Name: _____
AP Chemistry
Gases Practice Problems

Multiple Choice
Identify the letter of the choice that best completes the statement or answers the question. You

____ 1. At standard temperature and pressure, a 0.50 mol sample of H_2 gas and a separate 1.0 mol sample of O_2 gas have the same
a. average molecular kinetic energy
b. average molecular speed
c. volume
d. effusion rate

____ 2. A rigid metal tank contains oxygen gas. Which of the following applies to the gas in the tank when additional oxygen is added at constant temperature?
a. The volume of the gas increases.
b. The pressure of the gas decreases.
c. The average speed of the gas molecules remains the same.
d. The total number of gas molecules remains the same.

____ 3. What volume of $O_{2(g)}$ is required to react with excess $CS_{2(\ell)}$ to produce 4.0 L of $CO_{2(g)}$? (Assume all gases are measured at 0°C and 1 atm.)

$$CS_{2(\ell)} + 3\ O_{2(g)} \rightarrow CO_{2(g)} + 2\ SO_{2(g)}$$

a. 12 L
b. 22.4 L
c. $1/3 \times 22.4$ L
d. 2×22.4 L

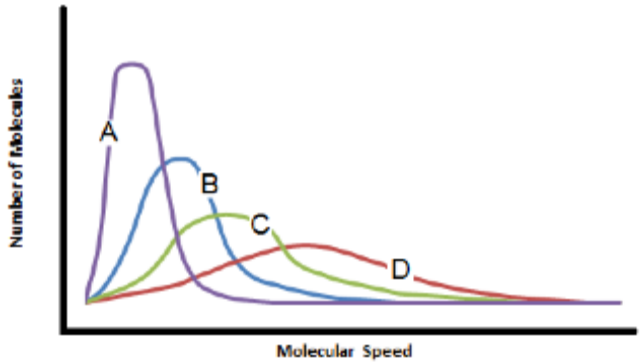
____ 4. A hydrocarbon gas with an empirical formula CH_2 has a density of 1.88 grams per liter at 0°C and 1.00 atmosphere. Which of the following is a possible molecular formula for the hydrocarbon?
a. CH_2
b. C_2H_4
c. C_3H_6
d. C_4H_8

____ 5. A 2 L container will hold about 4 g of which of the following gases at 0°C and 1 atm?
a. SO_2
b. N_2
c. CO_2
d. C_4H_8

____ 6. Under which conditions will a real gas behave most like an ideal gas?
a. high pressure and high temperature
b. low pressure and low temperature
c. low volume and high temperature
d. low pressure and high temperature

____ 7. When a sample of oxygen gas in a closed container of constant volume is heated until its absolute temperature is doubled, which of the following is also doubled?
a. The density of the gas
b. The pressure of the gas
c. The average velocity of the gas molecules
d. The number of molecules per cm^3

____ 8. Consider the graph below, which shows the speed distribution of a sample of gas molecules at four different temperatures.



Which of the following correctly sequences the curves in order of increasing temperature?

a. A, C, B, D
b. D, B, C, A
c. A, B, C, D
d. D, C, B, A

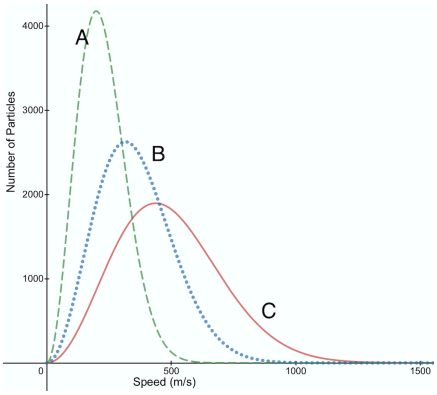
____ 9. Equal masses of three different ideal gases, X, Y, and Z, are mixed in a sealed rigid container. If the temperature of the system remains constant, which of the following statements about the partial pressure of gas X is correct?

a. It is equal to $^1/_3$ the total pressure
b. It depends on the intermolecular forces of attraction between molecules of X, Y, and Z.
c. It depends on the relative molecular masses of X, Y, and Z.
d. It depends on the average distance traveled between molecular collisions.

