Q- A well-sealed room contains 80 kg of air at 200 kPa and 25°C. Now solar energy enters the room from windows at an average rate of 1 kJ/s while a 100-W fan is turned on to circulate the air in the room. If heat transfer through the walls is negligible, what will be the air temperature in the room in 30 min?

Solution:

The process is isochoric means the volume remains constant. Heat supplied to the air in form of solar energy as well as the electrical energy consume to run the fan is also converted to the thermal energy and remains with the air hence the total rate of heat supplied to the air inside the room is

$$dQ/dt = 1000 + 100 = 1100 \text{ J/s.}$$

The amount of heat supplied is given by

$$Q = nC_v(T_2 - T_1)$$

Thus, the rate of heat supplied is given by

$$\left(\frac{dQ}{dt}\right) = \frac{nC_v(T_2 - T_1)}{t}$$ (As the rate is constant) …………………….. (1)

Where n is quantity of air in mols and Cv is molar specific heat capacity at constant volume. Also, the molar specific heat at constant volume is given by $C_v = \frac{R}{\gamma - 1} \ldots\ldots where \ldots \gamma = \frac{C_P}{Cv}$ the ratio of specific heat at constant pressure to the ratio of specific heat at constant volume. So equation (1) can be written as

$$\left(\frac{dQ}{dt}\right) = n\left(\frac{R}{\gamma - 1}\right)(T_2 - T_1)/t$$

Or $$\left(\frac{dQ}{dt}\right) = \frac{m}{M}\left(\frac{R}{\gamma - 1}\right)\left(\frac{T_2 - T_1}{t}\right)$$

Or $$\left(\frac{dQ}{dt}\right) * t = \frac{m}{M}\left(\frac{R}{\gamma - 1}\right)(T_2 - T_1)$$

For air molecular mass is taken 29 and the ratio of the two specific heats is 1.40 hence substituting the values

$$1100 \times 30 \times 60 = \frac{80000}{29} \times \frac{8.31}{1.4 - 1}(T_2 - T_1)$$

Or $$T_2 - T_1 = 34.549K \ldots or \ldots 34.6^0C$$

Therefore, the final temperature of the air is 25 + 34.549 = 59.6 ^{0}C.