Gas Laws: Ideal Gas Law

Video Workbook with Dr. B.

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We use the Ideal Gas Law when conditions don't change and mass or moles (n) are involved.

$$PV = nRT$$

P is usually in atm, mmHg, or kPa.
V must be in Liters (L).
n will be moles (mol).
R will be 0.08206 $L \cdot atm \cdot mol^{-1} \cdot K^{-1}$ when P is in atm.
R will be 62.364 $L \cdot mmHg \cdot K^{-1} \cdot mol^{-1}$ when P is mmHg.
R will be 8.314 $J \cdot mol^{-1} \cdot K^{-1}$ when P is kPa.
T must be in Kelvin (K).

There are no 100% ideal gases, but many are close at higher temperatures and lower pressures.

Ideal Gas Law

Gas laws playlist

Real vs Ideal Gases

When to Use the Ideal Gas Law

Memorize STP!

Standard Temperature and Pressure

- 273.15 K
- 1 atm (or 760 mmHg).

When is a gas closer to ideal?

- The molecules/atoms do not attract or repel each other.
- The atoms/molecules do not take up any space.

This is often at lower pressures and higher temperatures.

When is a gas less ideal (non-ideal)?

- At high pressure.
- At low temperatures.

Example 1

A sample of gas has a pressure of 2.0 atm, occupies a volume of 3.0 L, and contains 0.5 moles of gas. What is the temperature of the gas in Kelvin?

Video of worked solution.

Example 1 Solution

P = 2.0 atm
V = 3.0 L
n = 0.5 mol
T= ?

Because P is in atm we use

0.08206 (L·atm)/(mol·K) for R.

2.0atm * 3.0L = 0.5mol * 0.08206 (L·atm)/(mol·K) * T

Solving for **T** we get 146 K.

Example 2

What is the temperature of a 0.500 mol sample of gas at 820.2 mmHg and a volume of 2.7L?

Video of worked solution.

Example 2 Solution

P = 820.2mmHg
V = 2.7L
n = 0.500 mol
T= ?

> Because P is in mmHg we use
> 62.364 L·mmHg · K^{-1} · mol^{-1}
>
> Or convert mmHg to atm.

820.2mmHg * 2.7L = 0.500mol * 62.364 L· mmHg · K^{-1} · mol^{-1} * T

Solving for **T** we get 71 K.

Example 3

A sample of an ideal gas occupies a volume of 550 mL at 25°C. The pressure is measured to be 1.2 atm. What is the number of moles of the gas in the sample?

Video of worked solution.

Note: 1L = 1000mL

Note: K = °C + 273.15

Example 3 Solution

P = 1.2 atm
V = 550ml = 0.55 L
n = ?
T= 298.15K

> Because P is in atm we use
>
> 0.08206 (L·atm)/(mol·K) for R.

1.2atm * 0.55L = n * 0.08206 (L·atm)/(mol·K) * 298.15K

Solving for **n** we get 0.027 mol.

Example 4

How many moles of gas are contained in 321 mL at 25.0 °C and 745 mmHg pressure?

Note: You can also convert mmHg to atm or use a value for R that has mmHg.

1 atm = 760 mmHg

Video of worked solution.

Example 4 Solution

P = 745 mm Hg
V = 321ml = 0.321L
n = ?
T= 298.15K

> Convert Pressure to atm or use
>
> 62.36367 (mmHg·L)/(mol·K) for R.

745mmHg * 0.321 L = n * 62.364 L·mmHg · K^{-1} · mol^{-1} * 298.15K

Solving for **n** we get 0.0129 mol

Note: For problems where you solve for Pressure (P), the units for P will depend on the value of R you choose.

If R is:	P will be in:
0.08206 L· atm · mol^{-1} · K^{-1}	atm
62.364 L· mmHg · K^{-1} · mol^{-1}	mmHg
8.314 J · mol^{-1} · K^{-1}	kPa

Example 5	*Example 5 Solution*
Determine the volume occupied by 2.34 grams of Carbon dioxide gas (CO_2) at 27.2°C and 2.2 atm. Video of worked solution.	P = 2.2 atm V = ? n = 2.34g CO_2 = 0.0531 mol T= 300.35K 2.2.atm * V = 0.0531 mol * 0.08206 (L·atm)/(mol·K) * 300.35K Solving for **V** we get 0.59 L

Example 6	*Example 6 Solution*
Determine the volume of occupied by 32.0 grams of O_2 gas at STP. Video of worked solution. STP is 273.15 K and 1 atm or 760 mmHg	P = 1.0 atm V = ? n = 32.0g O_2 = 1.0 mol T= 273.15K 1 atm * V = 1mol * 0.0821 (L·atm)/(mol·K) * 273.15K Solving for **n** we get 22.4 L So 1 mole of an ideal gas at STP is equal to 22.4 L. The **molar volume** of a gas at STP is 22.4L.

Example 7	*Example 7 Solution*
A chemical reaction occurs, producing an oxide of nitrogen (e.g. NO, NO_2, N_2O) as a gas. The gas has a mass of 1.211g and occupies a volume of 0.677L. The temperature in the laboratory is 296.0 K and the air pressure is 0.987atm. Calculate the molar mass of the gas assuming the gas is ideal. Video of worked solution.	P = 0.987 atm V = 0.677L n = ? T= 296.0K 0.987atm * 0.677L = n * 0.08206 (L·atm)/(mol·K) * 296.0K Solving for **n** we get: 0.0275 mol. We divide the grams in the problem by the moles we found to get **molar mass**: 1.211g / 0.0275 mol = 44.04g/mol

Guides

KMT and the Gas Laws

Combined Gas Laws

Ideal Gas Law

Report errors and suggestions to DrB@breslyn.org