

24. a. $2200 \text{ psi} \times \frac{1 \text{ atm}}{14.7 \text{ psi}} = 150 \text{ atm}$; b. $150 \text{ atm} \times \frac{1.013 \times 10^5 \text{ Pa}}{\text{atm}} \times \frac{1 \text{ MPa}}{1 \times 10^6 \text{ Pa}} = 15 \text{ MPa}$
 c. $150 \text{ atm} \times \frac{760 \text{ torr}}{\text{atm}} = 1.1 \times 10^5 \text{ torr}$

30. The pressure exerted on the balloon is constant and the moles of gas present is constant. From Charles's law, $V_1/T_1 = V_2/T_2$ at constant P and n.

$$V_2 = \frac{V_1 T_2}{T_1} = \frac{700. \text{ mL} \times 100. \text{ K}}{(273.2 + 20.0) \text{ K}} = 239 \text{ mL}$$

As expected, as the temperature decreased, the volume decreased.

$$36. \quad P = \frac{nRT}{V} = \frac{\left(0.60 \text{ g} \times \frac{1 \text{ mol}}{32.00 \text{ g}}\right) \times \frac{0.08206 \text{ L atm}}{\text{mol K}} \times (273 + 22) \text{ K}}{5.0 \text{ L}} = 0.091 \text{ atm}$$

42. a. At constant n and V, $\frac{P_1}{T_1} = \frac{P_2}{T_2}$, $P_2 = \frac{P_1 T_2}{T_1} = 40.0 \text{ atm} \times \frac{318 \text{ K}}{273 \text{ K}} = 46.6 \text{ atm}$

b. $\frac{P_1}{T_1} = \frac{P_2}{T_2}$, $T_2 = \frac{T_1 P_2}{P_1} = 273 \text{ K} \times \frac{150. \text{ atm}}{40.0 \text{ atm}} = 1.02 \times 10^3 \text{ K}$

c. $T_2 = \frac{T_1 P_2}{P_1} = 273 \text{ K} \times \frac{25.0 \text{ atm}}{40.0 \text{ atm}} = 171 \text{ K}$

46. $PV = nRT$, P is constant. $\frac{nT}{V} = \frac{P}{R} = \text{constant}$, $\frac{n_1 T_1}{V_1} = \frac{n_2 T_2}{V_2}$

$$\frac{n_2}{n_1} = \frac{T_1 V_2}{T_2 V_1} = \frac{294 \text{ K}}{335 \text{ K}} \times \frac{4.20 \times 10^3 \text{ m}^3}{4.00 \times 10^3 \text{ m}^3} = 0.921$$

52. $2 \text{ NaN}_3(\text{s}) \rightarrow 2 \text{ Na}(\text{s}) + 3 \text{ N}_2(\text{g})$

$$n_{\text{N}_2} = \frac{PV}{RT} = \frac{1.00 \text{ atm} \times 70.0 \text{ L}}{\frac{0.08206 \text{ L atm}}{\text{mol K}} \times 273 \text{ K}} = 3.12 \text{ mol N}_2 \text{ needed to fill air bag.}$$

$$\text{mass NaN}_3 \text{ reacted} = 3.12 \text{ mol N}_2 \times \frac{2 \text{ mol NaN}_3}{3 \text{ mol N}_2} \times \frac{65.02 \text{ g NaN}_3}{\text{mol NaN}_3} = 135 \text{ g NaN}_3$$

56. Since P and T are constant, then V and n are directly proportional. The balanced equation requires 2 L of H₂ to react with 1 L of CO (2:1 volume ratio due to 2:1 mol ratio in balanced equation). The actual volume ratio present in one minute is 16.0 L/25.0 L = 0.640 (0.640:1). Since the actual volume ratio present is smaller than the required volume ratio, then H₂ is the limiting reactant. The volume of CH₃OH produced at STP will be one-half to the volume of H₂ reacted due to the 1:2 mol ratio in the balanced equation. In one minute 16.0 L/2 = 8.00 L CH₃OH are produced (theoretical yield).

