

## Chemistry 105, Chapter 5 Exercises

### Final and Initial State

1. A glass tube is filled with neon gas at 32.0°C and 1.31 atm pressure. The tube is sealed and put in a freezer at 12.0°C. What is the pressure in the tube when it is in the freezer? Ans. 1.22 atm
2. On a cold winter day, a person takes in a breath of 0.50 L of air at 751. mmHg and -6.0°C. What is the volume of this air in the lungs at 37.0°C and 1.0 atm pressure? Ans. 0.57 L
3. A 25.00L-flask has 1.35 mol of hydrogen gas at 25.°C and a pressure of 1.05 atm. Nitrogen gas is added to the flask at the same temperature until the pressure rises to 1.64 atm. How many moles of nitrogen gas are added? Ans. 0.76 moles
4. A balloon filled with helium has a volume of  $1.28 \times 10^3$  L at sea level where the pressure is 0.998 atm and temperature is 31.0°C. The balloon is taken to the top of a mountain where the pressure is 0.753 atm and the temperature is -25.0°C. What is the volume of the balloon at the top of the mountain? Ans.  $1.38 \times 10^3$  L
5. A container is filled with a gas to a pressure of 40.0 atm at 0.00°C. At what temperature would the pressure be 25.0 atm? Ans. -102.°C

### Ideal Gas Law

6. Use the ideal gas law to complete the following table for butane (C<sub>4</sub>H<sub>10</sub>) gas. Answers: at end of exercises

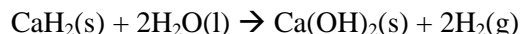
Pressure	Volume	Temperature	Moles	Grams
	1.75 L	19.0°C	1.66	
0.895 atm		6.0°C		14.0
433. mm Hg	92.4 mL		0.395	
1.72 atm	8.66 L	36.7°C		

### Gas Density and Molar Mass

7. Calculate the densities (in grams per liter) of the following gases at 23.9°C and 1.31 atm.  
a. argon Ans. 2.15 g/L    b ammonia (NH<sub>3</sub>) Ans. 0.915 g/L    c. acetylene (C<sub>2</sub>H<sub>2</sub>) Ans. 1.40 g/L
8. Phosgene is a highly toxic gas made up of carbon, oxygen, and chlorine atoms. Its density at 1.05 atm and 25.°C is 4.24 g/L. What is the molar mass of phosgene? Ans. 98.8 g/mol
9. Cyclopropane mixed in the proper ratio with oxygen can be used as an anesthetic. At 755. m Hg and 25.0°C, It has a density of 1.71 g/L. What is the molar mass of cyclopropane? Ans. 42.1 g/mol
10. The gas in the discharge cell of a laser contains (in mole percent) 11.% CO<sub>2</sub>, 5.3% N<sub>2</sub>, and 84.%He.  
a. What is the molar mass of this mixture? Ans. 9.7 g/mol  
b. Calculate the density of this gas mixture at 32.°C and 758. mm Hg. Ans. 0.39 g/L
11. Calculate the molar mass of exhaled air. It contains 74.5 % N<sub>2</sub>, 15.7% O<sub>2</sub>, 3.6% CO<sub>2</sub> and 6.2% H<sub>2</sub>O (mole percent). Ans. 28.6 g/mol
12. A 2.00-g sample of SX<sub>6</sub> (g) has a volume of 329.5 mL at 1.00 atm and 20.0°C. Identify the element X. Ans. X is fluorine

## Gas Stoichiometry

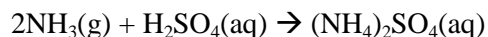
13. Calcium hydride,  $\text{CaH}_2$ , reacts with water to form hydrogen gas:



This reaction is sometimes used where a simple compact way of generating  $\text{H}_2$  is desired. How many grams of  $\text{CaH}_2$  (42.1 g/mole) are needed to generate 64.5 L of  $\text{H}_2$  gas if the pressure of  $\text{H}_2$  is 814 torr at  $32.0^\circ\text{C}$ ?

Ans. 58.1 g

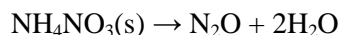
14. Ammonium sulfate, a fertilizer for plants, can be prepared by the following reaction.



