Ch 11 Gases – AP Practice Questions
AP Chem 2011-12

1984

1. 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$^3$
   e. The potential energy of the molecules

2. The density of an unknown gas is 4.20 grams per liter at 3.00 atmospheres pressure and 127°C. What is the molecular weight of this gas? ($R = 0.0821$ liter-atm / mole-K)
   a. 14.6  b. 46.0  c. 88.0  d. 94.1  e. 138

3. 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.
   e. It can be calculated with knowledge only of the volume of the container.

4. Two flexible containers for gases are at the same temperature and pressure. One holds 0.50 gram of hydrogen and the other holds 8.0 grams of oxygen. Which of the following statements regarding these gas samples is FALSE?
   a. The volume of the hydrogen container is the same as the volume of the oxygen container.
   b. The number of molecules in the hydrogen container is the same as the number of molecules in the oxygen container.
   c. The density of the hydrogen sample is less than that of the oxygen sample.
   d. The average kinetic energy of the hydrogen molecules is the same as the average kinetic energy of the oxygen molecules.
   e. The average speed of the hydrogen molecules is the same as the average speed of the oxygen molecules.

5. A compound is heated to produce a gas whose molecular weight is to be determined. The gas is collected by displacing water in a water-filled flask inverted in a trough of water. Which of the following is necessary to calculate the molecular weight of the gas, but does NOT need to be measured during the experiment?
   a. Mass of the compound used in the experiment
   b. Temperature of the water in the trough
   c. Vapor pressure of the water
   d. Barometric pressure
   e. Volume of water displaced from the flask

6. When the actual gas volume is greater then the volume predicted by the ideal gas law, the explanation lies in the fact that the ideal gas law does NOT include a factor for molecular
   a. volume  d. attractions
   b. mass         e. shape
   c. velocity

7. A sample of 9.00 grams of aluminum metal is added to an excess of hydrochloric acid. The volume of hydrogen gas produced at standard temperature and pressure is
   a. 22.4 L  b. 11.2 L  c. 7.46 L  d. 5.60 L  e. 3.74 L
8. A gaseous mixture containing 7.0 moles of nitrogen, 2.5 moles of oxygen, and 0.50 mole of helium exerts a total pressure of 0.90 atmosphere. What is the partial pressure of the nitrogen?
   a. 0.13 atm  
   b. 0.27 atm  
   c. 0.63 atm  
   d. 0.90 atm  
   e. 6.3 atm

9. Hydrogen gas is collected over water at 24°C. The total pressure of the sample is 755 millimeters of mercury. At 24°C, the vapor pressure of water is 22 millimeters of mercury. What is the partial pressure of the hydrogen gas?
   a. 22 mm Hg  
   b. 733 mm Hg  
   c. 755 mm Hg  
   d. 760 mm Hg  
   e. 777 mm Hg

10. A 2.00-liter sample of nitrogen gas at 27°C and 600. millimeters of mercury is heated until it occupies a volume of 5.00 liters. If the pressure remains unchanged, the final temperature of the gas is
    a. 68°C  
    b. 120°C  
    c. 477°C  
    d. 677°C  
    e. 950.°C

11. \[2 \text{ K} + 2 \text{ H}_2\text{O} \rightarrow 2 \text{ K}^+ + 2 \text{ OH}^- + \text{ H}_2\]
    When 0.400 mole of potassium reacts with excess water at standard temperature and pressure as shown in the equation above, the volume of hydrogen gas produced is
    a. 1.12 liters  
    b. 2.24 liters  
    c. 3.36 liters  
    d. 4.48 liters  
    e. 6.72 liters

12. As the temperature is raised from 20°C to 40°C, the average kinetic energy of neon atoms changes by a factor of
    a. 1/2  
    b. \((313/293)^{1/2}\)  
    c. 313/293  
    d. 2  
    e. 4

1994 Multiple Choice
24. A sample of 0.010 mole of oxygen gas is confined at 127 °C and 0.80 atmosphere. What would be the pressure of this sample at 27 °C and the same volume?
   (A) 0.10 atm  
   (B) 0.20 atm  
   (C) 0.60 atm  
   (D) 0.80 atm  
   (E) 1.1 atm
37. A sample of 3.0 grams of an ideal gas at 127°C and 1.0 atmosphere pressure has a volume of 1.5 liters. Which of the following expressions is correct for the molar mass of the gas? The ideal gas constant, R, is 0.08 (L-atm) / (mole K).

