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Unit 5: Gases

1. Units of Gases pressure

$$1\ atm = 760mmHg = 760\ torr = 101\ 325\ Pa = 101.325\ kPa = 1.01325\ bar = 14.7\ psi$$

Converting among units of pressures:

Example 1: Convert each of the following to the indicated unit.

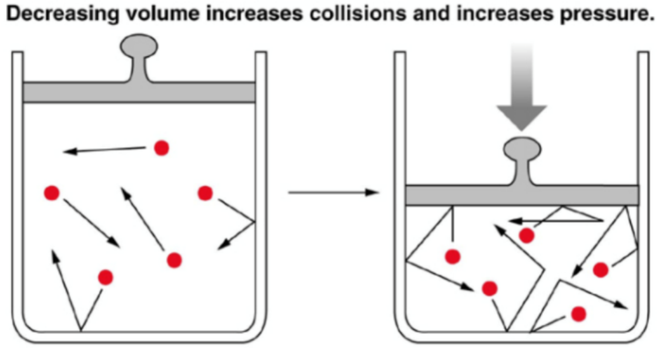
a) *3.58atm to kPa* b) *20.5psi to atm* c) *770mmHg to kPa* d) *470 torr to Pa*

2. The relationship between gas pressure and volume

Boyle's law: a gas law stating that the volume of a fixed amount of gas at a constant temperature is inversely proportional to the applied (external) pressure on the gas: $\mathbf{V} \propto \frac{1}{P}$

In mathematical expression for Boyle's law: $P_1V_1 = P_2V_2$

Decreasing volume increases collisions and increases pressure.



Example 2: A weather balloon with a volume of $2.00 \times 10^3 L$ at pressure of 96.3kPa rises to an altitude of $1.00 \times 10^3 m$, where the atmospheric pressure if measured to be 60.8 kPa. Assuming there is no change in temperature or amount of gas, what is the final volume of the weather balloon?

Practice: An oxygen tank has a volume of 45L and is pressurized to 120psi.

a) What volume of gas would be released at 765 torr?
b) If the flow of gas from the tank is 6.5L per minute, how long would the tank last?

Homework: McGraw Hill Textbook pg515. #5, 11, 12, 13

3. The Kelvin temperature scale and absolute zero

For converting Celsius to Kelvin: $\boldsymbol{K} = ℃ + \mathbf{273.15}$
For converting Kelvin to Celsius: $℃ = \boldsymbol{K} - \mathbf{273.15}$

Absolute zero: the lowest theoretical temperature, equivalent to – 273.15 ℃; the temperature at which the volume of a gas approaches zero and no kinetic energy at all, no movement at all.

4. The relationship between gas volume and temperature

Charles's Law: a gas law stating that the volume of a fixed amount of gas at a constant pressure is directly proportional to the Kelvin temperate of the gas: $\mathbf{V \propto T}$

In mathematical expression for Charles's law: $\boldsymbol{\frac{V_1}{T_1} = \frac{V_2}{T_2}}$

Example 3: A birthday balloon is filled to a volume of 1.50 L of helium gas in an air-conditioned room at 294K. the balloon is then taken outdoors on a warm sunny day and left to float as a decoration. The volume of the balloon expands to 1.55 L. Assuming that the pressure and amount of gas remain constant, what is the air temperature outdoors in Kelvins?

5. The relationship between temperature and pressure

Gay-Lussac's Law: a gas law stating that the pressure of a fixed amount of gas at a constant volume is directly proportional to its Kelvin temperature: $\mathbf{P \propto T}$

In mathematical expression for Gay-Lussac's law: $\boldsymbol{\frac{P_1}{T_1} = \frac{P_2}{T_2}}$

Example 4: The pressure of the oxygen gas inside a canister with a fixed volume is 5.0atm 298K. what is the pressure of the oxygen gas inside the canister if the temperature changes to 263K? Assume the amount of gas remains constant.

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Practice: if a gas sample has a pressure of 30.7kPa at 0.00℃, by how many degrees Celsius does the temperature have to increase to cause the pressure to double?

Homework: McGraw Hill Textbook pg527. #3, 4, 6, 8, 9, 11, 12, 13

6. Combined gas law

Combined gas law: A gas stating that the pressure and volume of a given amount of gas are inversely proportional to each other and directly proportional to the Kelvin temperature of the gas: $\mathbf{V} \propto \boldsymbol{\frac{T}{P}}$

In mathematical expression for Combined gas law: $\boldsymbol{\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}}$

Example 5: A small balloon contains 275mL of helium gas at a temperature of 25.0 ℃ and a pressure of 350 kPa. What volume would this gas occupy at 10.0℃ and 101kPa?

Practice: A sample of Freon-12, $CF_2Cl_{2(g)}$, formerly used in refrigerators, is circulated through a series of pipes for refrigeration. If the gas occupies 350 cm^3 at a pressure of 150psi and a temperature of 15℃, what volume of gas will be released if there is a break in the line where the external temperature is 25℃ and the external pressure if 102 kPa?

7. Molar volume of gases:

Avogadro's law: a gas law stating that equal volumes of all ideal gases at the same temperature and pressure contain the same number of molecules

In mathematical expression for Combined gas law: $\boldsymbol{\frac{n_1}{V_1} = \frac{n_2}{V_2}}$

Molar Volume of gases: amount of space occupied by 1 mol of gaseous substance:

- 22.5L/mol for an ideal gas at standard temperature and pressure (STP) and,
- 24.8L/mol for an ideal gas at standard ambient temperature and pressure (SATP)

Standard temperature and pressure (STP) conditions defined as a temperature of 0℃ (273.15K) and a pressure of 101.325 kPa

Standard ambient temperature and pressure (SATP) conditions defined as a temperature of 25℃ (298K) and a pressure of 100 kPa

Example 6: At STP, 1 mol of oxygen gas has a volume of 22.4L. Determine the mass and number of molecules in a 44.8L sample of the gas.