Calculate the volume of  $\text{NH}_3(\text{g})$  needed at  $42.0^\circ\text{C}$  and 15.6 atm to react with 87 Kg of  $\text{H}_2\text{SO}_4$  (98 g/mole).

Ans.  $2.9 \times 10^3$  L

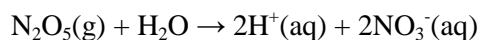
15. Dinitrogen monoxide, also called nitrous oxide, is used as a propellant gas for whipped-cream dispensers. It is prepared by heating ammonium nitrate to  $250.^\circ\text{C}$ .



What volume of dinitrogen monoxide gas is formed at  $250.^\circ\text{C}$  and 1.0 atm when 5.00 g of  $\text{NH}_4\text{NO}_3$  is heated?

Ans. 2.7 L

16. Nitric acid can be prepared by bubbling dinitrogen pentoxide into water

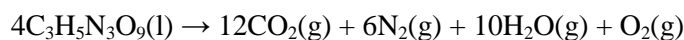


a. How many moles of  $\text{H}^+$  are obtained when 1.50 L of  $\text{N}_2\text{O}_5$  at  $25.0^\circ\text{C}$  and 1.00 atm pressure is bubbled into water? Ans. 0.123 moles

b. The solution obtained in part a. after the reaction is complete has a volume of 437. mL. What is the molarity of the nitric acid obtained? Ans. 0.281 M

## Gas Mixtures and Partial Pressures

17. Nitroglycerine is an explosive used by the mining industry. It detonates according to the following equation



When 10.00 g of nitroglycerine explodes what volume is occupied by the gases produced? The total pressure is 1.45 atm at  $523.^\circ\text{C}$ . Ans. 14.4 L

18. Ammonium nitrate can be used as an effective explosive because it decomposes into a large number of gaseous products. At a sufficiently high temperature, ammonium nitrate decomposes by the following reaction



If 1.00 Kg of ammonium nitrate is sealed into a 50.0-L steel drum and heated to  $787.^\circ\text{C}$ , what is the pressure in the drum, assuming 100% decomposition? Ans. 76.1 atm

19. To prevent a condition called the "bends," deep-sea divers breath a mixture containing, in mole percent, 10.0%  $\text{O}_2$ , 10.0%  $\text{N}_2$ , and 80.0% He. What is the partial pressure of each gas if the total pressure is 825. mm Hg? Ans.  $P_{\text{O}_2} = 82.5$  mmHg     $P_{\text{He}} = 660.$  mmHg     $P_{\text{N}_2} = 82.5$  mmHg

20. A certain laser uses a gas mixture made up of 9.00 g HCl, 2.00 g H<sub>2</sub>, and 165.0 g Ne. What pressure is exerted by the mixture in a 75.0-L tank at 22.0°C? Ans. 3.04 atm

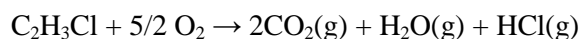
21. Methane burns in oxygen by the following reaction  
$$\text{CH}_4(\text{g}) + 2\text{O}_2(\text{g}) \rightarrow \text{CO}_2(\text{g}) + 2\text{H}_2\text{O}(\text{g})$$

When 8.00 L of methane at 125.°C and 1.00 atm is burned in an excess of oxygen, the products are collected into a separate 10.0-L flask.

a. What is the total pressure of the products in the flask at 125.°C? Ans. 2.40 atm

b. What is the partial pressure of each of the products in the flask? Ans. P<sub>CO<sub>2</sub></sub> = 0.800 atm P<sub>H<sub>2</sub>O</sub> = 1.60 atm

22. Ethylene chloride burns in oxygen by the following reaction



Twenty-five grams of ethylene chloride is burned in an excess of oxygen. The products are collected at 75.0°C into a separate 5.00-L flask.

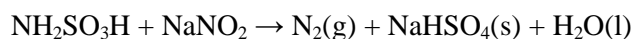
a. What is the total pressure of the products in the flask? Ans. 9.14 atm

b. What is the partial pressure of each of the products in the flask?