(A) \( \frac{(0.08)(400)}{(3.0)(1.0)(1.5)} \)

(B) \( \frac{(1.0)(1.5)}{(3.0)(0.08)(400)} \)

(C) \( \frac{(0.08)(1.0)(1.5)}{(3.0)(400)} \)

(D) \( \frac{(3.0)(0.08)(400)}{(1.0)(1.5)} \)

(E) \( \frac{(3.0)(0.08)(1.5)}{(1.0)(400)} \)

39. Samples of F₂ gas and Xe gas are mixed in a container of fixed volume. The initial partial pressure of the F₂ gas is 8.0 atmospheres and that of the Xe gas is 1.7 atmospheres. When all of the Xe gas reacted, forming a solid compound, the pressure of the unreacted F₂ gas was 4.6 atmospheres. The temperature remained constant. What is the formula of the compound?

(A) XeF

(B) XeF₃

(C) XeF₄

(D) XeF₆

(E) XeF₈

40. The system shown below is at equilibrium at 28°C. At this temperature, the vapor pressure of water is 28 millimeters of mercury. The partial pressure of O₂(g) in the system is

(A) 28 mm Hg

(B) 56 mm Hg

(C) 133 mm Hg

(D) 161 mm Hg

(E) 189 mm Hg

45. A sample of an ideal gas is cooled from 50.0 °C to 25.0 °C in a sealed container of constant volume. Which of the following values for the gas will decrease?

I. The average molecular mass of the gas

II. The average distance between the molecules

III. The average speed of the molecules

(A) I only

(B) II only

(C) III only

(D) I and III

(E) II and III

64. At 25 °C, a sample of NH₃ (molar mass 17 grams) effuses at the rate of 0.050 mole per minute. Under the same conditions, which of the following gases effuses at approximately one-half that rate?

(A) O₂ (molar mass 32 grams)

(B) He₂ (molar mass 4.0 grams)

(C) CO₂ (molar mass 44 grams)

(D) Cl₂ (molar mass 71 grams)

(E) CH₄ (molar mass 16 grams)
### 1999 Multiple Choice

23. A hot-air balloon, shown above, rises. Which of the following is the best explanation for this observation?

- (A) The pressure on the walls of the balloon increases with increasing temperature.
- (B) The difference in temperature between the air inside and outside the balloon produces convection currents.
- (C) The cooler air outside the balloon pushes in on the walls of the balloon.
- (D) The rate of diffusion of cooler air is less than that of warmer air.
- (E) The air density inside the balloon is less than that of the surrounding air.

44. 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.
- (E) The average distance between the gas molecules increases.

\[ W(g) + X(g) \rightarrow Y(g) + Z(g) \]

53. Gases \( W \) and \( X \) react in a closed, rigid vessel to form gases \( Y \) and \( Z \) according to the equation above. The initial pressure of \( W(g) \) is 1.20 atm and that of \( X(g) \) is 1.60 atm. No \( Y(g) \) or \( Z(g) \) is initially present. The experiment is carried out at constant temperature. What is the partial pressure of \( Z(g) \) when the partial pressure of \( W(g) \) has decreased to 1.0 atm?

- (A) 0.20 atm
- (B) 0.40 atm
- (C) 1.0 atm
- (D) 1.2 atm
- (E) 1.4 atm

64. Equal numbers of moles of \( \text{He}(g) \), \( \text{Ar}(g) \), and \( \text{Ne}(g) \) are placed in a glass vessel at room temperature. If the vessel has a pinhole-sized leak, which of the following will be true regarding the relative values of the partial pressures of the gases remaining in the vessel after some of the gas mixture has effused?

