A point dipole $= \vec{p} - p_o \hat{x}$ kept at the origin. The potential and electric field due to this dipole on the y-axis at a distance d are, respectively : (Take V = 0 at infinity)

[12 April 2019 I]

(a) $\frac{|\vec{p}|}{4\pi\varepsilon_0 d^2}, \frac{\vec{p}}{4\pi\varepsilon_0 d^3}$

(b) $0, \frac{-\vec{p}}{4\pi\varepsilon_0 d^3}$

(c) $0, \frac{|\vec{p}|}{4\pi\varepsilon_0 d^3}$

(d) $\frac{|\vec{p}|}{4\pi\varepsilon_0 d^2}, \frac{-\vec{p}}{4\pi\varepsilon_0 d^3}$

(b) The electric potential at the bisector is zero and electric field is antiparallel to the dipole moment.

$$\therefore V = 0 \text{ and } \vec{E} = \frac{1}{4\pi\varepsilon_0}\left(\frac{-\vec{P}}{d^3}\right)$$

Concentric metallic hollow spheres of radii R and $4R$ hold charges Q_1 and Q_2 respectively. Given that surface charge densities of the concentric spheres are equal, the potential difference $V(R) - V(4R)$ is : **[Sep. 03, 2020 (II)]**

(a) $\frac{3Q_1}{16\pi\varepsilon_0 R}$

(b) $\frac{3Q_2}{4\pi\varepsilon_0 R}$

(c) $\frac{Q_2}{4\pi\varepsilon_0 R}$

(d) $\frac{3Q_1}{4\pi\varepsilon_0 R}$

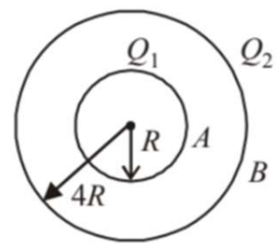
(a) We have given two metallic hollow spheres of radii R and $4R$ having charges Q_1 and Q_2 respectively.

Potential on the surface of inner sphere (at A)

$$V_A = \frac{kQ_1}{R} + \frac{kQ_2}{4R}$$

Potential on the surface of outer sphere (at B)

$$V_B = \frac{kQ_1}{4R} + \frac{kQ_2}{4R} \qquad \left(\text{Here, } k = \frac{1}{4\pi\varepsilon_0}\right)$$



Potential difference,

$$\Delta V = V_A - V_B = \frac{3}{4} \cdot \frac{kQ_1}{R} = \frac{3}{16\pi \in_0} \cdot \frac{Q_1}{R}$$

A charge of total amount Q is distributed over two concentric hollow spheres of radii r and R ($R > r$) such that the surface charge densities on the two spheres are equal. The electric potential at the common centre is

[Online May 19, 2012]

(a) $\frac{1}{4\pi\varepsilon_0}\frac{(R-r)Q}{(R^2+r^2)}$ (b) $\frac{1}{4\pi\varepsilon_0}\frac{(R+r)Q}{2(R^2+r^2)}$

(c) $\frac{1}{4\pi\varepsilon_0}\frac{(R+r)Q}{(R^2+r^2)}$ (d) $\frac{1}{4\pi\varepsilon_0}\frac{(R-r)Q}{2(R^2+r^2)}$

(c) Let q_1 and q_2 be charge on two spheres of radius 'r' and 'R' respectively

As, $q_1 + q_2 = Q$

and $\sigma_1 = \sigma_2$ [Surface charge density are equal]

$$\therefore \frac{q_1}{r\pi r^2} = \frac{q_2}{4\pi R^2}$$

So, $q_1 = \frac{Qr^2}{R^2+r^2}$ and $q_2 = \frac{QR^2}{R^2+r^2}$

Now, potential, $V = \frac{1}{4\pi\varepsilon_0}\left[\frac{q_1}{r} + \frac{q_2}{R}\right]$

$$= \frac{1}{4\pi\varepsilon_0}\left[\frac{Qr}{R^2+r^2} + \frac{QR}{R^2+r^2}\right]$$

$$= \frac{Q(R+r)}{R^2+r^2}\frac{1}{4\pi\varepsilon_0}$$

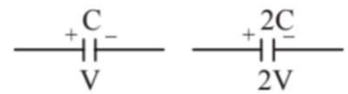
Two capacitors of capacitances C and 2C are charged to potential differences V and 2V, respectively. These are then connected in parallel in such a manner that the positive terminal of one is connected to the negative terminal of the other. The final energy of this configuration is :

