Answer on Question#78392 - Physics - Other

A typical scuba tank, when fully charged, contains 12 L of air at 204 atm. Assume an empty tank contains air at 34 atm and is connected to an air compressor at sea level. The air compressor intakes air from the atmosphere, compresses it to a high pressure, and then inputs this high pressure into the scuba tank. If the average flow rate of air from the atmosphere into the intake port of the air compressor is 290 L/min, how long will it take to fully charge the scuba tank? Assume the tank remains at same temperature as the surrounding air during the filling process.

Solution:

Lets compute the volume occupied by initial air in the tank at 204 atm and the same temperature. Since initial and final temperatures are the same, the process is isothermal ($PV = const$). Thus we obtain

$$P_1 V = P_f V_1,$$

where $P_1 = 34$ atm, $V = 12$ L, $P_f = 204$ atm, V_1 – the volume occupied by initial air at 204 atm.

Therefore

$$V_1 = \frac{P_1}{P_f} V$$

The rest of the tanks volume $V_2 = V - V_1 = \left(1 - \frac{P_1}{P_f}\right) V$ must be filled with the atmospheric air compressed to 204 atm the air compressor. The initial volume V_i of this air (at atmospheric pressure) may be obtained from the same law $PV = const$, since temperature doesn't change:

$$P_{atm} V_i = P_f V_2,$$

where $P_{atm} = 1$ atm. Thus

$$V_i = \frac{P_f}{P_{atm}} V_2 = \frac{P_f}{P_{atm}} \left(1 - \frac{P_1}{P_f}\right) V = \frac{204 \text{ atm}}{1 \text{ atm}} \left(1 - \frac{34 \text{ atm}}{204 \text{ atm}}\right) 12 \text{ L} = 2040 \text{ L}.$$

So the time needed for compression is $2040 \text{ L} / 290 \frac{\text{L}}{\text{min}} = 7 \text{ min}.$

Answer: 7min.