6. KIRCHOFF'S LAW FOR ANALYSIS OF CAPACITIVE CIRCUITS

Many electric circuits cannot be reduced to simple series-parallel combinations.

However, it is always possible to analyze such circuits by applying two rules, devised by Kirchhoff in 1845 and 1846 when he was still a student.

First here are the two terms that we will use often.

Junction : A junction in a circuit is a point where three or more conductors meet. Junctions are also called nodes or branch points.

Loop : A loop is any closed conducting path.

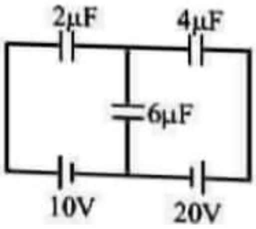
Kirchhoff's rules consist of the following two statements.

First law : The sum of all the charges entering a junction in a circuit is equal to the sum of all the charges exiting from the junction.

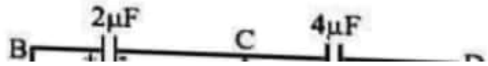
This is basically the law of conservation of charge.

Second law : The algebraic sum of all the potential differences along a closed loop in a circuit is zero.

Illustration : 5 Find the charges on the three capacitors shown in figure.



Solution :



This relation can also be obtained in a different manner. The charges on the three plates which are in contact add to zero. Because these plates taken together form an isolated system which can't receive charges from the batteries. Thus,

$$q_3 - q_1 - q_2 = 0$$

or $$q_3 = q_1 + q_2$$

Applying second law in loops BCFAB and CDEFC, we have

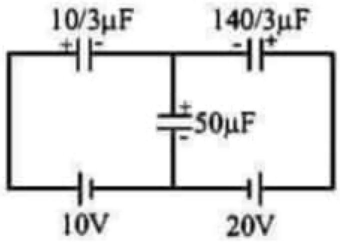
$$-\frac{q_1}{2} - \frac{q_3}{6} + 10 = 0$$

or $$q_3 + 3q_1 = 60 \quad \text{..... (ii)}$$

and $$-\frac{q_2}{4} - 20 + \frac{q_3}{6} = 0$$

or $$3q_2 + 2q_3 = 240 \quad \text{.....(iii)}$$

Solving the above three equations, we have



$$q_1 = \frac{10}{3}\mu C$$

Intensity of the field at surface of any plate due to other is half of the field between plates

$$= \frac{E}{2} = \frac{\sigma}{2\epsilon_0}$$

Force on area dS of any plate dF $= \sigma ds \frac{E}{2} = \frac{\sigma^2 ds}{2\epsilon_0}$

Net force on any plate $F = \int dF = \frac{\sigma^2 A}{2\epsilon_0}$

Force per unit area $= \frac{\sigma^2}{2\epsilon_0}$

8. ENERGY STORED IN A CAPACITOR