Honors Gases Introduction

Kinetic Theory of Gases ...

1. Gases consist of tiny particles (atoms or molecules). ______________
2. These particles are so small compared with the distances between them that the volume (size) of the individual particles can be assumed to be negligible (zero). ____________
3. The particles are in constant random motion, colliding with the walls of the container. These collisions with the walls cause the pressure exerted by the gas. ______________
4. The particles are assumed not to attract or to repel each other. ______________
5. The average kinetic energy of the gas particles is directly proportional to the Kelvin temperature of the gas. ______________

Variables ... what can we change that effects a gas?

1. T - Temp (K)
2. P - pressure
3. V - volume
4. n - amount (moles)

Real vs. Ideal Gases ...

1. A perfect gas that obeys all the postulates ... no bonding, small size, independent is a/an ideal Gas.
2. An observable gas that deviates from theory is a/an Real Gas.
3. What factors cause deviation to occur?

→ low temp and/or high pressure

Pressure ...

1. What causes pressure? - gas particles collisions
2. Increased pressure is due to increased number of collisions

Units of Pressure ...

1. The barometer is a device used to measure pressure. It was invented by Torricelli in 1643.
2. At sea level, the atmosphere will support a tube of mercury 760. mmHg long that is inverted into a dish of mercury. What will happen at higher altitudes? Lower?

Higher will be less than 760mmHg

Lower mmHg will be greater than 760. mmHg

3. Additional units used to measure pressure include …
    a. 760 mmHg = 760 torr (in honor of Torricelli)
    b. 760 mmHg = 1 atmosphere (atm)
    c. 760 mmHg = 14.7 pounds/sq. inch (psi)
    d. 760 mmHg = 101,325 pascals (Pa)
    e. 760 mmHg = 101.325 kPa

760 mmHg = 760. torr = 1 atm = 14.7 psi = 101,325 Pa = 101.325 kPa

Sample Problems: Use D.A.!!! to solve each!

1. 1.25 atm = 950. mmHg

$$\frac{1.25\text{ atm}}{} \Big/ \frac{760\text{ mmHg}}{1\text{ atm}}$$

2. 10.6 psi = .721 atm

$$\frac{10.6\text{ psi}}{} \Big| \frac{1\text{ atm}}{14.7\text{ psi}}$$

3. 0.234 kPa = 234 Pa = 1.76 torr

$$\frac{.234\text{ kPa}}{} \Big/ \frac{101,325\text{ Pa}}{101.325\text{ kPa}} = \qquad \frac{}{} \Big/ \frac{760\text{ torr}}{101,325\text{ Pa}} =$$

4. 825 mmHg = 1.10×10^5 Pa

$$\frac{825\text{ mmHg}}{} \Big/ \frac{101,325\text{ Pa}}{760\text{ mmHg}} =$$

5. 752 torr = ~~[illegible]~~ psi

$$\frac{752\text{ torr}}{} \Big/ \frac{14.7\text{ psi}}{760.\text{ torr}} = 14.5\text{ psi}$$

Assignment: Read 440 – 457

Honors Chem Unit 11 Gases
Boyle's Law

Boyle's Law: Pressure and Volume relationships in gases

Review:

- Pressure is due to collisions of particles with the walls of a container.
- Units include: 760. mmHg = 760. torr = 1 atm = 14.7 psi = 101,325 Pa = 101.325 kPa

Boyle's Law:

- Robert Boyle first studied the relationship between P & V in gases.
- He found that P & V are ***inversely*** related! ($\uparrow P = \downarrow V$)
- Wrote the relationship mathematically as ...

  $P_1V_1 = P_2V_2$ (1 = initial conditions; 2 = new conditions)
- This is called Boyle's Law!

Examples:

(1) 5 L of a gas at 2 atm P will have what volume at 5 atm?

$$V_2 = \frac{V_1 P_1}{P_2} \qquad \frac{5\,L \;|\; 2\,atm}{\;|\; 5\,atm} = \boxed{2\,L}$$

(2) 325 mL of a gas at 730 torr will have what volume at 15.09 psi?

$$V_2 = \frac{V_1 P_1}{P_2} \qquad \frac{325\,mL \;|\; 730\,torr \;|\; 14.7\,psi}{\;|\; 15.09\,psi \;|\; 760\,torr} = 304.103 \qquad \boxed{300\,mL}$$

Cautions:

1. Always watch your units ... use the same volume and pressure on both sides.
2. Use common sense ... think about your answer!

Assignment:

1. Read 13.1-13.2 (pp. 440-257)
2. Work the following problems

Problems:

1. Synthetic diamonds can be manufactured at pressures of 6.00 X 10^4 atm. If a chemist took 2.00 L of gas at 1.00 atm and compressed it to a pressure of 6.00 X 10^4 atm, what would the volume of that gas be?

