Gas Stoichiometry

Suppose we have 1 mole of an ideal gas at 0℃ $(273\ K)$ and 1 *atm*. From the ideal gas law, the volume of the gas is given by:

$$V = \frac{nRT}{P} = \frac{(1\ mol)(0.08206\ L \cdot atm/K \cdot mol)(273\ K)}{1\ atm} = 22.4\ L$$

This volume of 22.4 L is called the **molar volume** of any ideal gas (at 0℃ and 1 *atm*). The conditions 0℃ and 1 *atm*, called **standard temperature and pressure** (**STP**) are common reference conditions for the properties of gases.

The molar volume can be used to convert between the volume of an ideal gas at STP, the number of moles of the gas, the number of particles of the gas, and the mass of the gas. But, you must remember that the value of $22.4\ L/mol$ only applies to gases and only at STP.

Note: The molar volume of a gas at 25℃ and 1 *atm* is $24.5\ L/mol$.

Example 1
A student fills a 1.0 L flask with carbon dioxide (CO_2) at standard temperature and pressure. How many molecules of gas are in the flask?

Example 2
Determine the volume of 29.9 g of argon gas (Ar) at 25℃ and 1 atm.

Example 3
Calculate the molar volume of hydrogen gas if its density is $0.08999\ g/L$ at STP.

Using the ideal gas law, it is possible to determine the volume of a gas at conditions other than STP.

Example 4
Calculate the molar volume of an ideal gas at 27℃ and 1.5 atm. Determine the identity of the gas if its density is $1.95\ g/L$.

Example 5
Calculate the density of ethane gas (C_2H_4) at $-73℃$ and 0.445 *atm*.

Example 6
Calculate the volume of 11.0 *g* of carbon dioxide gas at 173℃ and 55.6 *kPa*.

Worksheet

1. Determine the number of moles of chloride ions in 2.50 $mol\ ZnCl_2$.

2. Calculate the number of moles of each element in 1.25 *mol* of glucose ($C_6H_{12}O_6$).

3. Determine the number of moles of sulfate ions present in 3.0 *mol* of iron(III) sulfate ($Fe_2(SO_4)_3$).

4. How many moles of oxygen atoms are present in 5.0 *mol* of diphosphorus pentoxide (P_2O_5)?

5. Calculate the number of moles of hydrogen atoms in 11.5 *mol* of water.

6. A room with a volume of 4000 *L* contains how many moles of air at STP?

7. A chemical reaction produces 0.82 *mol* of oxygen gas. What volume will that gas occupy at STP?

8. What volume would a 200 *g* sample of hydrogen sulfide gas occupy at STP?

9. A gas occupies a volume of 6.75 *L* at 89.0 *atm*. What volume will this gas occupy at 0.09 *atm* if the temperature remains constant?

10. A 500 *mL* sample of gas was collected at 20℃ and 1.0 *atm*. What would its volume be at STP?

11. Determine the density of carbon dioxide gas at 0.98 *atm* and 65℃.

12. A 2.929 *g* sample of gas occupies a volume of 426 *mL* at STP. What is the molar mass of the gas?

13. An unknown gas has a density of 3.167 g/L at STP. What is the identity of the gas?

14. A 0.30 *g* sample of a gas occupies a volume of 82.0 *mL* at 3.0 *atm* and 27℃. Calculate the molar mass of the gas.

15. Calculate the density of SF_6 at STP.