Name: _____
Hour: ____ Date: _____

Chemistry: *Review Problems for the Gas Laws*

Do the following problems, showing your work and including all proper units.

Graham's Law

1. At 350^{o}C, nitrogen has a velocity of 800 m/s. Find the velocity of helium at the same temperature.

2. At room temperature, acetylene (C_2H_2) has a velocity of 480 m/s. At the same temperature, an unknown noble gas has a velocity of 267 m/s. What is the unknown gas?

Gas Laws with One Term Constant

3. A sample of gas has an initial volume of 25 L and an initial pressure of 3.5 atm. If the pressure changes to 1.3 atm, find the new volume, assuming that the temperature remains constant.

4. A sample of neon is at 89^{o}C and 123 kPa. If the pressure changes to 145 kPa and the volume remains constant, find the new temperature, in ^{o}C.

Combined Gas Law

5. A gas at STP occupies 28 cm^3 of space. If the pressure changes to 3.8 atm and the temperature increases to 203^{o}C, find the new volume.

6. A sample of sulfur dioxide (SO_2) is initially at a temperature of 133^{o}C, a volume of 20 L, and a pressure of 850 mm Hg. If the volume changes to 25 L and the temperature increases to 181^{o}C, find the new pressure.

Ideal Gas Law

7. 25 g of methane (CH_4) has a pressure of 4.44 atm at 250°C. Find the volume occupied by the gas.

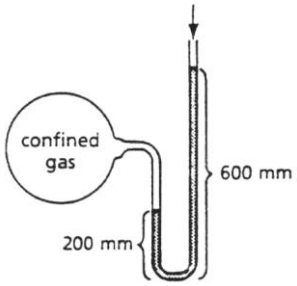
8. A sample of gas has a volume of 5.0 L when at a temperature of 310 K and a pressure of 220 kPa.

   a) Find the number of moles of gas.

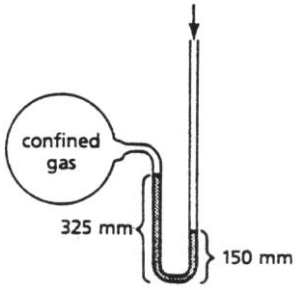
   b) If there are 56 g of the gas in the sample, which noble gas is it?

Manometers: For each manometer, find the pressure of the confined gas, in kPa.

9. atmospheric pressure = 101.3 kPa



10. atmospheric pressure = 100.4 kPa



Gas Stoichiometry

11. a) Write a balanced chemical equation for the combustion of methane to form carbon dioxide and water.

   b) If the methane has a volume of 0.65 L when under 100 kPa of pressure and at a temperature of 305 K, find the mass of oxygen that is needed to use up all of the methane.

Answers:

1. 2117 m/s
2. mm ~ 84 g, Kr
3. 67 L
4. 154°C
5. 12.8 cm^3
6. 760 mm Hg
7. 15.1 L

8a. 0.43 moles

8b. mm ~ 130 g, Xe
9. 154.6 kPa
10. 77.1 kPa

11b. 1.64 g O_2

KEY

Chemistry: *Review Problems for the Gas Laws*

Do the following problems, showing your work and including all proper units.

Graham's Law

1. At 350°C, nitrogen has a velocity of 800 m/s. Find the velocity of helium at the same temperature.

Nitrogen $\begin{cases} m_2 = 28 \text{ amu} \\ v_2 = 800 \text{ m/s} \end{cases}$ $\quad \frac{v_1}{v_2} = \sqrt{\frac{m_2}{m_1}}$ $\quad \frac{v_1}{800 \text{ m/s}} = 2.64$

Helium $\begin{cases} m_1 = 4 \text{ amu} \\ v_1 = \text{ ? m/s} \end{cases}$ $\quad \frac{v_1}{800 \text{ m/s}} = \sqrt{\frac{28 \text{ amu}}{4 \text{ amu}}}$ $\quad v_1 = 2117 \text{ m/s}$

2. At room temperature, acetylene (C_2H_2) has a velocity of 480 m/s. At the same temperature, an unknown noble gas has a velocity of 267 m/s. What is the unknown gas?

