Mr. Dehne AMSAT Chem 1H

Name:_____

Date: _____

Per#:___

Gases Topic#11

WS#1: Pressure, Volume, and Temperature

(Show all work on separate sheet of paper for ALL assignments. No Work, No Credit)

Matching

1. ___A bicycle tire inflates when you pump air into a valve on one side.
2. ___A car is supported on a "cushion of air."
3. ___An air mattress springs back to its original shape after being pressed.
4. ___A balloon filled with air weighs more than an empty balloon.
5. ___The color of a gas is uniform throughout the bottle containing it.

a. compressibility
b. has mass
c. fills container
d. exerts pressure
e. diffuses through other gases

Variables can be used more than once.

6. ___ K
7. ___ newtons per square meter
8. ___ L
9. ___ pascal
10. ___ moles
11. ___ kPa
12. ___ atm

a. pressure
b. temperature
c. amount
d. volume

T/F Correct if false.

13. Although <u>air</u> is a mixture of several gases, it behaves like a single gas.
14. Oxygen is diatomic, and, under similar conditions, its volume is <u>twice</u> that of monatomic helium.
15. Air bags are used as safety devices in cars because air <u>cannot</u> be compressed.
16. Most gases are made up of <u>single atoms</u>.
17. According to the kinetic-molecular theory, the collisions between gas particles are <u>100 percent</u> elastic.
18. The <u>pressure</u> of a gas is simply a measure of the kinetic energy of the gas particles.
19. The <u>volume</u> of a gas is equal to the volume of its container.

Fill in the blank.

perfectly elastic / zero / weak / kinetic energy / no force / pressure / random motion / potential energy

20. The volume of gas particles themselves is assumed to be _____.
21. Gas molecules are said to be in _____.
22. The collisions between gas particles are _____.
23. The temperature of a gas is a measure of the average _____ of the gas particles.
24. Gas particles exert _____ on one another.

Problems

25. Convert the following pressures. (1atm = 101.3kPa = 101,300Pa = 760torr = 760mmHg = 14.7psi)
    a. 4.45 atm to torr
    b. 2350 torr to atm
    c. 1043 mmHg to kPa
    d. 120.1kPa to mmHg
    e. 125 kPa to atm
    f. 1.17atm to kPa
    g. 790 torr to kPa
    h. 240 kPa to torr
    i. 120, 000 Pa to atm
    j. 2.35 atm to mmHg
    k. 856 mmHg to atm
    l. 2.34×10^5Pa to mmHg
26. Convert the following volumes ($1000cm^3 = 1000mL = 1L = 1dm^3$)
    a. 353ml to L
    b. 23.4L to mL
    c. $3.86dm^3$ to L
    d. 456mL to dm^3
    e. $0.23dm^3$ to mL
    f. 784mL to dm^3
27. Convert the following temperatures. (K = ºC + 273)
    a. 273ºC to K
    b. 373K to ºC
    c. 32ºC to K
    d. 421K to ºC
28. Solve for the unknown variable. *n* is the variable for moles.

$$n = \frac{grams\_of\_substance}{molar\_mass\_of\_substance} = \frac{g}{MM}$$

a) n = 3.2 mol, MM = 32.07g/mol, and g = ?
b) n = 0.245mol, MM = ?, and 38.1g
c) n = ?, MM = 44.01g/mol, and g = 54.00
d) n = 0.0879mol, MM = 38.00g/mol, and ?g

Key: (25) (a) 3380torr (b) 3.09atm (c) 139.0kPa (d) 901.0mmHg (e) 1.23atm (f) 119kPa (g) 110kPa (h) 1800torr (i) 1.2atm (j) 1790mmHg (k) 1.13atm (l) 1760mmHg
(26) (a) 0.353L (b) 23,400mL (c) 3.86L (d) $0.456dm^3$ (e) 230mL (f) $0.784dm^3$
(27) (a) 546K (b) 100.ºC (c) 305K (d) 148 ºC
(28) (a) 1.0×10^2g (b) 156g/mol (c) 1.227mol (d) 3.34g

WS#2: Dalton's Law and Mole Fraction

Dalton's Law states that the sum of the individual pressures of all the gases that make up a mixture of gases is equal to the total pressure. The partial pressure of each gas is equal to the mole fraction of each gas x total pressure.

$$P_T = P_1 + P_2 + P_3 + \ldots \text{ and } P_T = P_{\text{dry gas}} + P_{H2O} \text{ and } X_a = n_a/n_T \text{ and } (X_a)(P_T) = P_a$$