$$n_{\text{CH}_3\text{OH}} = \frac{PV}{RT} = \frac{1.00 \text{ atm} \times 8.00 \text{ L}}{\frac{0.08206 \text{ L atm}}{\text{mol K}} \times 273 \text{ K}} = 0.357 \text{ mol CH}_3\text{OH in one minute}$$

$$0.357 \text{ mol CH}_3\text{OH} \times \frac{32.04 \text{ g CH}_3\text{OH}}{\text{mol CH}_3\text{OH}} = 11.4 \text{ g CH}_3\text{OH (theoretical yield per minute)}$$

$$\% \text{ yield} = \frac{\text{actual yield}}{\text{theoretical yield}} \times 100 = \frac{5.30 \text{ g}}{11.4 \text{ g}} = 46.5\% \text{ yield}$$

$$60. \quad d = \frac{P \times (\text{molar mass})}{RT} = \frac{(635 \text{ torr} \times \frac{1 \text{ atm}}{760 \text{ torr}}) \times \frac{17.03 \text{ g}}{\text{mol}}}{\frac{0.08206 \text{ L atm}}{\text{mol K}} \times 300. \text{ K}} = 0.578 \text{ g/L for NH}_3$$

$$62. \quad n_{\text{H}_2} = 1.00 \text{ g H}_2 \times \frac{1 \text{ mol H}_2}{2.016 \text{ g H}_2} = 0.496 \text{ mol H}_2; \quad n_{\text{He}} = 1.00 \text{ g He} \times \frac{1 \text{ mol He}}{4.003 \text{ g He}} = 0.250 \text{ mol He}$$

$$P_{\text{H}_2} = \frac{n_{\text{H}_2} \times RT}{V} = \frac{0.496 \text{ mol} \times \frac{0.08206 \text{ L atm}}{\text{mol K}} \times (273 + 27) \text{ K}}{1.00 \text{ L}} = 12.2 \text{ atm}$$

$$P_{\text{He}} = \frac{n_{\text{He}} \times RT}{V} = 6.15 \text{ atm}; \quad P_{\text{total}} = P_{\text{H}_2} + P_{\text{He}} = 12.2 \text{ atm} + 6.15 \text{ atm} = 18.4 \text{ atm}$$

68. To calculate the volume of gas, we can use P_{total} and n_{total} (V = n_{total}RT/P_{total}) or we can use P_{He} and n_{He} (V = n_{He}RT/P_{He}). Since n_{H₂O} is unknown, then we will use P_{He} and n_{He}.

$$P_{\text{He}} + P_{\text{H}_2\text{O}} = 1.00 \text{ atm} = 760. \text{ torr} = P_{\text{He}} + 23.8 \text{ torr}, \quad P_{\text{He}} = 736 \text{ torr}$$

$$n_{\text{He}} = 0.586 \text{ g} \times \frac{1 \text{ mol}}{4.003 \text{ g}} = 0.146 \text{ mol He}$$

$$V = \frac{n_{\text{He}} RT}{P_{\text{He}}} = \frac{0.146 \text{ mol} \times \frac{0.08206 \text{ L atm}}{\text{mol K}} \times 298 \text{ K}}{736 \text{ torr} \times \frac{1 \text{ atm}}{760 \text{ torr}}} = 3.69 \text{ L}$$

72. $(KE)_{\text{avg}} = (3/2) RT$. Since the kinetic energy depends only on temperature, CH_4 (Exercise 5.71) and N_2 at the same temperature will have the same average kinetic energy. So for N_2 the average kinetic energy is $3.40 \times 10^3 \text{ J/mol}$ (at 273 K) and $6.81 \times 10^3 \text{ J/mol}$ (at 546 K).

78.	a	b	c	d
avg. KE	inc	dec	same ($KE \propto T$)	same
avg. velocity	inc	dec	same ($\frac{1}{2} mv^2 = KE \propto T$)	same
coll. freq wall	inc	dec	inc	inc

Average kinetic energy and average velocity depend on T. As T increases, both average kinetic energy and average velocity increase. At constant T, both average kinetic energy and average velocity are constant. The collision frequency is proportional to the average velocity (as velocity increases it takes less time to move to the next collision) and to the quantity n/V (as molecules per volume increases, collision frequency increases).

82. $\frac{\text{Rate}_1}{\text{Rate}_2} = \left(\frac{M_2}{M_1} \right)^{1/2}$; $\text{Rate}_1 = \frac{24.0 \text{ mL}}{\text{min}}$, $\text{Rate}_2 = \frac{47.8 \text{ mL}}{\text{min}}$, $M_2 = \frac{16.04 \text{ g}}{\text{mol}}$ and $M_1 = ?$

$$\frac{24.0}{47.8} = \left(\frac{16.04}{M_1} \right)^{1/2} = 0.502, \quad 16.04 = (0.502)^2 \times M_1, \quad M_1 = \frac{16.04}{0.252} = \frac{63.7 \text{ g}}{\text{mol}}$$