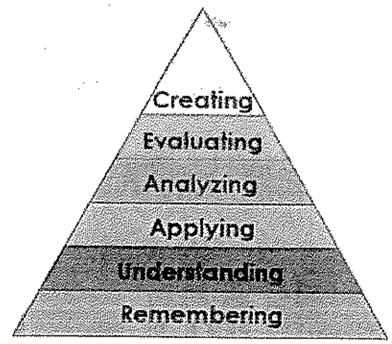
Chapter 12: Gases

Use resources such as your class notes, book, practice problems and online resources to help you prepare for your test. You are responsible for the information in the packet and the information in the text book. This packet is just the backbone and must be supplemented with the readings and additional practice problems from the textbook. This course aims to utilize chemistry to lead you into higher level thinking which includes applying, analyzing, evaluating and creating

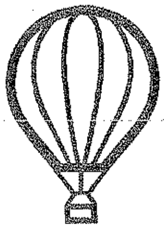


Learning Targets:

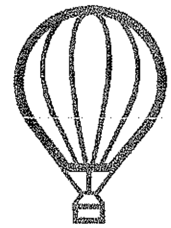
1. Describe the general properties of gases
2. Define pressure and convert between standard units of pressure.
3. Relate the kinetic molecular theory to the properties of an ideal gas.
4. Describe the relationships between pressure, temperature, volume, and number of moles.
5. Use the combined gas laws to solve problems involving pressure, temperature, volume, and number of moles.
6. Solve problems using the ideal gas law.

Labs:

- Lab 12.1: Properties of Gas Lab
- Lab 12.2: Pressure vs Volume Lab
- Lab 12.3: Temperature vs. Volume Lab



Chapter Twelve
Gases



PRACTICE PROBLEMS: PRESSURE * TEMPERATURE CONVERSIONS

Perform the following conversions:

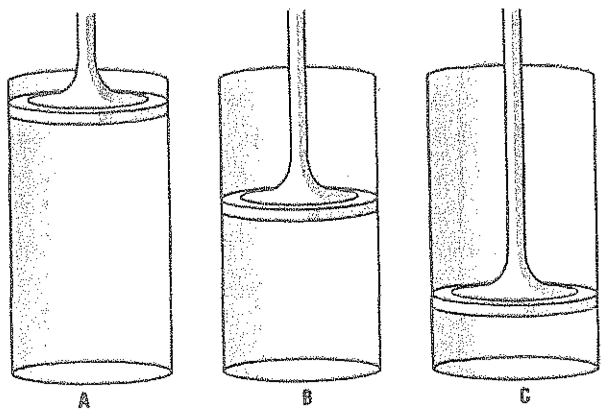
Remember: 101.325 kPa = 760 mmHg = 1 atm

°C +273 = Kelvin

1. 520 mmHg = __0.684__ atm
2. 75 kPa = __562.5__ mmHg
3. 93.7 kPa = __0.925__ atm
4. 97.25 kPa = __97250__ Pa
5. 120,354 Pa = __120.35__ atm
6. 323 mmHg = __43.06__ kPa
7. 25 °C = __298__ K
8. −30 °C = __243__ K
9. 19 °C = __292__ K
10. 323 K = __50__ °C
11. 0 K = __-273__ °C
12. 255 K = __-18__ °C

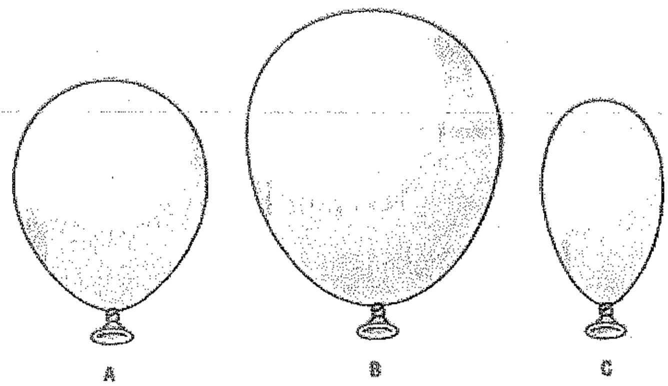
GAS -CONCEPTS - PRACTICE PROBLEMS

1. There are three cylinders drawn in the space below. The sizes of the cylinders can be changed by raising or lowering the piston. The volumes of the cylinders are labeled. Draw 15 particles in each cylinder to represent the particles of a gas. Remember that a gas expands to fill its container.



2. How do the numbers of particles in each cylinder vary with the volume of the cylinder?

3. How does the volume of the cylinder affect the pressure within the cylinder? Explain your answer.



4. Three balloons have been drawn in the space above. Initially all of the balloons were exactly the same size and they were filled with exactly the same amount of air. One balloon has been heated, one balloon is at room temperature and one balloon has been cooled. Fill each balloon with 15 particles to represent the particles of a gas. Then label which balloon has been heated, which is at room temperature and which has been cooled.

