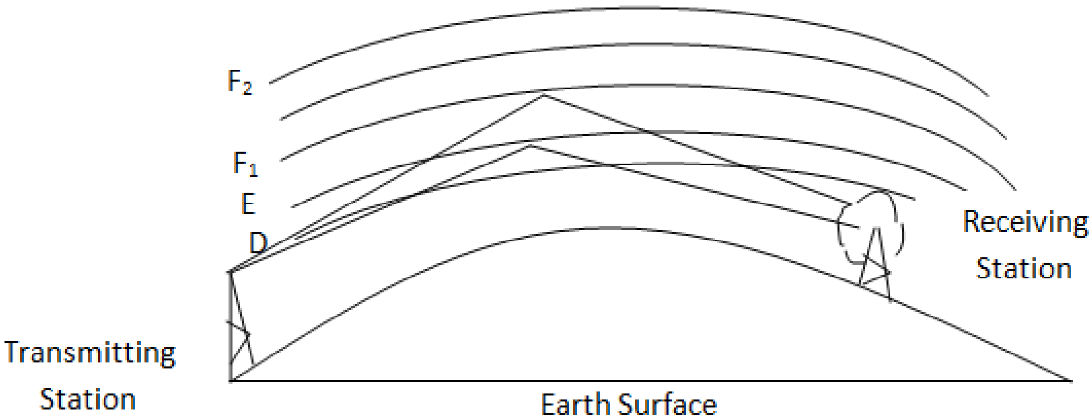
Q. 19. Which mode of propagation is used by short wave broadcast services having frequency range from a few MHz up to 30 MHz? Explain diagrammatically how long distance communication can be achieved by this mode. Why is there an upper limit to frequency of waves used in this mode?

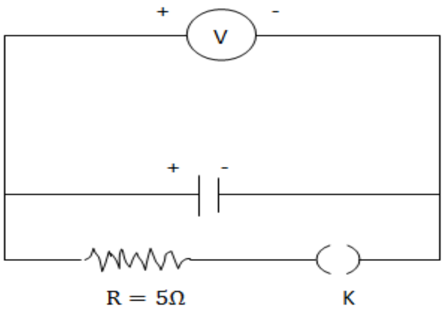
Answer: For short wave broadcast services having frequency range from a few MHz up to 30 to 40 MHz , Sky wave propagation is used.

Diagrammatic explanation: Long distance communication achieved through ionosphere reflection of radio waves, which after reflection from layers sends the waves back to the earth as shown in the figure.



Ionosphere layer extends up to 400 miles above earth surface (various sub layers are D layer: 30-60 miles, E layer: 60-70 miles, F_1 layer: 100-140 miles, F_2 layer: 200-300 miles).This mode of propagation is called sky wave propagation. Electromagnetic wave of frequencies higher than 30 MHz penetrate the ionosphere and escape.

Q. 20. Write any two factors on which internal resistance of a cell depends. The reading on a high resistance voltmeter, when a cell is connected across it, it reads 2.2 V. When the terminals of the cell are also connected to a resistance of 5Ω as shown in the circuit, the voltmeter reading drops to 1.8 V. Find the internal resistance of the cell.



Answer: Factors affecting internal resistance of a cell are

1. The nature of the electrolyte.
2. The nature of electrodes.
3. Distance between the electrodes.
4. Area of the electrodes, immersed in the electrolyte. If area increases, internal resistance decreases.

Problem: Let r = internal resistance of the cell.

$I = \frac{E}{r} \therefore I = \frac{2.2}{r} \dots\dots\dots\dots\dots (i)$

When the terminals of the cell are connected to a resistance of 5Ω then

$I = \frac{\frac{1.8}{5r}}{5+r}$

$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} \quad \therefore R = \frac{R_1 R_2}{R_1+R_2}$

$\therefore I = 1.8 \times \left(\frac{5+r}{5r}\right) \dots\dots\dots\dots\dots (ii)$

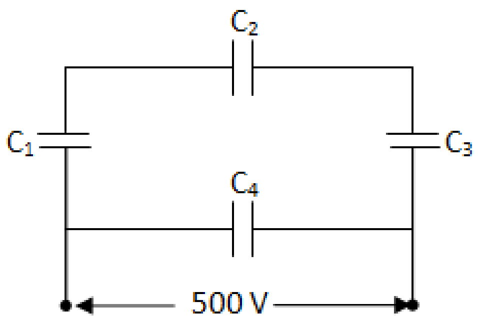
Solving equation (i) and (ii), we get

$\frac{2.2}{r} = 1.8 \times \left(\frac{5+r}{5r}\right) \Rightarrow \frac{2.2}{1.8} = \frac{5+r}{5}$

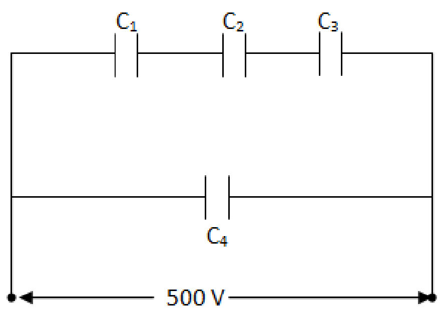
$\Rightarrow \frac{11}{9} = \frac{5+r}{5} \Rightarrow 45 + 9r = 55$

$\Rightarrow \quad 9r = 55 - 45 \quad \therefore r = \frac{10}{9}\ \Omega$

Q.21. A network of four capacitors each of 12μF capacitance is connected to a 500 V supply as shown in the figure. Determine (a) equivalent capacitance of the network and (b) charge on each capacitor.



Answer: From the figure it is clear that C_1,C_2,C_3 are in series and this combination is in parallel to C_4 therefore above circuit can be simplified with the equivalent network of the circuit as



The capacitors C_1, C_2 and C_3 are in series

$$\therefore \frac{1}{C_{series}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} \Rightarrow \frac{1}{C_{Series}} = \frac{1}{12} + \frac{1}{12} + \frac{1}{12}$$

$$\frac{1}{C_{Series}} = \frac{3}{12} \Rightarrow C_{Series} = 4\ \mu F$$

Now C_{Series} and C_4 are in parallel combination.

(a) Therefore the equivalent capacitance of the network is $C = C_{Series} + C_4 = 4 + 12 = 16\ \mu F = 16 \times 10^{-6} F$

(b) Total charge of capacitor q = CV, $q = 16 \times 10^{-6} \times 500 = 8000 \times 10^{-6} = 8000\ \mu C$

Charge on capacitor C_4 is $q = C_4\, V = 12 \times 10^{-6} \times 500 = 6000 \times 10^{-6}\ C = 6000\ \mu C$

Charge on each capacitor C_1, C_2 and C_3 is $q = C_s\, V = 4 \times 10^{-6} \times 500 = 2000 \times 10^{-6}\ C = 2000\ \mu C$