1. A 250.mL sample of O_2 is collected over H_2O at 25ºC and has a total pressure of 760.0torr. What is the pressure of the dry gas alone? (Ans: 736.0torr)
2. A 54.0mL sample of O_2 is collected over H_2O at 23ºC and has a total pressure of 770.0torr . What is the pressure of the dry gas? (Ans: 749.0torr)
3. A mixture of 2.00mol of H_2, 3.00mol of NH_3, 4.00mol of CO_2, and 5.00mol of N_2 exerts a pressure of 800.torr. (a) What is the n_T? (b) Calculate the mole fraction for each gas. (c) What is the partial pressure, P_a, of each gas? (Ans: 114torr H_2, 171torr NH_3, 229torr CO_2, 286torr N_2)
4. The partial pressure of F_2 is 300.torr in a mixture of gases where the total pressure is 1.00 atm. What is the mole fraction of F_2? (Ans: 0.395)

Vapor Pressure of Water

Temperature (ºC)	Pressure (kPa)	Temperature (ºC)	Pressure (kPa)	Temperature (ºC)	Pressure (kPa)	Temperature (ºC)	Pressure (kPa)
0	0.6	18	2.1	26	3.4	50	12.3
5	0.9	20	2.3	27	3.6	60	19.9
8	1.1	21	2.5	28	3.8	70	31.2
10	1.2	22	2.6	29	4.0	80	47.3
12	1.4	23	2.8	30	4.2	90	70.1
14	1.6	24	3.0	35	5.6	100	101.3
16	1.8	25	3.2	40	7.4		

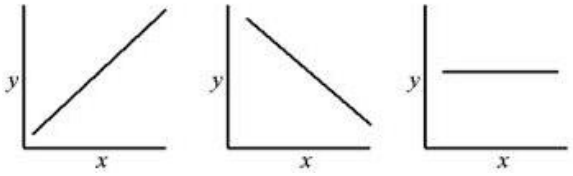
WS#3: Boyles/Charles/Combined Gas Law

Matching

1. ___ The pressure of a gas is inversely proportional to its volume.
2. ___ The sum of the partial pressures of gases in a mixture is equal to the total pressure of the mixture.
3. ___ Equal volumes of gases contain equal numbers of particles.
4. ___ The volume of a gas is directly proportional to its temperature.

a. Avogadro
b. Charles
c. Boyle
d. Dalton

The graphs below are "trend graphs" not necessarily the actual shape of the graph. Match relationship to appropiate graph.



A B C

5. ___ the relationship between gas pressure and its temperature
6. ___ the relationship between gas volume and its pressure
7. ___ the relationship between gas temperature and its volume
8. ___ the relationship between gas volume and its molar mass

Determine whether the circumstance will result in an increase, a decrease, or no change.

9. If the temperature of a gas increases, the pressure of the gas will increase/decrease/not be affected.
10. If the molecular weight of a gas increases, the total volume of the gas will increase/decrease/not be affected.
11. If the temperature of a gas decreases, the pressure of the gas will increase/decrease/not be affected.

As a gas is compressed in a cylinder…

12. the distance between gas molecules will increase/decrease/not be affected.
13. the number of gas molecules will increase/decrease/not be affected.
14. its volume will increase/decrease/not be affected.
15. its pressure will increase/decrease/not be affected.
16. its density will increase/decrease/not be affected.
17. its mass will increase/decrease/not be affected.

Problems

Boyle's Law [$P_1V_1 = P_2V_2$] [standard conditions (STP): 0°C(273K) and 1atm]

18. Correct the following gas volumes from the initial conditions to the new conditions (assume temperature remains constant).
    a. 100.0mL oxygen at 10.50kPa to 9.91kPa (Ans:106mL)
    b. 50.0mL hydrogen at 97.3kPa to 101,000Pa (Ans: 48.2mL)
19. A flask containing 90.0mL of hydrogen was collected under a pressure of 0.962atm. At what pressure would the volume be 70.0mL, assuming the temperature is kept constant? (Ans: 1.24atm)
20. A gas has a volume of 275mL when measured at a pressure of 735torr. If the temperature is held constant, what would the gas volume be at standard pressure? (Ans: 266mL)
21. A gas has a volume of $5.0x10^4$L at standard pressure. Assuming no temperature change, what volume will the gas occupy?
    a. If the pressure is doubled? (Ans: $2.5x10^4$L)
    b. If the pressure is tripled? (Ans: $1.7x10^4$L)
    c. If the original pressure is cut in half? (Ans: $1.0x10^5$L)
22. A gas is confined in a cylinder with a moveable piston at one end. When the volume of the cylinder is 760.0mL the pressure of the gas is 937.8mmHg. When the cylinder volume is reduced to 450.mL, what is the pressure? (Ans: 1580mmHg)