____ 10. A flask contains 0.25 mole of $SO_{2(g)}$, 0.50 mole of $CH_{4(g)}$, and 0.50 mole of $O_{2(g)}$. The total pressure of the gases in the flask is 800 mm Hg. What is the partial pressure of the $SO_{2(g)}$ in the flask?

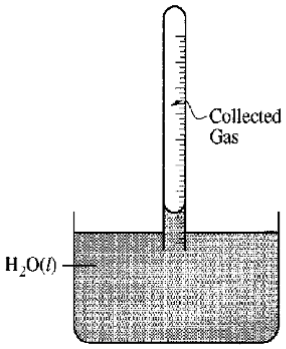
a. 800 mm Hg
b. 600 mm Hg
c. 250 mm Hg
d. 160 mm Hg

____ 11. Consider the graph below, which shows the speed distribution of three different pure substances in the gas phase at a temperature of 566 ºC. Which of the following statements accurately describes the molar masses of the substances and provides the correct explanation?



a. Substance A has the highest molar mass, because Substance A has the lowest average speed.
b. Substance C has the highest molar mass, because Substance C has the highest average speed.
c. Substance A has the lowest molar mass, because Substance A has the lowest average speed.
d. Substances A, B and C all have the same molar mass.

____ 12. In a laboratory experiment, $H_2(g)$ is collected over water in a gas-collection tube as shown in the diagram below.



The temperature of the water is 21ºC and the atmospheric pressure in the laboratory is measured to be 772 torr. Before measuring the volume of gas collected in the tube, what step, if any, must be taken to make it possible to determine the total gas pressure inside the tube?

a. Tilt the tube to the side enough to let some air in to break the partial vacuum in the tube.
b. Lift the tube upward until it is just barely immersed in the water
c. Move the tube downward until the water level is the same inside and outside the tube.
d. Adjust the temperature of the water to 25ºC.

Free Response Questions

2003 B

A rigid 5.00 L cylinder contains 24.5 g of $N_{2(g)}$ and 28.0 g of $O_{2(g)}$

13. a). Calculate the total pressure, in atm, of the gas mixture in the cylinder at 298 K

b) The temperature of the gas mixture in the cylinder is decreased to 280 K. Calculate each of the following.

(i) The mole fraction of $N_{2(g)}$ in the cylinder.

(ii) The partial pressure, in atm, of $N_{2(g)}$ in the cylinder.

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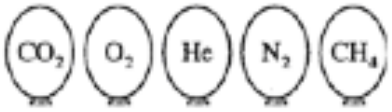
c) If the cylinder develops a pinhole-sized leak and some of the gaseous mixture escapes, would the ratio $\frac{N_{2(g)}}{O_{2(g)}}$ in the cylinder increase, decrease, or remain the same? Justify your answer.

1996

Represented below are five identical balloons, each filled to the same volume at 25°C and 1.0 atmosphere pressure with the pure gases indicated.



14. a) Which balloon contains the greatest mass of gas? Explain.

b) Which balloon contains the gas that would be expected to deviate most from the behavior of an ideal gas? Explain your answer.

c) Compare the average kinetic energies of the gas molecules in the balloons. Explain.

d) Twelve hours after being filled, all the balloons have decreased in size. Predict which balloon will be the smallest. Explain your reasoning.

15. When NH_3 gas is introduced at one end of a long tube while HCl gas is introduced simultaneously at the other end, a ring of white ammonium chloride is observed to form in the tube after a few minutes. This ring is closer to the HCl end of the tube than the NH_3 end. Explain this observation in terms of molecular motion. (1993, modified)

1994 B

A student collected a sample of hydrogen gas by the displacement of water as shown by the diagram above. The relevant data are given in the following table.

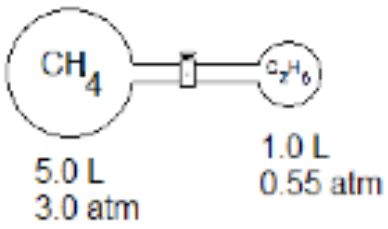
GAS SAMPLE DATA	
Volume of sample	90.0 mL
Temperature	25°C
Atmospheric Pressure	745 mm Hg
Equilibrium Vapor Pressure of H_2O (25°C)	23.8 mm Hg

16. a) Calculate the number of moles of hydrogen gas collected.

b) Calculate the number of molecules of water vapor in the sample of gas.

c) Which of the two gases, H_2 or H_2O, deviates more from ideal behavior? Explain your answer.