5. In which balloon are the particles the farthest apart? Why?

6. Make a general statement that reflects how the temperature of a gas is related to its volume.

7. As the temperature of a gas decreases, its volume decreases until a temperature of absolute zero (O K) is reached. Using the kinetic molecular theory, explain why the volume of a gas should eventually reach 0L as the temperature decreases. Be sure to also mention the speed of particles at temperatures above and equal to absolute zero.

$$\frac{PV}{T} = \frac{PV}{T}$$

PRACTICE PROBLEMS: GAS LAW PROBLEMS

Pressure vs. Volume

1. A sample of oxygen gas occupies a volume of 250 ml at 0.88 atm pressure. What volume will it occupy at 1.2 atm pressure?

   $(.88)(250) = 1.2\,V$ $\quad V = 183.3\text{mL}$

2. A sample of carbon dioxide occupies a volume of 3.50 liters at 1.5 atm pressure. What pressure would the gas exert if the volume were decreased to 2.00 L?

   $(1.5)(3.5) = P(2.00)$ $\quad P = 2.63\text{ atm}$

3. A 2.0 liter container of nitrogen had a pressure of 3.2 atm. What volume would be necessary to decrease the pressure to 1.0 atm?

   $(3.2)(2.0) = (1.0)V$ $\quad V = 6.4\text{ L}$

4. Ammonia gas occupies a volume of 450 ml at a pressure of 0.89 atm. What volume will it occupy at a standard pressure?

   $(.89)(450) = (1\text{ atm})(V)$ $\quad V = 400.5\text{ mL}$

5. A 175 ml sample of neon had its pressure changed from 0.6 atm to 1.4 atm. What is its new volume?

   $(.6)(175) = (1.4)(V)$ $\quad V = 75\text{mL}$

Volume vs. Temperature

6. When measured at a temperature of 60°C, a volume of gas is 600 mL. What is the volume at 10°C?

   $$\frac{600\text{mL}}{333\text{K}} = \frac{V}{283} \qquad V = 509.9\text{mL}$$

7. If 105 ml of oxygen at 25°C were heated until its volume expanded to 120 ml, what would be its final temperature?

   $$\frac{105}{298} = \frac{120}{T} \qquad T = 120\text{K}$$

$$\frac{PV}{NT} = \frac{PV}{NT}$$

8. What will be the volume of 4°C of a quantity of gas that occupies 1L at 20°C?

$$\frac{1L}{293} = \frac{V}{277} \qquad V = .945\ L$$

9. A quantity of hydrogen has a volume of 103 ml at a temperature of 20°C. To what temperature would this gas need to be cooled to reduce the volume to 92 ml?

$$\frac{103}{293} = \frac{92}{T} \qquad T = 264\ K$$

10. The temperature of a gas changes to 14.8°C from its original value of 1.6°C. If the original volume was 16.2 ml, what is the final volume of the gas at the new temperature?

$$\frac{16.2\,mL}{274.6\,K} = \frac{V}{287.8\,K} \qquad V = 16.9\,mL$$

11. If 136 ml of nitrogen at 25°C is cooled to 0°C, what will be the new volume?

$$\frac{136}{298} = \frac{V}{273} \qquad V = 124\,mL$$

Pressure vs Temperature and Avogadro's

12. A commercial airliner has an internal pressure of 1.00 atm and temperature of 25° C at takeoff. If the temperature of the airliner drops to 17° C during the flight, what is the new cabin pressure?

$$\frac{1\ atm}{298\,K} = \frac{P}{290\,K} \qquad P = .973\ atm$$

13. 5.00 L of a gas is known to contain 0.965 mol. If the amount of gas is increased to 1.80 mol, what new volume will result (at an unchanged temperature and pressure)?

$$\frac{5L}{.965\,mol} = \frac{V}{1.8\,mol} \qquad V = 9.32\ L$$

$$\frac{PV}{NT} = \frac{PV}{NT}$$

14. A cylinder with a movable piston contains 2.00 g of helium, He, at room temperature. More helium was added to the cylinder and the volume was adjusted so that the gas pressure remained the same. How many grams of helium were added to the cylinder if the volume was changed from 2.00 L to 2.70 L? (The temperature was held constant.)