Example 7: An empty, sealed container has a volume of 0.652L and a mass of 2.50g. When filled with nitrogen gas, the container has a mass of 3.23g. The pressure of the nitrogen in the container is 97.5kPa when the temperature is 21.0℃. Calculate the molar volume of nitrogen gas at STP.

Homework: McGraw Hill Textbook pg549. #17, 18, 19

8. Ideal gas Law

Ideal gas law: a gas law that describes the relationship among volume, pressure, temperature, and amount (in mole) of an ideal gas: $PV = nRT$

Universal gas constant (R): a proportionality constant that relates the pressure on and the pressure on and the volume of an ideal gas to its amount and temperature: $R = 8.314 \frac{kPa \cdot L}{mol \cdot K}$

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An ideal gas has the following properties:

- All entities of an **ideal gas** have high translational energy, moving randomly in all directions in straight lines.
- When ideal gas entities collide with each other or with the container walls, the collisions are perfectly elastic. (There is no loss of kinetic energy.)
- The volume of an ideal gas entity is insignificant (zero) compared to the volume of the container.
- There are no attractive or repulsive forces between ideal gas entities.
- Ideal gases do not condense into liquids when cooled.

Example 8: Find the volume of 100 g of oxygen gas at SATP.

Example 9: What is the molecular formula of an unknown gas that is composed of 80.0% carbon and 20.0% hydrogen if a 4.60 g sample occupies a 2.50 L volume at 25 ℃ and 152 kPa?

Example 10: What is the density of nitrogen gas in grams per litre, at 25 ℃ and 126.63 kPa?

Homework: McGraw Hill Textbook pg556. 21 – 30

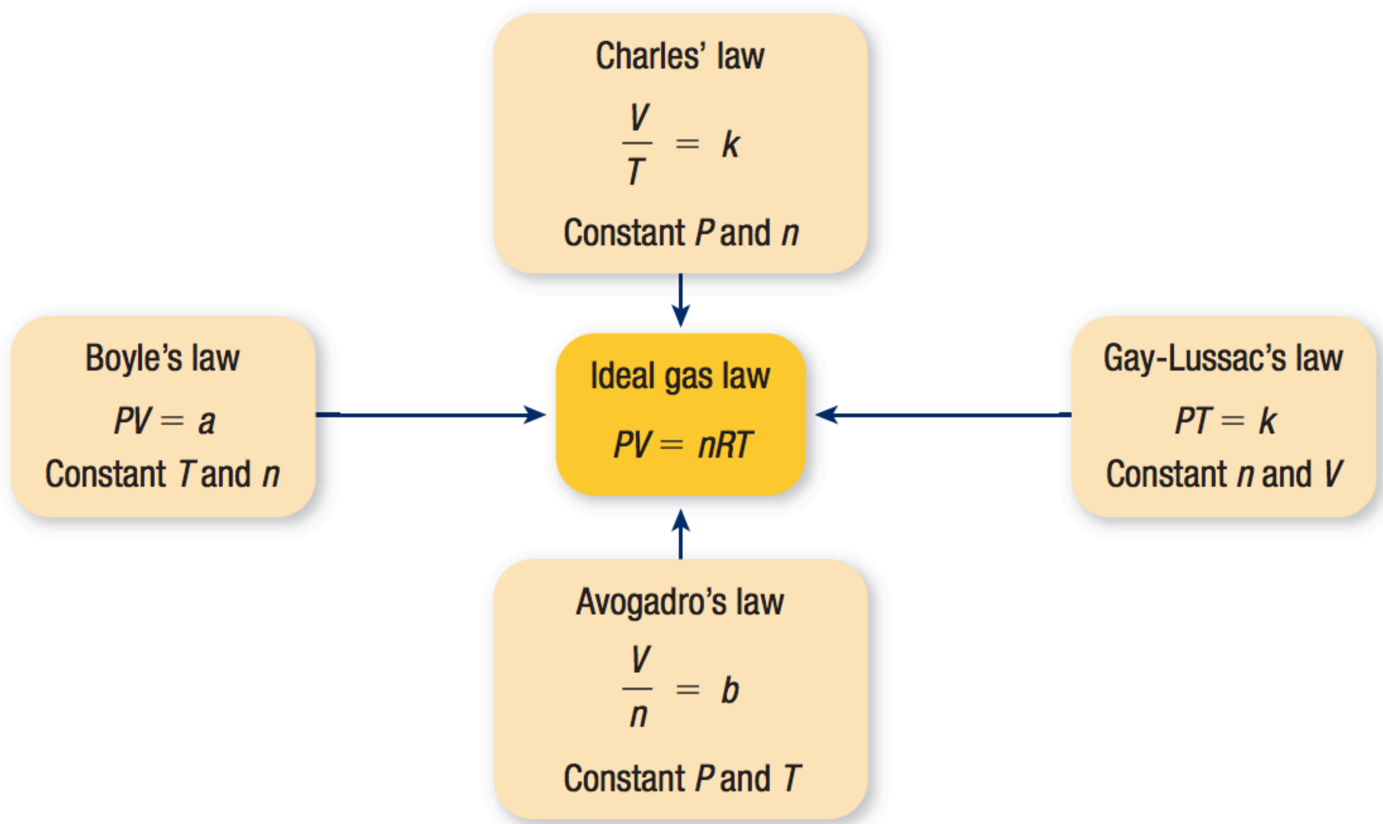

Figure 3 We can combine the individual gas laws to form the ideal gas law.