

Chemistry 20 – Lesson 30
Gas Law Theory

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1. What is the kinetic molecular theory?

/2 **The kinetic molecular theory states that all matter is composed of atoms, ions or molecules that are in continual motion.**
2. Name and describe the three types of motion found in matter at the atomic level.

/3 **Translation – particles move through space in a straight line**
 Rotation – particles are turning or spinning over top of one another
 Vibration – particles are vibrating or oscillating in one spot
3. What type of molecular motion predominates in:
 a. a solid **vibration**
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 b. a liquid **rotation**

 c. a gas **translation**
4. List and describe three physical properties of gases.

 compressible – a gas can be squeezed into a smaller volume

/3 **no shape – gases will fill the container they are in**

 diffusion – gases will move or flow into any free volume
5. Give an operational definition of a gas.

/2 **A gas is a substance that (a) fills and assumes the shape of its container, (b) is compressible, (c) diffuses easily, and (d) mixes with other gases.**
6. What is pressure and what are its two basic units?

/2 **Pressure is the net effect of all of the gas particles colliding with a surface – it is the force per unit area.**

 Units include kilopascals (kPa) and atmospheres (atm).

7. What do STP and SATP stand for.

STP **standard temperature and pressure**

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SATP **standard ambient temperature and pressure**

What are the pressures and temperatures for:

STP **T = 0°C or 273 K P = 101.3 kPa**

SATP **T = 25°C or 298 K P = 100 kPa**

8. What is Boyle's law? Give the equation and an explanation of what it means.

/2 **Boyle's law states that the product of the pressure and the volume is a constant – i.e. $PV = k$. In a different form $P_1V_1 = P_2V_2$. If the volume of a gas is decreased the pressure will increase.**

9. If the pressure of a given amount of gas were to be increased by four times, by what factor would the volume change? (Show your work.)

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$$P_1V_1 = P_2V_2 \quad P_2 = 4P_1$$
$$P_1V_1 = 4P_1V_2$$
$$V_1 = 4V_2$$
$$V_2 = \frac{V_1}{4}$$

10. What is the difference between the Kelvin scale and the Centigrade scale? Which of these two units do you use in gas theory? Explain why.

/2 **Kelvin and Centigrade have the same gradations of temperature, but the zero point for the Kelvin scale is absolute zero while the zero point for Centigrade is the freezing point of water. For gas theory calculations we use the Kelvin scale since the zero point does not actually exist for gases – i.e. gases cannot be cooled to absolute zero.**

11. Express the following temperatures in Kelvin:

/3 a. 0°C = **273** c. 25°C = **298** e. 100°C = **373**
b. -40°C = **233** d. 60°C = **333** f. 250°C = **523**

12. Express the following temperatures in degrees Celsius:

/3 a. 0 K = **-273°C** c. 273 K = **0°C** e. 298 K = **25°C**
b. 373 K = **100°C** d. 288 K = **15°C** f. 1000 K = **727°C**

13. What is Charles' law? Give the equation and an explanation of what it means.

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$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$
 At constant pressure as temperature increases the volume of a gas increases.

14. The piston inside a cylinder is free to move easily. If the temperature were to be tripled, what would happen to the volume of the gas? (Show your work.)

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$$\frac{V_1}{T_1} = \frac{V_2}{T_2} \quad T_2 = 3T_1$$

$$\frac{V_1}{T_1} = \frac{V_2}{3T_1}$$

$$3V_1 = V_2$$

15. What is the combined gas law? Show how it becomes (a) Boyle's law and (b) Charles' law under the right conditions.

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the combined gas law is

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

for Boyle's law, $T_1 = T_2$

$$\therefore P_1 V_1 = P_2 V_2$$

for Charles' law, $P_1 = P_2$

$$\therefore \frac{V_1}{T_1} = \frac{V_2}{T_2}$$

16. Kinetic molecular theory is strongly supported by experimental evidence. In your own words, how does kinetic molecular theory explain:
- a. The compressibility of gases?

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Gases have a lot of space between the molecules. Compression of a gas removes the space.

- b. Gas pressure?

Gas pressure is the net effect of gas particles colliding with a surface.

- c. Boyle's law?

Boyle's law is the relation between the pressure and volume of a gas at constant temperature. As a gas becomes more confined (less volume) the pressure (number of collisions per second with the container) increases.

- d. Charles' law?

Charles' law is the relation between the volume and temperature of a gas at constant pressure. As the temperature of a gas increases the molecules have more energy causing them to collide with each other more often and with greater force resulting in an increase in volume.

17. What is Avagadro's theory?

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Avagadro's theory is that equal volumes of different gases under the same conditions contain the same number of moles.

18. What is molar volume? Explain why 1.0 L of chlorine gas has the same number of moles as 1.0 L of oxygen gas at the same temperature and pressure.

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Molar volume is a similar concept to molar mass. Molar volume is the volume that one mole of gas occupies at a given temperature and pressure. According to Avagadro's theory, the type of gas has no effect on the molar volume of gases.

20. What is the molar volume of a gas at:

a. STP $V = 22.4 \text{ L/mol}$

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b. SATP $V = 24.8 \text{ L/mol}$

21. How many moles are contained in 10.0 L of $\text{O}_2(\text{g})$

a. at STP

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$$n = 10.0 \text{ L} \times \frac{1 \text{ mol}}{22.4 \text{ L}} = \boxed{0.446 \text{ mol}}$$

b. at SATP?

/2
$$n = 10.0 \text{ L} \times \frac{1 \text{ mol}}{24.8 \text{ L}} = \boxed{0.403 \text{ mol}}$$

22. What volume does 0.250 mol of $\text{CO}_2(\text{g})$ displace at:

a. at STP

/2
$$v = 0.250 \text{ mol} \times \frac{22.4 \text{ L}}{1 \text{ mol}} = \boxed{5.6 \text{ L}}$$

b. at SATP?

/2
$$v = 0.250 \text{ mol} \times \frac{24.8 \text{ L}}{1 \text{ mol}} = \boxed{6.2 \text{ L}}$$

23. What are the two major differences between an ideal gas and a real gas?

/2 **1. Ideal gases do not phase change into liquids.**

2. Real gases have intermolecular forces between the molecules that change their properties.

24. What is the ideal gas law? Show how this law becomes (a) the combined gas law, (b) Boyle's law and (c) Charles' law.

/4 The ideal gas law is $PV = nRT$

For the combined gas law the amount of gas (n) remains constant.

$$\frac{PV}{T} = nR = \text{constant}$$

$$\therefore \frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

For Boyle's Law the amount of gas (n) and the temperature (T) remain constant.

$$PV = nRT = \text{constant}$$

$$\therefore P_1 V_1 = P_2 V_2$$

For Charles' law the amount of gas (n) and the pressure (P) remain constant.

$$\frac{V}{T} = \frac{nR}{P} = \text{constant}$$

$$\therefore \frac{V_1}{T_1} = \frac{V_2}{T_2}$$