Acetylene $\begin{cases} m_2 = 26 \text{ amu} \\ v_2 = 480 \text{ m/s} \end{cases}$ $\quad \frac{v_1}{v_2} = \sqrt{\frac{m_2}{m_1}}$ $\quad (1.80)^2 = \frac{m_2}{26 \text{ amu}}$

$m_2 = 84 \text{ amu}$

Unknown $\begin{cases} m_1 = \text{ ? amu} \\ v_1 = 267 \text{ m/s} \end{cases}$ $\quad \frac{480 \text{ m/s}}{267 \text{ m/s}} = \sqrt{\frac{m_2}{26 \text{ amu}}}$ $\quad \therefore \text{Krypton (Kr} = 83.80 \text{ amu)}$

Gas Laws with One Term Constant

3. A sample of gas has an initial volume of 25 L and an initial pressure of 3.5 atm. If the pressure changes to 1.3 atm, find the new volume, assuming that the temperature remains constant.

$P_1V_1 = P_2V_2$

$V_1 = 25 \text{ L}$ $\quad V_2 = \text{ ? L}$

$P_1 = 3.5 \text{ atm}$ $\quad P_2 = 1.3 \text{ atm}$ $\quad (3.5 \text{ atm})(25 \text{ L}) = (1.3 \text{ atm})(V_2)$

$V_2 = 67.3 \text{ L}$

4. A sample of neon is at 89°C and 123 kPa. If the pressure changes to 145 kPa and the volume remains constant, find the new temperature, in °C.

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

$T_1 = 89^\circ\text{C} + 273 = 362 \text{ K}$ $\quad T_2 = \text{ ? }^\circ\text{C}$ $\quad \frac{123 \text{ kPa}}{362 \text{ K}} = \frac{145 \text{ kPa}}{T_2}$ $\quad \text{K} - 273 = {}^\circ\text{C}$

$P_1 = 123 \text{ kPa}$ $\quad P_2 = 145 \text{ kPa}$ $\quad 427 - 273 = {}^\circ\text{C}$

$T_2 = 154^\circ\text{C}$

$T_2 = 427 \text{ K}$

Chemistry: *Review Problems for the Gas Laws*

Combined Gas Law

5. A gas at STP occupies 28 cm^3 of space. If the pressure changes to 3.8 atm and the temperature increases to 203°C, find the new volume.

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

$V_1 = 28\ cm^3$ $\quad V_2 = ?\ cm^3$

$T_1 = 273\ K$ $\quad T_2 = 203^oC + 273 = 476\ K$

$P_1 = 1\ atm$ $\quad P_2 = 3.8\ atm$

$$\frac{(1\ atm)(28\ cm^3)}{273\ K} = \frac{(3.8\ atm)(V_2)}{476\ K}$$

$$V_2 = 12.8\ cm^3$$

6. A sample of sulfur dioxide (SO_2) is initially at a temperature of 133°C, a volume of 20 L, and a pressure of 850 mm Hg. If the volume changes to 25 L and the temperature increases to 181°C, find the new pressure.

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

$V_1 = 20\ L$ $\quad V_2 = 25\ L$

$T_1 = 133^oC + 273 = 406\ K$ $\quad T_2 = 181^oC + 273 = 454\ K$

$P_1 = 850\ mm\ Hg$ $\quad P_2 = ?\ mm\ Hg$

$$\frac{(850\ mm\ Hg)(20\ L)}{406\ K} = \frac{(P_2)(25\ L)}{454\ K}$$

$$P_2 = 760\ mm\ Hg$$

Ideal Gas Law

7. 25 g of methane (CH_4) has a pressure of 4.44 atm at 250°C. Find the volume occupied by the gas.

$$n = 25\ g\ CH_4\left(\frac{1\ mol\ CH_4}{16\ g\ CH_4}\right) = 1.5625\ mol\ CH_4$$

$P = 4.44\ atm$

$T = 250^oC + 273 = 523\ K$

$V = ?\ L$

$\therefore R = 0.0821\ atm \cdot L/mol \cdot K$

$$PV = nRT$$

$$\therefore V = \frac{nRT}{P}$$

$$V = \frac{(1.5625\ mol\ CH_4)(0.0821\ atm \cdot L/mol \cdot K)(523\ K)}{4.44\ atm}$$

$$V = 15.1\ L$$

Chemistry: *Review Problems for the Gas Laws*

8. A sample of gas has a volume of 5.0 L when at a temperature of 310 K and a pressure of 220 kPa.

   a) Find the number of moles of gas.

