upper plate of the capacitor is__________μC.



22. A parallel plate capacitor of capacitance 200 μF is connected to a battery of 200 V. A dielectric slab of dielectric constant 2 is now inserted into the space between plates of capacitor while the battery remain connected. The change in the electrostatic energy in the capacitor will be_____J.

23. A capacitor is connected to a 20 V battery through a resistance of 10Ω. It is found that the potential difference across the capacitor rises to 2 V in 1 μs. The capacitance of the capacitor is ....μF. Given : $\ln\left(\frac{10}{9}\right) = 0.105$

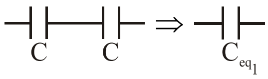
(1) 9.52 (2) 0.95

(3) 0.105 (4) 1.85

SOLUTION

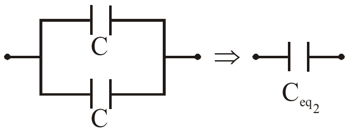
1. Official Ans. by NTA (3)

Sol. For series combination



$$\frac{1}{C_{eq_1}} = \frac{1}{C} + \frac{1}{C} \Rightarrow \boxed{C_{eq_1} = \frac{C}{2}}$$

For parallel combination

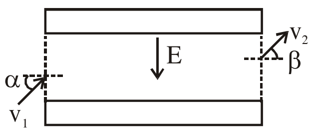


$$C_{eq_2} = C + C \Rightarrow C_{eq_2} = 2C$$

$$\Rightarrow \frac{C_{eq_1}}{C_{eq_2}} = \frac{(C/2)}{2C} = \frac{1}{4} = 1:4$$

2. Official Ans. by NTA (2)

Sol.



velocity along the plate will not change.

$\therefore v_1 \cos\alpha = v_2 \cos\beta$

$$\frac{K_1}{K_2} \Rightarrow \frac{v_1^2}{v_2^2} = \frac{\cos^2\beta}{\cos^2\alpha}$$

3. Official Ans. by NTA (BONUS)

Sol. When connected in parallel

$C_{eq} = C_1 + C_2$

When in series

$$C'_{eq} = \frac{C_1C_2}{C_1 + C_2}$$

$$C_1 + C_2 = \frac{15}{4}\left(\frac{C_1C_2}{C_1 + C_2}\right)$$

$4(C_1 + C_2)^2 = 15\, C_1C_2$

$4C_1^2 + 4C_2^2 - 7C_1C_2 = 0$

dividing by C_1^2

$$4\left(\frac{C_2}{C_1}\right)^2 - \frac{7C_2}{C_1} + 4 = 0$$

Let $\frac{C_2}{C_1} = x$

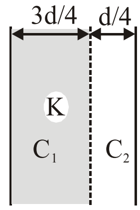
$4x^2 - 7x + 4 = 0$

$b^2 - 4ac = 49 - 64 < 0$

No solution exits

4. Official Ans. by NTA (3)

Sol.



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

C' = C_1 and C_2 in series.

i.e. $\frac{1}{C'} = \frac{1}{C_1} + \frac{1}{C_2}$ $\quad \frac{1}{C'} = \frac{(3d/4)}{\epsilon_0 KA} + \frac{d/4}{\epsilon_0 A}$

$$\frac{1}{C'} = \frac{d}{4\epsilon_0 A}\left(\frac{3+K}{K}\right)$$

$$C' = \frac{4KC_0}{(3+K)}$$

5. Official Ans. by NTA (3)

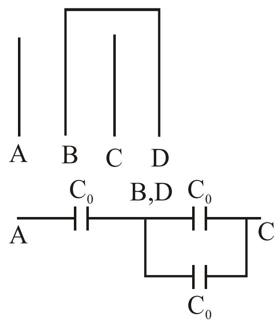
Sol. Ans. (3)

$$C = \frac{\varepsilon_0 A}{\frac{d}{2K} + \frac{d}{2}} = \frac{2\varepsilon_0 A}{\frac{d}{K} + d}$$

$$= \frac{2 \times 2\varepsilon_0}{\frac{1}{3.2} + 1} = \frac{4 \times 3.2}{4.2}\varepsilon_0 = 3.04\,\varepsilon_0$$