- (A) \( P_{\text{He}} < P_{\text{Ne}} < P_{\text{Ar}} \)
- (B) \( P_{\text{He}} < P_{\text{Ar}} < P_{\text{Ne}} \)
- (C) \( P_{\text{Ne}} < P_{\text{Ar}} < P_{\text{He}} \)
- (D) \( P_{\text{Ar}} < P_{\text{He}} < P_{\text{Ne}} \)
- (E) \( P_{\text{He}} = P_{\text{Ar}} = P_{\text{Ne}} \)

74. Which of the following gases deviates most from ideal behavior?

- (A) \( \text{SO}_2 \)
- (B) \( \text{Ne} \)
- (C) \( \text{CH}_4 \)
- (D) \( \text{N}_2 \)
- (E) \( \text{H}_2 \)
Questions 8-10 refer to the following gases at 0°C and 1 atm.

(A) Ne  (B) Xe  (C) O₂  (D) CO  (E) NO

8. Has an average atomic or molecular speed closest to that of N₂ molecules at 0°C and 1 atm
9. Has the greatest density
10. Has the greatest rate of effusion through a pinhole

20. A flask contains 0.25 mole of SO₂(g), 0.50 mole of CH₄(g), and 0.50 mole of O₂(g). The total pressure of the gases in the flask is 800 mm Hg. What is the partial pressure of the SO₂(g) in the flask?
   (A) 800 mm Hg
   (B) 600 mm Hg
   (C) 250 mm Hg
   (D) 200 mm Hg
   (E) 160 mm Hg

CS₂(l) + 3 O₂(g) → CO₂(g) + 2 SO₂(g)

31. What volume of O₂(g) is required to react with excess CS₂(l) to produce 4.0 L of CO₂(g).
   (Assume all gases are measured at 0°C and 1 atm.)
   (A) 12 L  (D) 2 × 22.4 L
   (B) 22.4 L  (E) 3 × 22.4 L
   (C) 1/3 × 22.4 L

40. An excess of Mg(s) is added to 100. mL of 0.400 M HCl. At 0°C and 1 atm pressure, what volume of H₂ gas can be obtained?
   (A) 22.4 mL  (D) 448 mL
   (B) 44.8 mL  (E) 896 mL
   (C) 224 mL

66. A 2 L container will hold about 4 g of which of the following gases at 0°C and 1 atm?
   (A) SO₂  (D) C₄H₈
   (B) N₂  (E) NH₃
   (C) CO₂

Free Response

1973
A 6.19 gram sample of PCl₅ is placed in an evacuated 2.00 liter flask and is completely vaporized at 252°C.
   (a) Calculate the pressure in the flask if no chemical reaction were to occur.
   (b) Actually at 252°C the PCl₅ is partially dissociated according to the following equation:
       \[ \text{PCl}_5(g) \rightarrow \text{PCl}_3(g) + \text{Cl}_2(g) \]
       The observed pressure is found to be 1.00 atmosphere. In view of this observation, calculate the partial pressure of PCl₃ and PCl₅ in the flask at 252°C.
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.

<table>
<thead>
<tr>
<th>GAS SAMPLE DATA</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Volume of sample</td>
<td>90.0 mL</td>
</tr>
<tr>
<td>Temperature</td>
<td>25°C</td>
</tr>
<tr>
<td>Atmospheric Pressure</td>
<td>745 mm Hg</td>
</tr>
<tr>
<td>Equilibrium Vapor Pressure of H₂O (25°C)</td>
<td>23.8 mm Hg</td>
</tr>
</tbody>
</table>

(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) Calculate the ratio of the average speed of the hydrogen molecules to the average speed of the water vapor molecules in the sample.
(d) Which of the two gases, H₂ or H₂O, deviates more from ideal behavior? Explain your answer.

2003
A rigid 5.00 L cylinder contains 24.5 g of N₂(g) and 28.0 g of O₂(g).
(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 N₂(g) in the cylinder.
   (ii) The partial pressure, in atm, of N₂(g) in the cylinder.
(c) If the cylinder develops a pinhole-sized leak and some of the gaseous mixture escapes, would the ratio \( \frac{N₂(g)}{O₂(g)} \) in the cylinder increase, decrease, or remain the same? Justify your answer.