[Sep. 05, 2020 (I)]

(a) $\frac{25}{6}CV^2$ (b) $\frac{3}{2}CV^2$

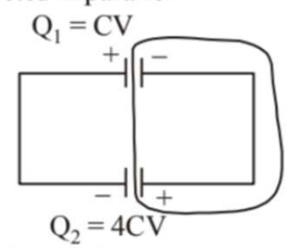
(c) zero (d) $\frac{9}{2}CV^2$

(b) When capacitors C and $2C$ capacitance are charged to V and 2V respectively.



$Q_1 = CV \quad Q_2 = 2C \times 2V = 4CV$

When connected in parallel



By conservation of charge

$$4CV - CV = (C + 2C)V_{\text{common}}$$

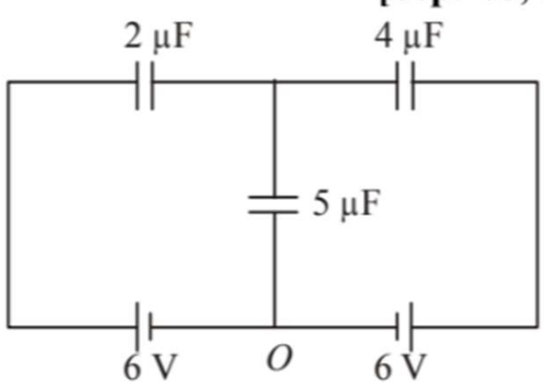
$$V_{\text{common}} = \frac{3CV}{3C} = V$$

Therefore final energy of this configuration,

$$U_f = \left(\frac{1}{2}CV^2 + \frac{1}{2} \times 2CV^2\right) = \frac{3}{2}CV^2$$

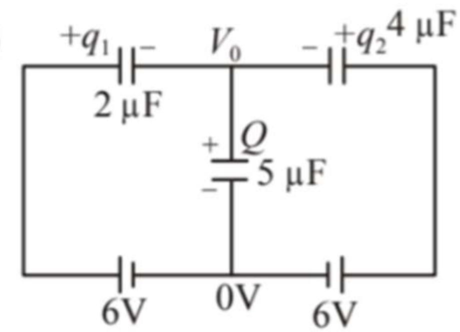
In the circuit shown, charge on the 5 μF capacitor is :

[Sep. 05, 2020 (II)]



(a) 18.00 μC
(b) 10.90 μC
(c) 16.36 μC
(d) 5.45 μC

(a)



Let q_1 and q_2 be the charge on the capacitors of 2μF and 4μF. Then charge on capacitor of 5μF

$$Q = q_1 + q_2$$

$$\Rightarrow 5V_0 = 2(6 - V_0) + 4(6 - V_0)$$

$$\Rightarrow 5V_0 = 12 - 2V_0 + 24 - 4V_0$$

$$\Rightarrow 11V_0 = 36 \Rightarrow V_0 = \frac{36}{11} V$$

$$\Rightarrow Q = 5V_0 = \frac{180}{11} \mu C$$

A 60 pF capacitor is fully charged by a 20 V supply. It is then disconnected from the supply and is connected to another uncharged 60 pF capacitor in parallel. The electrostatic energy that is lost in this process by the time the charge is redistributed between them is (in nJ)

[NA 7 Jan. 2020 II]

(6) In the first condition, electrostatic energy is

$$U_i = \frac{1}{2}CV_0^2 = \frac{1}{2} \times 60 \times 10^{-12} \times 400 = 12 \times 10^{-9} J$$