$V_2 = \frac{V_1 P_1}{P_2}$ $\frac{2.00L \times 1.00 atm}{6.00 \times 10^4 atm} = \boxed{3.33 \times 10^{-5} L}$

2. Atmospheric pressure on the peak of Mt. Everest can be as low as 150 mmHg, which is why climbers need to bring oxygen tanks for the last part of the climb. If the climbers carry 10.0 L tanks with an internal gas pressure of 3.04 X 10^4 mmHg, what will be the volume of the gas when it is released from the tanks?

$V_2 = \frac{V_1 P_1}{P_2}$ $\frac{10.0L \times 3.04 \times 10^4 mmHg}{150 mmHg} = 2026.664$

$\boxed{2.0 \times 10^3 L}$

3. An experimental research submarine with a volume of 15,000 L has an internal pressure of 1.2 atm. If the submarine ruptures while underwater at a pressure of 250 atm and the gas is released, how large a bubble will form?

$V_2 = \frac{V_1 P_1}{P_2}$ $\frac{15,000L \times 1.2 atm}{250 atm} = \boxed{72 L}$

4. In a thermonuclear device, the pressure of 0.50 L of gas within the bomb casing reaches 4.0 X 10^6 atm. When the bomb casing is destroyed by the explosion, the gas is released into the atmosphere where it reaches a pressure of 1.00 atm. What is the volume of the gas after the explosion?

$V_2 = \frac{V_1 P_1}{P_2}$ $\frac{.50L \times 4.0 \times 10^6 atm}{1.00 atm} = \boxed{2.0 \times 10^6 L}$

Honors Chem Unit 11 Gases
Charles' Law

Charles' Law: Temperature and Volume relationships in gases

Review:

- As you know Boyle's Law deals with the P & V relationship in gases when everything else is held constant.
- You also know that the relationship between P & V is ***inverse***.

Notes / Demonstrations:

- Today we look at another relationship … between T & V. Jacques Charles, 1746-1823 first studied this aspect of gases. What he found was that T & V are directly related when everything else is kept constant.
- His experiment began with a volume of gas at a certain temperature. He then cooled the gas and measured the new volume!
- He also extrapolated the data … absolute zero. (Real vs. Ideal gases issues!)

Charles' Law:

- T & V are ***directly*** related.
- $V_1 / T_1 = V_2 / T_2$ (always use temperatures in Kelvin [K = °C + 273])

Practical Applications:

- Tire pressure after driving.
- Hot Air Balloon
- Food storage containers
- Incinerating an aerosol can or lightbulb

Examples:

(1) 5.0 L (V_1) of a gas at 293 K (T_1) will have what volume (V_2) at 323 K (T_2)?

$$V_2 = \frac{V_1 T_2}{T_1} \qquad \frac{5.0L \times 325\,k}{293\,k} = \boxed{5.5L}$$

(2) 325 mL (V_1) of a gas at 298 K (T_1) will have what volume (V_2) at 12.0 °C (T_2)?

$$12.0 + 273 = 285\,k$$

$$V_2 = \frac{V_1 T_2}{T_1} \qquad \frac{325\,mL \times 285\,k}{298\,k} = \boxed{311\,mL}$$

Cautions:

1. Always watch your units ... use the same volume units on both sides.
2. All temperatures in Kelvin (no negative values)
3. Use common sense ... think about your answer!

Assignment:

1. Read (pp. 440 - 457)
2. Work problems following problems

Problems:

(1) **A child blows a 250 cm^3 bubble that contains air at 28°C. As the bubble rises it cools. If there is no change in pressure, what volume will the bubble have at 18°C?**

V_1 T_1 V_2 T_2

$T_1 = 28 + 273 = 301\,K$
$T_2 = 18 + 273 = 291\,K$

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

$$\frac{291\,k}{301\,k} \Big/ 250\,cm^3 = \boxed{240\,cm^3}$$

(2) **A 24 L sample of nitrogen gas is cooled from 25°C to a final temperature of -100.°C. What is the new volume of the gas?**

V_1 T_1 T_2 V_2

$T_1 = 25 + 273 = 298\,k$
$T_2 = -100 + 273 = 173\,k$

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

$$\frac{173\,k}{298\,K} \Big/ 24\,L = \boxed{14\,L}$$

(3) **The label on an aerosol spray can contains a warning that the can should not be heated to over 54°C because of the danger of explosion. Although the pressure in an aerosol can also increase if it is heated, calculate the potential volume of the gas in a 500. mL aerosol can when it is heated from 25°C to 54°C if the pressure remains constant?**

V_2 V_1 T_1 T_2

$T_1 = 25 + 273 = 298\,k$
$T_2 = 54 + 273 = 327\,k$

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

$$\frac{327\,k}{298\,k} \Big/ 500.\,mL = \boxed{549\,mL}$$

Honors Chem Unit 11 Gases
Combined Gas Law

Combined Gas Law: Pressure, Temperature and Volume relationships in gases

Review:

- There are four variables related to gases: P, V, T, and n (moles)
- Boyle's Law deals with P & V $P_1V_1 = P_2V_2$
- Charles' Law covers T & V $V_1 / T_1 = V_2 / T_2$

Notes:

- The Combined Gas Law combines Boyle's and Charles' Laws. It puts P, V, & T into one equation.
- The equation is: $P_1V_1 / T_1 = P_2V_2 / T_2$
- STP (standard temperature and pressure) = 0°C and 760 mmHg
- Temperature must be in Kelvin [K = °C + 273]

Cautions:

1. Always watch your units ... use the same P, V on both sides.
2. All temperatures in Kelvin.
3. Use common sense ... think about your answer!

