A 3 m³ tank of CO₂ was initially at \( P_{1,\text{gage}} = 50 \text{ kPa} \) and 300 K. After a charging process, the gage pressure becomes \( P_{2,\text{gage}} = 0.3 \text{ MPa} \) and temperature rise to 400 K. Assume CO₂ behave like an ideal gas during the process. If the initial mass of CO₂ in the tank is \( M_1 \), the amount of CO₂ that has been added to the tank during the charging process is \( M_c \). Determine the ratio \( M_c/M_1 \).

Local atmospheric pressure is \( P_{\text{atm}} = 0.1 \text{ MPa} \). \((m_{\text{CO₂}} = 44.0 \text{ kg/kmol}, R_u = 8.314 \text{ kJ/kmol·K}, P_v = RT)\) Plot approximately the above process on the following \( P-v \) diagram for 2 bonus points.

**Sketch:**

- Known: \( P_{1,\text{gage}}, T_1, v \)
- \( P_{2,\text{gage}}, T_2 \)
- Find: \( M_c/M_1 \)

**Analysis:**

Before charging:

\[
T_1 = T_{\text{atm}} = \frac{P_1 V_1}{R_u T_1}
\]

After charging:

\[
M_2 = \frac{P_2 V_2}{R_u T_2}
\]

\[
M_c = M_2 - M_1 = \frac{P_2 V_2}{R_u T_2} - \frac{P_1 V_1}{R_u T_1}
\]

\[
= \left( \frac{P_2}{P_1} \right) \left( \frac{T_2}{T_1} \right) - 1
\]

\[
P_2 = P_{2,\text{gage}} + P_{\text{atm abs}} = 0.3 \text{ MPa} + 0.1 \text{ MPa} = 0.4 \text{ MPa}
\]

\[
P_1 = P_{1,\text{gage}} + P_{\text{atm abs}} = 0.05 \text{ MPa} + 0.1 \text{ MPa} = 0.15 \text{ MPa}
\]

Plot in \( M_c/M_1 = \frac{0.4 \text{ MPa}}{0.15 \text{ MPa}} \cdot \frac{300 \text{ K}}{400 \text{ K}} - 1 = 1 \) for 2 bonus points.