Charles' Law [$V_1/T_1 = V_2/T_2$]

23. A gas has a volume of $1.00x10^4$L at standard temperature. Assuming no pressure change, what volume will the gas occupy?
    a. If the Kelvin temperature is doubled? (Ans: $2.00x10^4$L)
    b. If the original Kelvin temperature is halved? (Ans: $5.0x10^3$L)
24. Correct the following gas volumes from the initial conditions to the new conditions (assuming that the pressure remains constant).
    a. 250.0mL chlorine at 10°C to 60.0°C (Ans: 294mL)
    b. 75.0mL hydrogen at 20.0°C to -10.0°C (Ans: 67.3mL
25. A gas occupies a volume of 560mL at a temperature of 120.°C. to what temperature must the gas be lowered, if it is to occupy 400.0mL? Assume a constant pressure. (Ans: 8°C, 281K)
26. What is the new temperature for 250.mL of a gas that has an initial temperature of -10.6°C and a volume 28.7mL? (Ans: -243°C, 30.K)

Combined Gas Law [$(P_1V_1)/T_1 = (P_2V_2)/T_2$] [STP = 1atm(101.3kPa) and 0°C (273K)]

27. Convert the following gas volumes to the new volumes using the combined gas law and new conditions.
    a. $5.00x10^2$mL hydrogen at 20°C and 120kPa to STP conditions (Ans: 552mL)
    b. 140mL hydrogen at 15°C and 11.0kPa to 40.0°C and 94.5kPa (Ans: 18mL)
28. A gas occupied 550.0mL at a pressure of $9.95x10^4$Pa and a temperature of 21°C. Several days later it was measured at a pressure of $9.78x10^4$Pa and a temperature of 15°C. What volume does the gas occupy under these new conditions? (Ans: 548mL)
29. The following gases are collected over water at the given temperatures. Using the table for water partial pressures below, calculate the volume occupied by the <u>dry</u> gas at standard conditions.
    a. 200.mL O_2 at 15°C and 786.2mmHg (Ans: 192mL)
    b. 325mL neon at 25°C and 98.6kPa (Ans: 280.mL)
30. A 47.0mL volume of nitrogen gas collected over water at a temperature of 18°C and a pressure of 98.5kPa. What volume will the gas occupy at standard conditions? (Ans: 42.0mL)

Vapor Pressure of Water

Temperature (°C)	Pressure (kPa)	Temperature (°C)	Pressure (kPa)	Temperature (°C)	Pressure (kPa)	Temperature (°C)	Pressure (kPa)
0	0.6	18	2.1	26	3.4	50	12.3
5	0.9	20	2.3	27	3.6	60	19.9
8	1.1	21	2.5	28	3.8	70	31.2
10	1.2	22	2.6	29	4.0	80	47.3
12	1.4	23	2.8	30	4.2	90	70.1
14	1.6	24	3.0	35	5.6	100	101.3
16	1.8	25	3.2	40	7.4		

WS#4: Molar Volume

Molar Volume [1mol (of any gas at STP) = 22.4L] and [STP is standard temperature (0^oC) and pressure (1atm)]

All chemical equations must be balanced.

