Q- A well-insulated rigid cylinder is divided in to 2 compartments by a **fixed** conducting piston. Initially one side of the piston contains 1 m^3 of O_2 at 5 bar, 80^0C and the other side contains 1m^3 of N_2 at 7 bar, 20^0C. Determine the final equilibrium temperature and pressure.

As the piston is not moving, the volume of the sides will remain constant. Let the final pressure at both sides are P_1' and P_2' and the final temperature is T (Piston is conducting) then applying Charles's law for constant volume we get

$$\frac{P_1}{T_1} = \frac{P_2}{T_2}$$

For oxygen (1 bar = 10^5 Pa)

$$\frac{5*10^5}{353} = \frac{P_1'}{T} \quad \text{---------------------------------} \ (1)$$

And for nitrogen

$$\frac{7*10^5}{293} = \frac{P_2'}{T} \quad \text{---------------------------------} \ (2)$$

Now as no work is done and no heat transferred from the cylinder the net energy will be the same and we have (for diatomic gases the internal energy of the gas is 5PV/2)

$$\frac{5}{2}P_1V_1 + \frac{5}{2}P_2V_2 = \frac{5}{2}P_1'V_1 + \frac{5}{2}P_2'V_2$$

As both volumes are equal, we get

$$P_1 + P_2 = P_1' + P_2'$$

Substituting value of final pressures from equations (3) and (4) we get

$$5 * 10^5 + 7 * 10^5 = \frac{5*10^5 T}{353} + \frac{7*10^5 T}{293}$$

Gives $12 * 10^5 = \left(\frac{5*10^5}{353} + \frac{7*10^5}{293}\right)T$

Or $T = \frac{12*10^5*353*293}{(5*293+7*353)*10^5} = 315.33\ K$

And the pressures using equations (3) and (4)

$$P_1' = \frac{5*10^5*315.33}{353} = 4.47 * 10^5\ Pa = 4.47\ bar$$

And $P_2' = \frac{7*10^5*315.33}{293} = 7.53 * 10^5\ Pa = 7.53\ bar$