Problem: The pressure in an automobile tire depends on the temperature of the air in the tire. When the air temperature is at $25 \, ^\circ C$, the pressure gauge reads $210 \, kPa$. If the volume of the tire is $0.025 \, m^3$, determine the pressure rise in the tire when the air temperature in the tire rises to $50 \, ^\circ C$. Also determine the amount of air that must be bled off to restore pressure to its original value at this temperature. Assume the atmospheric pressure to be $100 \, kPa$.

Assumptions
1. air behaves as an ideal gas
2. the volume of the tire remains constant

Properties
From Table A-1, the gas constant for air is $R = 0.287 \, kJ/kg \cdot K$

Part a) The absolute pressure in the tire is

$$P_1 = P_g + P_{atm} = 210 + 100 = 310 \, kPa$$

The final pressure in the tire can be determined using the ideal gas equation where

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

Since the volume in the tire remains constant

$$P_2 = \frac{T_2}{T_1} P_1 = \frac{323 \, K}{298 \, K} (210 \, kPa) = 336 \, kPa$$

The pressure rise in the tire is

$$\Delta P = P_2 - P_1 = 336 - 310 = 26 \, kPa \iff \text{part a}$$
Part b)

The amount of air that needs to be bled off to restore the pressure to its original value is determined as follows:

\[
m_1 = \frac{PV}{RT_1} = \frac{(310 \text{ kPa})(0.025 \text{ m}^3)}{(0.287 \text{ kJ/kg} \cdot \text{K}) \left(\frac{1 \text{ kPa} \cdot \text{m}^3}{1 \text{ kJ}}\right)(298 \text{ K})} = 0.0906 \text{ kg}
\]

\[
m_2 = \frac{PV}{RT_2} = \frac{(310 \text{ kPa})(0.025 \text{ m}^3)}{(0.287 \text{ kJ/kg} \cdot \text{K}) \left(\frac{1 \text{ kPa} \cdot \text{m}^3}{1 \text{ kJ}}\right)(323 \text{ K})} = 0.0836 \text{ kg}
\]

The change in the mass of the air is given as

\[
\Delta m = m_1 - m_2 = 0.0906 - 0.0836 = 0.0070 \text{ kg} \quad \Leftarrow \text{part b}
\]