6. Official Ans. by NTA (2)

Sol.



$$C_{eq} = \frac{2C_0}{3} = \frac{2}{3}\frac{\epsilon_0 A}{d}$$

$$C_{eq} = \frac{2\epsilon_0}{3d} \times \left(2 \times \frac{3}{2}\right) = 2 \quad (\because A = lb = 2 \times \frac{3}{2})$$

7. Official Ans. by NTA (864)

Sol. $U_i = \frac{1}{2} \times 14 \times 12 \times 12$ pJ $\quad (\because U = \frac{1}{2}CV^2)$

= 1008 pJ

$U_f = \frac{1008}{7}$ pJ = 144 pJ $\qquad (\because C_m = kC_0)$

Mechanical energy = ΔU

= 1008 – 144 = 864 pJ

8. Official Ans. by NTA (16)

Sol. $20 = (C_1 + C_2)V \Rightarrow V = 2$ volt.

$Q_2 = C_2V = 16\mu C = 16$

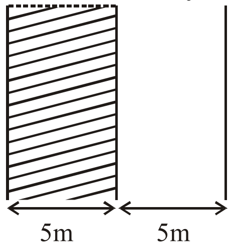
9. Official Ans. by NTA (2)

Sol. $i_0 = \frac{V}{R} = \frac{30/3}{5\times10^6} = 2\times10^{-6}$

$\therefore$ Ans. = 2.00

10. Official Ans. by NTA (161)

Sol.



A = 100 m²

Using $C = \frac{k\in_0 A}{d}$

$C_1 = \frac{10\in_0(100)}{5} = 200\in_0$

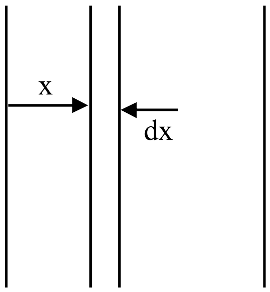
$C_2 = \frac{\in_0(100)}{5} = 20\in_0$

C_1 & C_2 are in series so $C_{eqv.} = \frac{C_1C_2}{C_1+C_2}$

$= \frac{4000\in_0}{220} = 160.9\times10^{-12} \simeq 161$ pF

11. Official Ans. by NTA (2)

Sol.



Taking an element of width dx at a distance x (x < d/2) from left plate

$dc = \frac{(\varepsilon_0 + kx)A}{dx}$

Capacitance of half of the capacitor

$\frac{1}{C} = \int_0^{d/2}\frac{1}{dc} = \frac{1}{A}\int_0^{d/2}\frac{dx}{\varepsilon_0 + kx}$

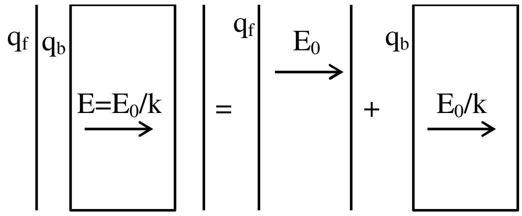
$\frac{1}{C} = \frac{1}{kA}\ln\left(\frac{\varepsilon_0 + kd/2}{\varepsilon_0}\right)$

Capacitance of second half will be same

$C_{eq} = \frac{C}{2} = \frac{kA}{2\ln\left(\frac{2\varepsilon_0 + kd}{2\varepsilon_0}\right)}$

12. Official Ans. by NTA (2)

Sol.