In the second condition $U_F = \frac{1}{2}C'V'^2$

$$U_f = \frac{1}{2}2C.\left(\frac{V_0}{2}\right)^2 \qquad \left(\because C' = 2C, V' = \frac{V_0}{2}\right)$$

$$= \frac{1}{4} \times 60 \times 10^{-12} \times (20)^2 \quad = 6 \times 10^{-9} J$$

Energy lost $= U_i - U_f = 12\times10^{-9}J - 6 \times 10^{-9}J = 6\, nJ$

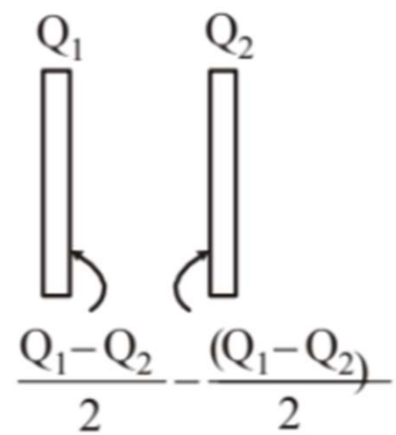
A parallel plate capacitor has $1\mu F$ capacitance. One of its two plates is given $+2\mu C$ charge and the other plate, $+4\mu C$ charge. The potential difference developed across the capacitor is : **[8 April 2019 II]**

(a) 3V (b) 1V (c) 5V (d) 2V

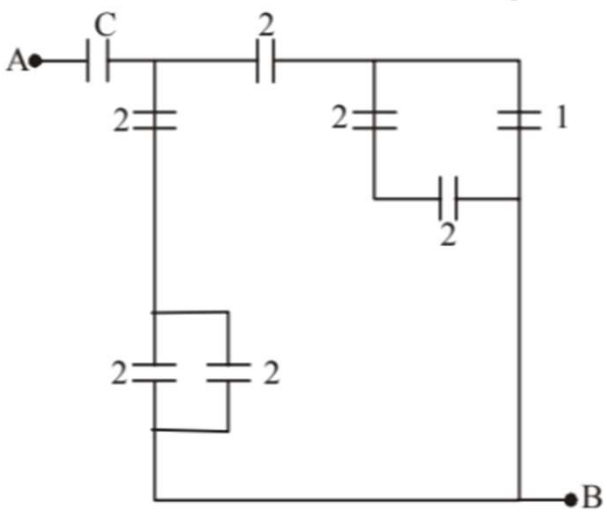
(b) $V = \frac{Q}{C}$

$= \left(\frac{Q_1 - Q_2}{2C}\right)$

$= \left(\frac{4-2}{2 \times 1}\right) = 1\,V$

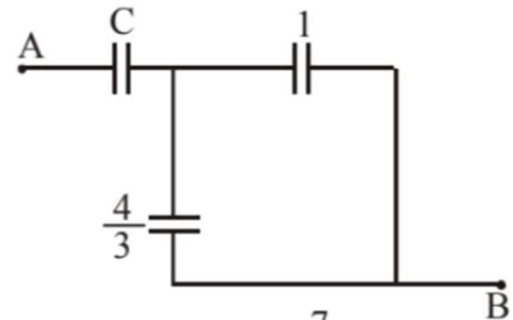


In the circuit shown, find C if the effective capacitance of the whole circuit is to be 0.5 μF. All values in the circuit are in μF. **[12 Jan. 2019 II]**



(a) $\frac{7}{11}$ μF (b) $\frac{6}{5}$ μF (c) 4 μF (d) $\frac{7}{10}$ μF

(a)



For series combination

$$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2}$$

$$\Rightarrow \frac{\frac{7C}{3}}{\frac{7}{3}+C} = \frac{1}{2}$$

$$\Rightarrow 14C = 7 + 3C$$

$$\Rightarrow C = \frac{7}{11} \mu F$$