1. Find the mass of benzene (C_6H_6) required to produce 2.66L of carbon dioxide gas at STP from the reaction.
   $C_6H_6(l) + O_2(g) \rightarrow H_2O(l) + CO_2(g)$ (Ans: 1.55g C_6H_6)
2. How many liters of oxygen are necessary for the combustion of 277g of carbon monoxide, assuming that the reaction occurs at STP? $CO(g) + O_2(g) \rightarrow CO_2(g)$ (Ans: 111L O_2)
3. Find the mass of aluminum required to produce 4.72L of hydrogen gas at STP from the following reaction.
   $Al(s) + H_2SO_4(aq) \rightarrow Al_2(SO_4)_3(s) + H_2(g)$ (Ans:3.79g Al)
4. How many liters of hydrogen are produced if 225g of iron reacts with hydrochloric acid, assuming that the reaction occurs at STP? $Fe(s) + HCl(aq) \rightarrow FeCl_2(aq) + H_2(g)$ (Ans: 90.2L H_2)
5. Find the mass of S_8 required to produce 2.47L of sulfur dioxide gas at STP from the following equation.
   $S_8(s) + O_2(g) \rightarrow SO_2(g)$ (Ans: 3.54g S_8)
6. Propane (C_3H_8) burns in oxygen to produce carbon dioxide and water vapor. What volume of carbon dioxide is produced when 2.8L of oxygen are consumed? $C_3H_8(g) + O_2(g) \rightarrow CO_2(g) + H_2O(l)$ (Ans: 1.7L CO_2)
7. The compound TNT (trinitrotoluene) decomposes explosively into carbon, carbon monoxide, hydrogen, and nitrogen. What volume of hydrogen and nitrogen are produced if 5.8L of CO is produced?
   $C_7H_5(NO_2)_3(s) \rightarrow C(s) + CO(g) + H_2(g) + N_2(g)$ (Ans: 2.4L H_2/1.4L N_2)
8. Nitroglycerin decomposes explosively to produce carbon dioxide, water, nitrogen, and oxygen. What volumes of nitrogen and oxygen are produced if 4.3L of carbon dioxide is produced?
   $C_3H_5(NO_3)_3(l) \rightarrow CO_2(g) + H_2O(g) + O_2(g) + N_2(g)$ (Ans: 2.2L N_2/0.36L O_2)

WS#5: Ideal Gas Law/Gas Density/Graham's Law

Complete sentences

1. Standard temperature is _____ degrees Celsius.
2. Absolute zero is _____ Kelvin.
3. The volume of 1 mole of any gas at STP is _____ L.
4. Standard pressure is equal to _____ kPa.
5. If the pressure of 2L of a gas at STP doubles, its new volume would be _____ L.

T of F Correct if false.

6. ____ Real gases behave like ideal gases except at very <u>high</u> temperatures.
7. ____ The gas constant, *R*, is equal to 0.0821 when the pressure is expressed in <u>kilopascals</u>.
8. ____ As more gas particles are added to a container, there are <u>fewer</u> collisions because the particles don't go as far.
9. ____ The number of moles of a gas is <u>inversely</u> proportional to its volume at STP.
10. ____ Real gases behave like ideal gases except at very <u>high</u> pressures.
11. ____ At a constant temperature, the pressure exerted by one mole of a gas <u>decreases</u> if the volume available is increased.
12. ____ The ideal gas equation will only give correct values if the temperature is expressed in <u>degrees</u>.
13. ____ One mole of oxygen at 760mmHg and 0^oC occupies a volume of <u>one</u> L.
14. ____ Gas density depends on <u>molar mass</u>.
15. ____ Under identical conditions, helium would probably leak out of a balloon faster than <u>oxygen</u>.

Fill in the blank.

molar mass / CFCs / ultraviolet light / helium / density / hydrogen / decrease / increase / heavier / effusion

16. The density of a gas depends on the _____ of the gas.
17. The density of a gas will _____ with increasing temperature.
18. The safest "lifting" gas used in today's lighter-than-air aircraft is _____.
19. The most useful property of ozone in the stratosphere is its ability to absorb_____.
20. A hot-air balloon uses heat to change the _____ of a given volume of air.
21. The slow escape of a gas through a porous membrane is an example of _____.
22. The density of a gas will _____ with increasing pressure.
23. The *Hindenburg* tragedy revealed the dangers of using _____ in commercial aircraft.
24. Chemical reactions that destroy ozone in the stratosphere are thought to be caused by _____.
25. Lighter gases diffuse faster than _____ gases.

Problems

Ideal Gas Law [$PV = nRT$] and $\boldsymbol{R}$ = 0.0821(atm), 8.31(kPa), or 62.35(mmHg/torr)

Use the Ideal Gas Law to solve the following problems. Volumes must be in liters (L).