When a dielectric is inserted in a capacitor

Due to free charge $\vec{E} = \vec{E}_0$ only

After dielectric $E' = \frac{E_0}{k}$

$q_B = q_f\left(1 - \frac{1}{k}\right)$

13. Official Ans. by NTA (3)

Sol. $V = V_0\left(1 - e^{-\frac{t}{RC}}\right)$

$50 = 100\left(1 - e^{-\frac{t}{RC}}\right)$

$t = 0.69\times10^{-4}$ sec.

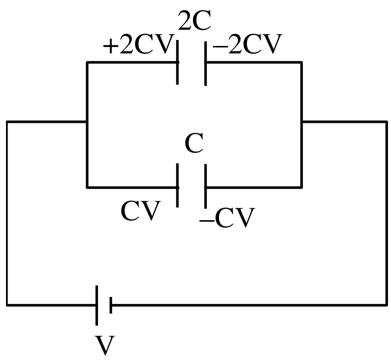
14. Official Ans. by NTA (1)

Sol. $\frac{1}{C_{eff}} = \frac{d}{K\in_0 A} + \frac{2d}{3K\in_0 A} + \frac{3d}{5K\in_0 A}$

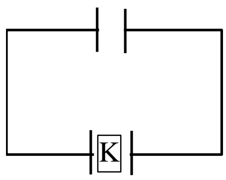
$C_{eff} = \frac{15K\in_0 A}{34d}$

15. Official Ans. by NTA (3)

Sol.



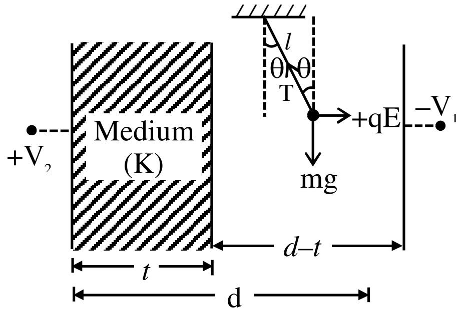
Now,



$V_C = \frac{2CV + CV}{KC + 2C} = \frac{3V}{K+2}$

16. Official Ans. by NTA (3)

Sol.

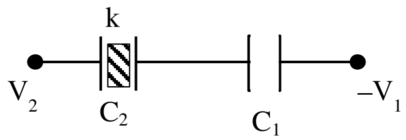


Let E be electric field in air

T sinθ = qE

T cosθ = mg

$\tan\theta = \dfrac{qE}{mg}$



$Q = \left[\dfrac{C_1C_2}{C_1+C_2}\right][V_1 + V_2]$

$E = \dfrac{Q}{A\in_o} = \left[\dfrac{C_1C_2}{C_1+C_2}\right]\dfrac{[V_1+V_2]}{A\in_o}$

$C_1 = \dfrac{\in_o A}{d-t} \quad \Rightarrow E = \dfrac{C_2[V_1+V_2]}{(C_1+C_2)(d-t)}$

Now $\theta = \tan^{-1}\left[\dfrac{q.E}{mg}\right]$

$\theta = \tan^{-1}\left[\dfrac{q}{mg}\times\dfrac{C_2(V_1+V_2)}{(C_1+C_2)(d-t)}\right]$

17. Official Ans. by NTA (3)

Sol. ρ = 200 Ωm

$C = 2\times10^{-12}$ F

V = 40 V

K = 56

$i = \dfrac{q}{\rho k\varepsilon_0} = \dfrac{q_0}{\rho k\varepsilon_0}e^{-\frac{t}{\rho k\varepsilon_0}}$

$i_{max} = \dfrac{2\times10^{-12}\times40}{200\times50\times8.85\times10^{-12}}$

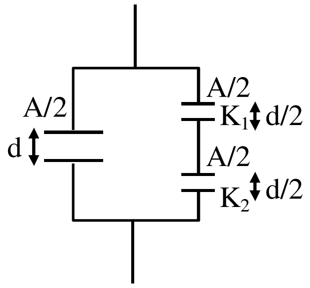
$= \dfrac{80}{10^4\times8.85} = 903\mu A = 0.9 mA$