17. Two flasks are connected by a stopcock as shown below. The 5.0L flask contains CH_4 at a pressure of 3.0 atm, and the 1.0 L flask contains C_2H_6 at a pressure of 0.55 atm. Calculate the total pressure of the system after the stopcock is opened. Assume that the temperature remains constant. (2 pts)



In an experiment, a sample of an unknown, pure gaseous hydrocarbon was analyzed. Results showed that the sample contained 6.000 g of carbon and 1.344 g of hydrogen. (1993B)

18. a) Determine the empirical formula of the hydrocarbon. (3 pts)

The density of the hydrocarbon at 25°C and 1.09 atm is 1.96 g L^{-1}.

c) Calculate the molar mass of the hydrocarbon. (2 pts)

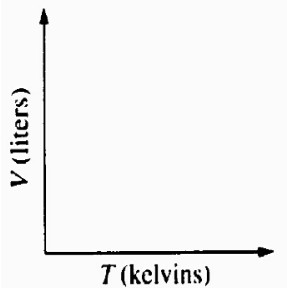
c) Determine the molecular formula of the hydrocarbon. (1 pt)

Answer the following questions about carbon monoxide, $CO_{(g)}$, and carbon dioxide, $CO_{2(g)}$. Assume that both gases exhibit ideal behavior. (2004D)

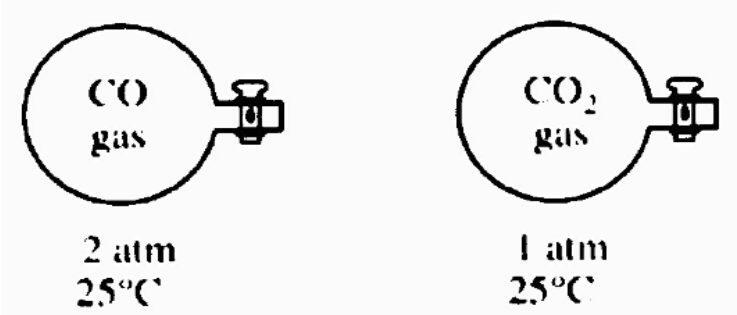
19. a) Draw the complete Lewis structure (electron dot diagram) for the CO molecule and for the CO_2 molecule. (2 pts)

b) Identify the geometry of the CO_2 molecule. (1 pt)

c) A 1.0 mol sample of $CO_{(g)}$ is heated at constant pressure. On the graph below, sketch the expected plot of volume verses temperature as the gas is heated. (1 pt)



d) Samples of $CO_{(g)}$ and $CO_{2(g)}$ are placed in 1 L containers at the conditions in the diagram below.



i) Indicate whether the average kinetic energy of the CO_2 is greater than, equal to, or less than the average kinetic energy of the $CO_{(g)}$ molecules. Explain your answer. (1 pt)

(ii) Indicate whether the average speed of the $CO_{2(g)}$ molecules is greater than, equal to or less than the average speed of the $CO_{(g)}$ molecules. Explain your answer. (1 pt)

(iii) Indicate whether the number of $CO_{2(g)}$ molecules is greater than, equal, or less than the number of $CO_{(g)}$ molecules. Justify your answer. (1 pt)

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Gases Practice Problems
Answer Section

MULTIPLE CHOICE

1. ANS: A PTS: 1
2. ANS: C PTS: 1
3. ANS: A PTS: 1
4. ANS: C PTS: 1
5. ANS: C PTS: 1
6. ANS: D PTS: 1
7. ANS: B PTS: 1
8. ANS: C PTS: 1
9. ANS: C PTS: 1
10. ANS: D PTS: 1
11. ANS: A PTS: 1
12. ANS: C PTS: 1

