Numerical Problems

13.1 The charge of how many negatively charged particles would be equal to 100 μC. Assume charge on one negative particle is 1.6×10^{19} C?

Answer

Number of negatively charged particles,

$n = ?$

Total charge, $q = 100\mu C$

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

Charge on one negative particle,

$e = 1.6 \times 10^{-19} C$

We know that,

$q = ne$

or $n = \frac{q}{e}$

Putting the values, we get,

$n = \frac{100 \times 10^{\ \ 6}}{1.6 \times 10^{\ \ 19}}$

$n = 0.625 \times 10^{15}$

or $\boxed{n = 6.25 \times 10^{13}}$

13.2 Two-point charges $q_1 = 10$ μC and $q_2 = 5$ μC are placed at distance of 150 cm. What will be the Coulomb's force between them? Also find the direction of the force.

Answer

Point charge, q_1 =10 μC

= 10×10^{-6} C

Point charge, q_2 = 5 μC

= 5×10^{-6}C

Distance between charges, r= 150 cm

= 1.5 m

Force, F =?

Electrostatic constant, k = $9 \times 10^9 Nm^2C^{-2}$

According to Coulomb's law,

$$F = k\frac{q_1 q_2}{r^2}$$

Putting the values, we get,

$$F = \frac{9 \times 10^9 \times (10 \times 10^{-6}) \times (5 \times 10^{-6})}{(1.5)^2}$$

$$F = 20 \times 10^{-2} \text{ N}$$

or $\boxed{F = 0.2 \text{ N}}$

As both the point charges have same charge in nature the force will be repulsive.

13.3 The force of repulsion between two identical positive charges is 0.8 N, when the charges are 0.1 m apart. Find the value of each charge.

Answer

Force, F = 0.8 N

Distance between charges 5T= 0.1 m

As the charges are identical, So, we can write,

$$q_1 = q_2 = q = ?$$

According to coulomb's law,

$$F = k\frac{q_1 q_2}{r^2}$$

or $$F = k\frac{q_2 q}{r^2}$$

or $$F = k\frac{q^2}{r^2}$$

or $$q^2 = \frac{F \times r^2}{k}$$

Putting the values, we get,

$$q^2 = \frac{0.8 \times (0.1)^2}{9 \times 10^9}$$

$$q^2 = 8.9 \times 10^{-13}$$

or $$q = 9.4 \times 10^{-7} C$$

So, $$\boxed{q_1 = q_2 = 9.4 \times 10^{-7} C}$$

13.4 Two charges repel each other with a force of 0.1 N when they are 5 cm apart. Find the forces between the same charges when they are 2 cm apart.

Answer

Force, $F = 0.1\ N$

Distance between charges, $r = 5$ cm

$= 0.05$ m

New force, $F' = ?$

New distance, $r' = 2$ cm

$= 0.02$ m

According to coulomb's law, when distance is 5 cm, we get,

$$F = k\frac{q_1 q_2}{r^2} \qquad \text{(i)}$$

Again, applying coulomb's law, when distance is 2 cm, i.e.

$$F' = k\frac{q_1 q_2}{r'^2} \qquad \text{(ii)}$$

∵ (the charges are same in both the cases)

So equ (1) becomes

$k\,(q_1 q_2) = F \times r^2$ putting in equ. (2),

We get.

$$F' = \frac{F \times r^2}{r'^2}$$

Putting the values,

$$F' = \frac{0.1 \times (0.05)^2}{(0.02)^2}$$

$$\boxed{F' = 0.62\text{ N}}$$

13.5 The potential at a point in an electric field is IO4 V. If a charge of + 100 μC is brought from infinity to this point. What would be the amount of work done on it?

Answer

Potential. $V = 10^4$ volts

Charge, $q = 100\mu C$

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

Work done, W =?

We know that,

$$V = \frac{W}{q}$$

or $W = V \times q$

Putting the values, we get,

$W = IO^4 \times 100 \times 10^{-6}$

$\boxed{\text{Work} = 1 \text{ Joule}}$

13.6 A point charge of + 2C is transferred from a point at potential 100 V to point at potential 50 V. What would be the energy supplied by the charge?

Answer

Potential at one point, $V_a = 100$ volts

Potential at other point, $V_b = 50$ volts

Charge, $q = 2C$

Energy supplied, E = 9

As we know,

Energy supplied $= q(V_a - V_b)$

Putting the values, we get.

$= 2(100 - 50)$

$\therefore$ $\boxed{\text{Energy supplied} = 100\text{J}}$

13.7 A capacitor holds 0.06 coulombs of charge when fully charged by a 9 volt battery. Calculate capacitance of the capacitor.