Option (3)

18. Official Ans. by NTA (1)

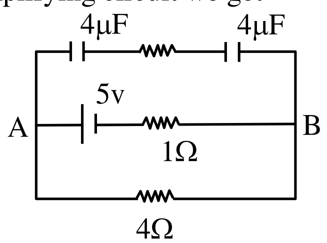
Sol. $C_{eq} = \dfrac{\frac{A}{2}\varepsilon_0}{d} + \dfrac{A\varepsilon_0}{d}\dfrac{K_1K_2}{K_1+K_2}$

$= \dfrac{A\varepsilon_0}{d}\left(\dfrac{1}{2}+\dfrac{K_1K_2}{K_1+K_2}\right)$



19. Official Ans. by NTA (1)

Sol. On simplifying circuit we get



No current in upper wire.

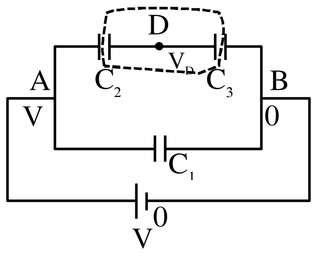
$\therefore \quad V_{AB} = \dfrac{5}{4+1}\times 4 = 4$ v.

$\therefore \quad \theta = (C_{eq})v$

$\Rightarrow 2\times4 = 8\mu C$

20. Official Ans. by NTA (3)

Sol.



$(V_D - V)\,C_2 + (V_D - 0)\,C_3 = 0$

$(V_D - V)\,6 + (V_D - 0)\,12 = 0$

$V_D - V + 2V_D = 0$

$V_D = \dfrac{V}{3}$

$q_2 = (V - V_D)\,C_2 = \left(V - \dfrac{V}{3}\right)(6\ \mu F)$

$q_2 = (4V)\ \mu F$

$q_3 = (V_D - 0)\,C_3 = \dfrac{V}{3}\times12\mu F = 4V\mu F$

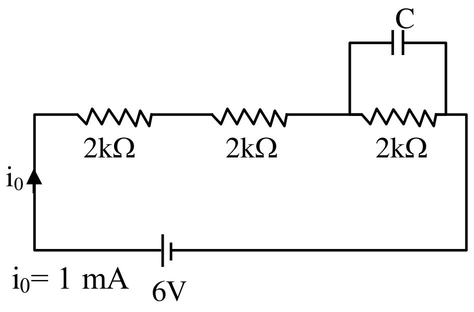
$q_1 = (V - 0)\,C_1 = V(2\mu F)$

$q_1 : q_2 : q_3 = 2 : 4 : 4$

$q_1 : q_2 : q_3 = 1 : 2 : 2$

21. Official Ans. by NTA (100)

Sol.



Pot. Diff. across each resistor = 2V

q = CV

$= 50 \times 10^{-6} \times 2 = 100 \times 10^{-6} = 100\ \mu C$

22. Official Ans. by NTA (4)

Sol. $\Delta U = \frac{1}{2}(\Delta C)V^2$

$\Delta U = \frac{1}{2}(KC - C)V^2$

$\Delta U = \frac{1}{2}(2-1)CV^2$

$\Delta U = \frac{1}{2} \times 200 \times 10^{-6} \times 200 \times 200$

$\Delta U = 4\ J$

23. Official Ans. by NTA (2)

Sol. $V = V_0\left(1 - e^{-t/RC}\right)$

$2 = 20\left(1 - e^{-t/RC}\right)$

$\frac{1}{10} = 1 - e^{-t/RC}$

$e^{-t/RC} = \frac{9}{10}$

$e^{t/RC} = \frac{10}{9}$

$\frac{t}{RC} = \ell n\left(\frac{10}{9}\right) \Rightarrow C = \frac{t}{R\ell n\left(\frac{10}{9}\right)}$

$C = \frac{10^{-6}}{10 \times .105} = .95\mu F$

Option (2)