1. Benzene vapor is compressed isothermally to 37.33 L/mol. The pressure at the end of the compression is 50.00 atm. What is the temperature?

\[
P = \frac{RT}{V - b} - \frac{a}{V^2} \Rightarrow P + \frac{a}{V^2} = \frac{RT}{V - b}
\]

\[
\frac{(V - b)(P + \frac{a}{V^2})}{R} = T = \left(0.3733 \frac{L}{mol} - 1.193 \frac{L/mol}{atm}\right) \left(50 \text{ atm} + \frac{18.5^2 \text{ atm}^2}{mol^2}ight) \frac{0.08206 \frac{L \text{ atm}}{mol \text{ K}}}{mol \text{ K}}
\]

\[T = 567 \text{ K}\]

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Note: IGL yields \( T = 227 \text{ K} \)

This is in serious error.

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Note 2: The experimental value is

\[T = 567.1 \text{ K} \]

The IGL value is a good fit; note that it is a much better estimate than the IGL, and the only alternative for which you possessed the necessary constants.
2. Assume a temperature of 20 degrees Celsius. A bottle contains 5.0 L of oxygen at 3.0 bar. Let us define the system as the gas that remains in the bottle. Calculate the heat, work, change in internal energy, and change in enthalpy for these two processes:

a. The piston is slowly and smoothly withdrawn from the bottle until the pressure inside matches the pressure outside. The bottle is not insulated.

\[
W = -\int_{V_i}^{V_f} P_{ex} \, dV = -\int_{V_i}^{V_f} \frac{nRT}{V} \, dV = -nRT \left[ \frac{V}{V_i} \right]_{V_i}^{V_f} = -nRT \left( \frac{V_f}{V_i} - 1 \right) = -nRT \left( \frac{P_2}{P_1} - 1 \right)
\]

\[
W = -nRT \left( \frac{P_2}{P_1} - 1 \right)
\]

\[
W = -(0.21 \text{ mol})(8.314 \text{ J/molK})(293 \text{ K}) \left( \frac{1}{1 \text{ bar}} - \frac{1}{3 \text{ bar}} \right) 1 \text{ bar}
\]

\[
W = -405 \text{ J}
\]

b. The bottle is punctured, and gas leaks into the room over several hours until the pressure inside matches the pressure outside. The bottle is not insulated.

\[
W = -\int_{V_i}^{V_f} P_{ex} \, dV = -P_{ex}(V_f - V_i) = -P_{ex} \left( \frac{nRT}{P_{ex}} - \frac{nRT}{P_1} \right)
\]

\[
W = -nRT \left( \frac{1}{P_{ex}} - \frac{1}{P_1} \right)
\]

\[
W = -(0.208 \text{ mol})(8.314 \text{ J/molK})(293 \text{ K}) \left( \frac{1}{1 \text{ bar}} - \frac{1}{3 \text{ bar}} \right) 1 \text{ bar}
\]

\[
W = -400 \text{ J}
\]

For both a and b, \(\Delta T = 0\), so if we treat as ideal gases (reasonable), then

\[
\Delta H = \Delta U = 0;
\]

\[
dU = C_v dT + \frac{1}{2} \rho T dV
dH = C_v dT + \frac{1}{2} \rho dV
\]

Also, the system (gas that remains) is

\[
n = \frac{PV}{RT} = \frac{(1 \text{ atm})(5 \text{ L})}{(0.8206 \text{ L atm/mol K})(293 \text{ K})}
\]

\[
n = 0.208 \text{ moles}
\]

If you ignored the statement in bold and defined the system as all the gas, then \(n\) would be 1.05 moles, and your answers for \(W\) and \(q\) would be 5\(\times\) too big.