Answer

Charge, $Q = 0.06C$

Potential, $V = 9V$

Capacitance. C =?

We know that,

$$Q = CV$$

or $$C = \frac{Q}{V}$$

Putting the values, we get

$$C = \frac{0.06}{9}$$

or $$\boxed{C = 6.67 \times 10^{-3} F}$$

13.8 A capacitor holds 0.03 coulombs of charge when fully charged by a 6-volt battery. How much voltage would be required for it to hold 2 coulombs of charge?

Answer

Charge, $Q = 0.03$ C

Potential, $V = 6$ V

New charge stored. $Q' = 2C$

New potential, $V' = ?$

As we know that. $Q = CV$ (i)

and $Q' = CV'$ (ii)

As capacitance is same in both the cases, So,

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

or $$V' = Q' \times \frac{V}{Q}$$

Putting the values, we get.

$$V' = \frac{2 \times 6}{0.03}$$

or $$\boxed{V' = 400\ V}$$

13.9 Two capacitors of capacitances 6 μF and 12 μF are connected in series with 12 V battery. Find the equivalent capacitance of the combination. Find the charge and the potential difference across each capacitor.

Answer

Capacitance of 1st, capacitor. $C_1 = 6\ \mu F$

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

Capacitance of 2nd capacitor, $C_2 = 12\ \mu F$

$= 12 \times 10^{-6}\ F$

Total voltage. $V = 12\ V$

Equivalent capacitance, $C_{eq} = ?$

Potential across 1st capacitor. $V_1 = ?$

Potential across 2nd capacitor, $V_2 = ?$

As, we have the series combination, So

Charge across each capacitor, $Q_1 = Q_2 = Q = ?$

As we know.

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

Putting the values, we get,

$$\frac{1}{C_{eq}} = \frac{1}{6_{\mu F}} = \frac{1}{12_{\mu F}}$$

$$\frac{1}{C_{eq}} = \frac{2\mu F + 1\mu F}{12_{\mu F}}$$

$$\frac{1}{C_{eq}} = \frac{3}{12}\ \mu F$$

Also, we know that. $Q = C_{eq} V$

$= 4 \times 10^{-6} \times 12$

$= 48 \times 10^{-6} C$

Charge at each Capacitor, $Q_1 = Q_2 = 48\ \mu C$

For first Capacitor, $Q = C_1 V_1$

$$V_1 = \frac{Q}{C_1}$$

or $$V_1 = \frac{48 \times 10^{\ 6}}{6 \times 10^{\ 6}}$$

$$\boxed{V_1 = 8\ V}$$

For second Capacitor, $Q = C_2 V_2$

$$V_2 = \frac{Q}{C_2}$$

or $$V_1 = \frac{48 \times 10^{\ 6}}{12 \times 10^{\ 6}}$$

$$\boxed{V_2 = 4\ V}$$

13.10 Two capacitors of capacitances 6 μF and 12 μF are connected in parallel with a 12V battery. Find the equivalent capacitance of the combination. Find the charge and the potential difference across each capacitor.

Answer

Capacitance of 1st capacitor, $C_1 = 6\mu F$

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

Capacitance of 2nd capacitor, $C_2 = 12\mu F$

$= 12 \times 10^{-6} F$

Total potential supplied, $V = 12\ V$

Equivalent capacitance, $C_{eq} =?$

Charge across 1st, capacitor, $Q_1 =?$

Charge across 2nd capacitor, $Q_2 =?$

As we have the parallel combination of capacitors. So,

$$V_1 = V_2 = V = ?$$

As, we know,

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

Putting the values, we get,

$$C_{eq} = 6\mu F + 12\mu F$$

$$\boxed{C_{eq} = 18\mu F}$$

Potential across each capacitor will be the same as that of battery due to parallel

combination of capacitors.

$\therefore$ $$\boxed{V_1 = V_2 = 12V}$$

Charge across 1st capacitor,

$$Q_1 = C_1 V$$

$$= 6 \times 10^{-6} \times 12$$

$$Q_1 = 72 \times 10^{-6} C$$

$$\boxed{Q_1 = 72\mu C}$$

Charge across 2nd capacitor,

$$Q_2 = C_2 V$$

$$= 12 \times 10^{-6} \times 12$$

$$Q_2 = 144 \times 10^{-6} C$$

$$\boxed{Q_2 = 144\mu C}$$

We know that

$$1 \text{ Kwh} = 36 \times 105 J$$

Or $$1 \text{ Wh} = 3600 J$$

Or $$1J = \frac{1}{3600} \text{ Watt} - \text{hours}$$

$$100J = \frac{1000}{3600} \text{ Watt} - \text{hours}$$

$$\boxed{1000J = 0.28 \text{ Watt-hour}}$$