A different rigid 5.00 L cylinder contains 0.176 mol of NO(g) at 298 K. A 0.176 mol sample of O₂(g) is added to the cylinder, where a reaction occurs to produce NO₂(g).
(d) Write the balanced equation for the reaction.
(e) Calculate the total pressure, in atm, in the cylinder at 298 K after the reaction is complete.

2004
8. Answer the following questions about carbon monoxide, CO\(_{(g)}\), and carbon dioxide, CO\(_2(g)\). Assume that both gases exhibit ideal behavior.
(a) Draw the complete Lewis structure (electron dot diagram) for the CO molecule and for the CO\(_2\) molecule.
(b) Identify the shape of the CO\(_2\) molecule.
(c) One of the two gases dissolves readily in water to form a solution with a pH below 7. Identify the gas and account for this observation by writing a chemical equation.
(d) A 1.0 mol sample of CO\(_{(g)}\) is heated at constant pressure. On the graph below, sketch the expected plot of volume versus temperature as the gas is heated.

(e) Samples of CO\(_{(g)}\) and CO\(_2(g)\) are placed in 1 L containers at the conditions in the diagram below.

\[
\begin{array}{c}
\text{CO}_\text{gas} \\
2 \text{ atm} \\
25^\circ\text{C} \\
\text{CO}_2 \text{gas} \\
1 \text{ atm} \\
25^\circ\text{C} \\
\end{array}
\]

(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. Justify your answer.
(ii) Indicate whether the root-mean-square speed of the CO\(_2\)\(_{(g)}\) molecules is greater than, equal to or less than the root-mean-square speed of the CO\(_{(g)}\) molecules. Justify your answer.
(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.

2004 Form B

2. Answer the following questions related to hydrocarbons.
(a) Determine the empirical formula of a hydrocarbon that contains 85.7 percent carbon by mass.
(b) The density of the hydrocarbon in part (a) is 2.0 g L\(^{-1}\) at 50°C and 0.948 atm.
   (i) Calculate the molar mass of the hydrocarbon.
   (ii) Determine the molecular formula of the hydrocarbon.
(c) Two flasks are connected by a stopcock as shown below. The 5.0 L flask contains CH\(_4\) at a pressure of 3.0 atm, and the 1.0 L flask contains C\(_2\)H\(_6\) 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.
(d) Octane, C\(_8\)H\(_{18}\)(\(l\)), has a density of 0.703 g mL\(^{-1}\) at 20°C. A 255 mL sample of C\(_8\)H\(_{18}\)(l) measured at 20°C reacts completely with excess oxygen as represented by the equation below.
\[
2 \text{C}_8\text{H}_{18}(l) + 25 \text{O}_2(g) \rightarrow 16 \text{CO}_2(g) + 18 \text{H}_2\text{O}(g)
\]
Calculate the total number of moles of gaseous products formed.

2009 Form B
2 H₂O₂(aq) → 2 H₂O(l) + O₂(g)

3. The mass of an aqueous solution of H₂O₂ is 6.951 g. The H₂O₂ in the solution decomposes completely according to the reaction represented above. The O₂(g) produced is collected in an inverted graduated tube over water at 23.4°C and has a volume of 182.4 mL when the water levels inside and outside of the tube are the same. The atmospheric pressure in the lab is 762.6 torr, and the equilibrium vapor pressure of water at 23.4°C is 21.6 torr.

(a) Calculate the partial pressure, in torr, of O₂(g) in the gas-collection tube.
(b) Calculate the number of moles of O₂(g) produced in the reaction.
(c) Calculate the mass, in grams, of H₂O₂ that decomposed.
(d) Calculate the percent of H₂O₂, by mass, in the original 6.951 g aqueous sample.
(e) Write the oxidation number of the oxygen atoms in H₂O₂ and the oxidation number of the oxygen atoms in O₂ in the appropriate cells in the table below.

<table>
<thead>
<tr>
<th>Substance</th>
<th>Oxidation Number of Oxygen Atoms</th>
</tr>
</thead>
<tbody>
<tr>
<td>H₂O₂</td>
<td></td>
</tr>
<tr>
<td>O₂</td>
<td></td>
</tr>
</tbody>
</table>

(f) Write the balanced oxidation half-reaction for the reaction.