PROBLEM

13. ANS:

$24.5\text{ g } N_2 \times \frac{1 mol}{28.0 g} = 0.875\text{ mol } N_2$

$28.0\text{ g } O_2 \times \frac{1 mol}{32.0 g} = 0.875\text{ mol } O_2$

$P = \frac{nRT}{V} = \frac{(1.75 mol)\left(0.0821 \frac{L\,atm}{mol\,K}\right)(298 K)}{5.00 L}$

$= 8.56$ atm

PTS: 1

b) :

(i) $\frac{0.875\text{ mol } N_2}{1.75\text{ mol mix}} = 0.500$ mole fraction N_2

(ii) $\frac{P_1}{T_1} = \frac{P_2}{T_2};\ P_2 = \frac{P_1 T_2}{T_1} = \frac{(8.56 atm)(280 K)}{298 K}$

$= 8.05$ atm $\times$ mole fraction $= 8.05$ atm $\times 0.500$

$= 4.02$ atm N_2

PTS: 1

d). decrease; since N_2 molecules are lighter than O_2 they have a higher velocity and will escape more frequently (Graham's Law), decreasing the amount of N_2 relative to O_2

PTS: 1

14. ANS:

a) CO_2; according to Avogadro's Hypothesis, they all contain the same number of particles, therefore, the heaviest molecule, CO_2 (molar mass = 44), will have the greatest mass.

b) CO_2; since they are all essentially non-polar, the largest intermolecular (London) force would be greatest in the molecule/atom with the largest number of electrons.

c) all the same; at the same temperature all gases have the same kinetic energy.

d) He; it has the smallest size and has the greatest particulate speed and, therefore, it's the easiest to penetrate the wall and effuse.

PTS: 1

15. ANS:

The molecules of gas are in constant motion so the HCl and NH_3 diffuse along the tube. Where they meet, $NH_4Cl_{(s)}$ is formed. Since HCl has a higher molar mass, its velocity (average) is lower, therefore, it doesn't diffuse as fast as the NH_3.

PTS: 1

16. ANS:

a) $P_{H2} = P_{atm} - P_{H2O}$ = (745 - 23.8) mm Hg) = 721.2 mm Hg

n = (PV)/(RT) = (721.2 mm Hg × 90.0 mL)/(62400 mm Hg.mL/mol.K × 298.15K)

$= 3.49\times10^{-3}$ mol

b) n_{H2O} = (23.8 mm Hg × 90.0 mL)/(62400 mm Hg.mL/mol.K × 298.15K) × 6.022×10^{23} molecules/mol = 6.93×10^{19} molecules

c) H_2O deviates more from ideal behavior: (any one of these is sufficient)

(i) greater number of electrons = larger electron cloud = stronger London forces

(ii) it is a polar molecule with strong polar attraction, and attractions between molecules decreases the observed gas pressure

(iii) it can interact via hydrogen bonds to other water molecules

(iv) H_2O has a larger molecular volume than H_2, so the available volume in the container is smaller than expected for H_2O, leading to a higher observed pressure.

17.

use P1V1 = P2V2

P_f of methane = 2.5 atm; final pressure of ethane = 0.092 atm (1 pt for either)

P_{tot} = 2.5 +0.092 atm = 2.6 atm (1 pt)

18.

a)C3H8

b) 43.9 g/mol

c). C3H8--must show work to verify/support answer to get the credit!

19. ANS:

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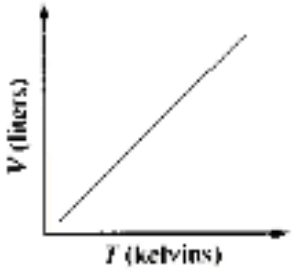
(a) :C:::O: :Ö::C::Ö:

b) linear

c)



d) (i) equal to; at the same temperature, all gas molecules have the same kinetic energy

(ii) less, since CO_2 has a molar mass of 44 and CO has a mass of 28, the lighter molecule is faster at the same temperature

(iii) less; Avogadro's Hypothesis, equal volumes of gas at the same temperature and pressure contain equal number of molecules. Since the pressure of CO_2 is half the pressure of the CO, it must contain half as many molecules.