$$PV = nRT$$

$P = 220\ \text{kPa}$
$T = 310\ \text{K}$
$V = 5.0\ \text{L}$
$\therefore R = 8.314\ \text{kPa}\cdot\text{L/mol}\cdot\text{K}$

$$\therefore n = \frac{PV}{RT}$$

$$n = \frac{(220\ \text{kPa})(5.0\ \text{L})}{(8.314\ \text{kPa}\cdot\text{L/mol}\cdot\text{K})(310\ \text{K})}$$

$$n = 0.43\ \text{mol}$$

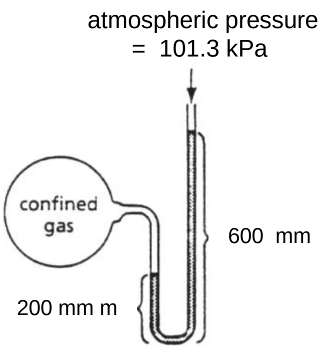
   b) If there are 56 g of the gas in the sample, which noble gas is it?

$$\text{Molar Mass (MM)} = \frac{g}{mol}$$

$$\text{Molar Mass} = \frac{56\ g}{0.43\ mol} \Rightarrow MM = 131.2\ g/mol \qquad \therefore \text{Xenon}\ \ (Xe = 131.29\ g/mol)$$

Manometers: For each manometer, find the pressure of the confined gas, in kPa.

9.

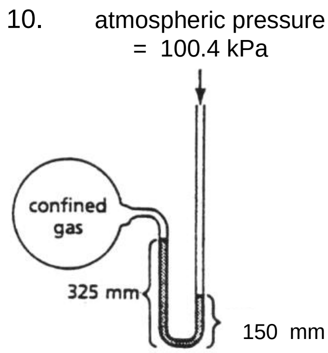


$$\begin{array}{r} 600\ mm \\ \underline{-\ 200\ mm} \end{array}$$

$$400\ mm\left(\frac{101.3\ kPa}{760\ mm\ Hg}\right) = 53.3\ kPa$$

$P_{Big} = P_{small} + P_{height}$
$P_{Big} = 101.3\ kPa + 53.3\ kPa$
$P_{Big} = 154.6\ kPa$

10.



$$\begin{array}{r} 325\ mm \\ \underline{-150\ mm} \end{array}$$

$$175\ mm\left(\frac{101.3\ kPa}{760\ mm\ Hg}\right) = 23.3\ kPa$$

$P_{Big} = P_{small} + P_{height}$
$100.4\ kPa = P_{small} + 23.3\ kPa$
$P_{small} = 77.1 kPa$

Chemistry: *Review Problems for the Gas Laws*

Gas Stoichiometry

11. a) Write a balanced chemical equation for the combustion of methane to form carbon dioxide and water.

$$\mathbf{CH_4(g) + 2\,O_2\,(g) \rightarrow CO_2\,(g) + 2\,H_2O\,(g)}$$

b) If the methane has a volume of 0.65 L when under 100 kPa of pressure and at a temperature of 305 K, find the mass of oxygen that is needed to use up all of the methane.

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

$V_1 = 0.65\ L$ $\quad V_2 = \ ?\ L$

$T_1 = 305\ K$ $\quad T_2 = 273\ K$

$P_1 = 100\ kPa$ $\quad P_2 = 101.3\ kPa$

$$\frac{(100\ kPa)(0.65\ L)}{305\ K} = \frac{(101.3\ kPa)(V_2)}{273\ K}$$

$$V_2 = 0.574\ L\ CH_4\ @\ STP$$

Substitute volume of methane gas @STP and solve ideal stoichiometry problem.

$$\underset{0.574\ L}{\mathbf{CH_4(g)}} + \underset{x\ g}{\mathbf{2\,O_2\,(g)}} \rightarrow \mathbf{CO_2\,(g) + 2\,H_2O\,(g)}$$

$$x\ g\ O_2 = 0.574\ L\left(\frac{1\ mol\ CH_4}{22.4\ L\ CH_4}\right)\left(\frac{2\ mol\ O_2}{1\ mol\ CH_4}\right)\left(\frac{32\ g\ O_2}{1\ mol\ O_2}\right) = 1.64\ g\ O_2$$

Answers:

1. 2117 m/s
2. mm ~ 84 g, Kr
3. 67 L
4. 154°C
5. 12.8 cm^3
6. 760 mm Hg
7. 15.1 L
8a. 0.43 moles
8b. mm ~ 131 g, Xe
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11b. 1.64 g O_2