$N = 2g\ He \left| \frac{1\ mol}{4g} \right. = 0.5\ mol$ $\quad \frac{2.00}{.5} = \frac{2.7}{N}$

$N = .675\ mol \left| \frac{4g}{1\ mol} \right. = 2.7$

15. A 6.0 L sample at 25 °C and 2.00 atm of pressure contains 0.5 moles of a gas. If an additional 0.25 moles of gas at the same pressure and temperature are added, what is the final total volume of the gas?

$$\frac{(6\ L)(2.0\ atm)}{(.5\ mol)(298)} = \frac{V(2.0)}{(.75)(298)} \qquad V = 9\ L$$

Combined Gas Law

16. A 952 cm^3 container of gas is exerting a pressure of 108 kPa while at a temperature of 48 °C. Calculate the pressure of this same amount of gas in a 1236 cm^3 container at a temperature of 64 °C

$$\frac{(108)(952)}{321} = \frac{P(1236)}{337} \qquad P = 87.3\ kPa$$

17. A 3.25 L container of ammonia gas exerts a pressure of 652 mm Hg at a temperature of 243 K. Calculate the pressure of this same amount of gas in a 2.50 L container at a temperature of 221 K.

$$\frac{(652)(3.25)}{243} = \frac{P(2.5)}{221}$$

$$P = 770.9\ mmHg$$

$$\frac{PV}{NT} = \frac{PV}{NT} \qquad PV = NRT$$

18. A sample of gas has a volume of 5.23 cm^3 at a pressure of 72.6 kPa and a temperature of 25 °C. What will be the volume of the gas if the pressure is changed to 124 kPa and the temperature is changed to 0 °C?

$$\frac{(72.6)(5.23)}{298} = \frac{(124)V}{273} \qquad V = 2.8 mL$$

IDEAL GAS LAW

19. Calculate the pressure (in kPa) of 0.421 mole of helium gas at 254 K when it occupies a volume of 3.32 L

$$P(3.32) = (.421)(8.314)(254)$$
$$P = 267.8 KPa$$

20. How many moles of argon are there in a 22.4 L sample of gas at 101.3 kPa and 0 °C?

$$(101.3)(22.4) = N(8.314)(273)$$
$$N = .999 mol$$

21. A 500.0 g block of dry ice (solid CO2, molar mass = 44.0 g) vaporizes to a gas at room temperature. Calculate the volume of gas produced at 25.0 °C and 1.50 atm.

$$1.50 atm \left| \frac{101.325}{1 atm} \right. = 151.98 KPa$$
$$500 g \left| \frac{1 mol}{44 g} \right. = 11.36 mol$$
$$(151.98) V = (11.36 mol)(8.314)(298)$$
$$V = 185.19 L$$

22. Calculate the volume, in liters, occupied by 2.00 mol of H_2 at 300 K and 1.25 atm.

$$(126.66)(V) = 2(8.314)(300)$$
$$1.25 \left| \frac{101.325}{1} \right. = 126.66 KPa$$
$$V = 39.38 L$$

23. Calculate the pressure, in atmospheres, exerted by 4.75 L of NO_2 containing 0.86 mol at 300 K.

$$P(4.75) = (.86)(8.314)(300)$$
$$P = 451.58 KPa \left| \frac{1 atm}{101.325} \right. = 4.46 atm$$

24. Calculate the pressure in atmospheres, exerted by 2.50 L of HF containing 1.35 mol at 320.0K. **(14.2 atm)**

$$P(2.5) = (1.35)(8.314)(320)$$

$$P = 1436 \text{ KPa} \left| \frac{1\text{atm}}{101.325 \text{ KPa}} \right. = 14.2 \text{ atm}$$

	P_1	V_1	T_1	P_2	V_2	T_2
1	1.5 atm	3.0 L	20 °C 293	2.5 atm	1.86	30°C 303
2	720 torr	256 ml	25°C 298	799	250 ml	50°C 323
3	600 mmHg	2.5 L	22°C 295	760 mmHg	1.8L	269 K
4	1.22	750 ml	0.0°C 273	2.0 atm	500 ml	25°C 298
5	95 kPa	4.0 L	295	101 kPa	6.0 L	471 K
6	650 torr	274	100°C 373	900 torr	225 ml	150°C 423
7	850 mmHg	1.5 L	15°C 288	536	2.5 L	30°C 303
8	125 kPa	125 ml	543	100 kPa	100 ml	75°C 348

$\frac{(1.5)(3)}{293} = \frac{(2.5)}{303}$

$\frac{600(2.5)}{295} = \frac{760(}{T}$

$\frac{P(750)}{273} = \frac{2(500}{298}$

$\frac{(95)(4}{T} = \frac{101(6)}{471}$

$\frac{650\,V}{373} = \frac{(900)22}{423}$

$\frac{850(1.5)}{288} = \frac{P(2}{303}$

$\frac{125(125)}{T} = \frac{(100)(100)}{348}$

$$\frac{PV}{T} = \frac{PV}{T}$$