26. How many moles of oxygen will occupy a volume of 2.5L at 1.2atm and 25ºC? (Ans: 0.12moles O_2)
27. What volume will 2.0mol of nitrogen occupy at 720torr and 20.ºC? (Ans: 51L)
28. What pressure will be exerted by 25g of CO_2 at a temperature of 25ºC and a volume of 500.mL? (Ans: 28atm)
29. At what temperature will 5.00g of Cl_2 exert a pressure of 900.torr at a volume of 750.mL? (Ans: 153K)
30. How many moles of nitrogen gas will occupy a volume of 347mL at 6680torr and 27ºC? (Ans: 0.124mol)

31. What volume will 454g (1lb) of hydrogen occupy at 1.05atm and 25ºC? (Ans: 5240L)
32. Find the number of grams of CO_2 that exert a pressure of 785torr at a volume of 32.5L and a temperature of 32ºC? (Ans: 59.0g)
33. An elemental gas has a mass of 10.3g. If the volume is 58.4L and the pressure is 758torr at a temperature of 2.5ºC, what is the gas? (Ans: *MM* = 4.00g/mol, He)

Gas Density [$d = m/V = (MM \times P)/(R \times T)$]

34. What is the density of NH_3 at 800.torr and 25ºC? (Ans: 0.73g/L)
35. If a density of a gas is 1.2g/L at745torr and 20.ºC, what is its molecular mass? (Ans: 29g/mol)
36. At 28ºC and 0.974atm, 1.00L of gas has a mass of 5.16g. What is the molar mass of this gas? (Ans: 131g/mol)
37. What is the molar mass of a gas if 0.427g of the gas occupies a volume of 125mL at 20.0ºC and 0.98atm? (Ans: 84g/mol)
38. What is the density of a sample of ammonia gas, NH_3, if the pressure is 0.928atm and the temperature is 63.0ºC? (Ans: 0.573g/L)
39. The density of a gas was found to be 2.0g/L at 1.50atm and 27ºC. What is the molar mass of the gas? (Ans: 33g/mol)
40. What is the density of argon gas, Ar, at a pressure of 551torr and a temperature of 25ºC? (Ans: 1.18g/L)

Graham's Law [$rate_a/rate_b = \sqrt{MM_b/MM_a}$]

Graham's Law says that a gas will effuse at a rate that is inversely proportional to the square root of its molecular mass, MM.

41. If the molecular speed of a gas increase, its rate of diffusion will <u>increase / decrease / not be affected</u>.

Solve the following problems.

42. Under the same conditions of temperature and pressure, how many times faster will hydrogen effuse compared to carbon dioxide? (Ans: 4.67 times faster than CO_2)
43. If the carbon dioxide in Problem 42 takes 32sec to effuse, how long will the hydrogen take? (Ans: 6.8sec)
44. What is the relative rate of diffusion of NH_3 compared to He? Does NH_3 effuse faster or slower than He? (Ans: 0.48 to 1, slower by about 50%)
45. If the He in Problem 3 takes 20sec to effuse, how long will NH_3 take? (Ans: 42sec)
46. An unknown gas diffuses 0.25times as fast as He. What is the molecular mass of the unknown gas? (Ans: 64 g/mol)

WS#6: Gas Stoichiometry [Use molar volume for gas at STP and $PV = nRT$ for gases NOT at STP]

1. What volume of chlorine is required to produce 25.4g of copper (II) chloride at 18ºC and 2.13atm? (Ans: 2.12L Cl_2)
$$Cu(s) + Cl_2(g) \rightarrow CuCl_2(s)$$
2. Hydrochloric acid and zinc react to produce zinc (II) chloride and hydrogen gas. At 778mmHg and 25ºC, how many grams of zinc are required to produce 25.2L of hydrogen gas? (Ans: 68.9g Zn)
$$2HCl(aq) + Zn(s) \rightarrow ZnCl_2(aq) + H_2(g)$$
3. If 5.45g of potassium chlorate decompose, how many liters of oxygen gas are given off at 1.58atm and 32ºC? (Ans: 1.06L O_2)
$$2KClO_3(s) \rightarrow 2KCl(s) + 3O_2(g)$$
4. When aluminum is burned in 15.0L of oxygen at 97.3kPa and 21ºC, how many grams of aluminum oxide are formed? (Ans: 40.6gAl_2O_3)
$$4Al(s) + 3O_2(g) \rightarrow 2Al_2O_3(s)$$
5. If 12.8g of $CaCO_3$ decomposes at 38ºC and 0.96atm, how many dm^3 of CO_2 are formed in addition to CaO? (Ans: 3.4L of O_2)
$$CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$$
6. What mass of glucose ($C_6H_{12}O_6$) is required to produce 150cm^3 of carbon dioxide at 102kPa and 23ºC? (Ans: 5.60g $C_6H_{12}O_6$)
$$C_6H_{12}O_6(s) + 2O_2(g) \rightarrow 2CH_3COOH(aq) + 2CO_2(g) + 2H_2O(l)$$