Ans. P<sub>CO<sub>2</sub></sub> = 4.57 atm P<sub>H<sub>2</sub>O</sub> = P<sub>HCl</sub> = 2.29 atm

### Collecting Gases over Water

23. A 0.80 g sample of NaNO<sub>2</sub> is reacted with excess sulfamic acid (NH<sub>2</sub>SO<sub>3</sub>H) and nitrogen gas is produced.



Assume that the reaction is complete. What volume of N<sub>2</sub> collects over water at 25.0°C and 745.0 mm Hg total pressure? P<sub>H<sub>2</sub>O</sub> = 23.8 mmHg at 25.0°C. Ans. 0.30 L

24. When heated KClO<sub>3</sub> decomposes to KCl and O<sub>2</sub>.



327. mL of O<sub>2</sub> are collected over water at 19.0°C. The total pressure of the gas in the collection flask is 735. mmHg. What mass of KClO<sub>3</sub> decomposed in this process? P<sub>H<sub>2</sub>O</sub> = 16.5 mmHg at 19.0°C. Ans. 1.05 g

### Effusion and Diffusion and Particle Speed

25. What is the ratio of the rate of effusion of nitrogen to hydrogen? Ans. 0.2682

26. A gas effuses 1.55 times faster than propane (C<sub>3</sub>H<sub>8</sub>) at the same temperature and pressure.

a. is the gas heavier or lighter than propane?

b. what is the molar mass of the gas?

Answers: at end of exercises

27. Rank the following gases

NO Ar N<sub>2</sub> N<sub>2</sub>O<sub>5</sub>

in order of

a. increasing speed of effusion through a tiny opening.

b. increasing time of effusion.

Answers: at end of exercises

28. What is the average speed of a bromine molecule at 28.0°C? Ans. 217. m/s

29. A balloon filled with nitrogen gas has a small leak. Another balloon filled with hydrogen gas has an identical leak. How much faster will the hydrogen balloon deflate? Ans. 3.74 times

### Miscellaneous

30. A sample of methane gas ( $\text{CH}_4$ ) is at  $50^\circ\text{C}$  and 20 atm. Would you expect it to behave more or less ideally if
- the pressure were reduced to 1atm?
  - the temperature were reduced to  $-50^\circ\text{C}$ ?

Answers: at end of exercises

31. Do this without a calculator. Two tanks have the same volume and are kept at the same temperature. Compare the pressure in both tanks if
- tank A has 2.00 mol of  $\text{CO}_2$  and tank B has 2.00 mol of He.
  - tank A has 2.00 g of  $\text{CO}_2$  and tank B has 2.00 g of He.

Answers: at end of exercises

32. If a rigid tank contains 4 moles of Ar at 5 atm and  $25^\circ\text{C}$ , what would the pressure be if 4 moles of  $\text{N}_2$  were added? Assume that the temperature remains the same. You don't need a calculator for this. Answers: at end.

33. If  $\text{H}_2$  and  $\text{Cl}_2$  are at the same temperature
- which molecules have the higher average kinetic energy?
  - which molecules have the higher average velocity?

Answers: at end

### 6. Answers

Pressure	Volume	Temperature	Moles	Grams
22.7 atm	1.75 L	$19^\circ\text{C}$	1.66	96.5
0.895 atm	6.16 L	$6.0^\circ\text{C}$	0.241	14.0
433. mm Hg	92.4 mL	1.62 K	0.395	23.0
1.72 atm	8.66 L	$36.7^\circ\text{C}$	0.584	33.9

26. Answers
- lighter
  - 18.4 g/mol

27. Answers
- $\text{N}_2\text{O}_5 < \text{Ar} < \text{NO} < \text{N}_2$
  - $\text{N}_2 < \text{NO} < \text{Ar} < \text{N}_2\text{O}_5$

30. Answers
- more ideally
  - less ideally

31. Answers
- same pressure
  - Tank B has a greater pressure because there are more moles of gas.

32. Answer. The number of moles of gas doubles therefore the pressure would double to 10 atm.

33. Answers
- The kinetic energy is the same for both.
  - $\text{H}_2$  molecules have the higher average velocity?