Examples:

(1) $V_1 = 256$ mL $V_2 = ?$

~~$T_1 = 23°C$~~ $+273 = 296k$ ~~$T_2 = 85°C$~~ $+273$ $358k$

$P_1 = 1.5$ atm $P_2 = 1.2$ atm

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

$$V_2 = \frac{T_2P_1V_1}{T_1P_2}$$

$$\frac{358k}{296k} \bigg| \frac{1.5 atm}{1.2 atm} \bigg| \frac{256 mL}{} = \boxed{390 mL}$$

(2) V_1 = 4.5 L V_2 = ?
T_1 = 38°C 311 K T_2 = 64°C 337 K
P_1 = 25 psi P_2 = 16 atm

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

$$\frac{337\text{ K}}{311\text{ K}} \cdot \frac{25\text{ psi}}{16\text{ atm}} \cdot 4.5\text{ L} = \boxed{1.52\text{ L}}$$

(3) V_1 = 645 mL V_2 = at STP
~~T_1 = 45°C~~ 318 K T_2 = 0 °C (STP) 273 K
P_1 = 1.5 atm P_2 = 1 atm (STP)

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

$$\frac{273\text{ K}}{318\text{ K}} \cdot \frac{1.5\text{ atm}}{1\text{ atm}} \cdot 645\text{ mL} \quad \boxed{830\text{ mL}}$$

has No sig figs!

(4) A 250 cm^3 of nitrogen gas is at 20.°C and 758 torr. What volume (cm^3) will it occupy at -15.0°C and 1.2 atm?

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

$$\frac{258.0\text{ K}}{293\text{ K}} \cdot \frac{758\text{ torr}}{1.2\text{ atm}} \cdot 250\text{ cm}^3 \cdot \frac{1\text{ atm}}{760\text{ torr}}$$

$$\boxed{180\text{ cm}^3}$$

Assignment:
Worksheet Combined Gas Law Problems

Name ____________________

Period ___ Date __________

Honors Combined Gas Law Problems

1. Use the following data to find P_2 in atm.

   $V_1 = 7.84\ cm^3$ $V_2 = 15.6\ cm^3$

   $P_1 = 71.8\ kPa$ $P_2 =$ _______ atm

   $T_1 = 25.0\ °C$ $T_2 = 0.0°C$

   298.0 K 273.0 K

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

$$\frac{273.0\,K}{298.0\,K} \Big/ \frac{7.84\,cm^3}{15.6\,cm^3} \Big/ \frac{71.8\,kPa}{} \Big/ \frac{1\,atm}{101.325\,kPa}$$

$$\boxed{.326\ atm}$$

2. When 3.50 L of CO_2 gas at 2.00 atm and 56.7°C is heated and compressed, the new pressure is 3.50 atm and the new temperature is 109.7°C. What is the new volume?

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

$$\frac{382.7\,K}{329.7\,K} \Big/ \frac{2.00\,atm}{3.50\,atm} \Big/ \frac{3.50\,L}{} = \boxed{2.32\ L}$$

3. The volume of a sample of gas is 200.0 mL at a temperature of 275 K and a pressure of 92.1 kPa. What will the new volume of this sample be if the temperature is increased to 350.0 K and the pressure is decreased to 78.6 kPa?

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

$$\frac{350.0\,K}{275\,K} \Big/ \frac{200.0\,mL}{} \Big/ \frac{92.1\,kPa}{78.6\,kPa} = \boxed{298\ mL}$$

4. A sample of gas at 25.0 °C has a volume of 15.7 mL at a pressure of 760 torr. What is the new temperature (in K) of the gas if the pressure changes to 10.0 atm, and the volume changes to 18.9 mL?

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

$$\frac{298.0\,K}{} \bigg/ \frac{18.9\,mL}{15.7\,mL} \bigg/ \frac{10.0\,atm}{760\,torr} \bigg/ \frac{760\,torr}{1\,atm}$$

$$\boxed{T_2 = 3600\,K}$$

5. A balloon man fills a balloon with 2.25 L of helium gas at ground level. The temperature is pleasant at 19.0 °C and it is sunny with a pressure of 770. mmHg. The balloon slips from the grasp of a small child and reaches at height of 1500 ft, where the temperature is 14.5 oC and the pressure is only 752 torr. What is the balloons new volume?

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

$$\frac{287.5\,K}{292\,K} \bigg/ \frac{770.\,mm\,Hg}{752\,torr} \bigg/ \frac{2.25\,L}{} \bigg/ \frac{760.\,torr}{760\,mm\,Hg}$$

(u)

$$\boxed{2.27\,L}$$