
Gases

Chapter 1

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Overview

- I. What is physical chemistry?
- II. Some meanings of the term state
- III. Kinetic theory and the ideal gas
- IV. Real gases for real people

I. What is physical chemistry?

A. The study of the underlying principles that govern the behavior of chemical systems

B. 2 views

- **microscopic - use of molecules**
- **macroscopic - large scale properties without the use of molecules**

C. Areas

- **Thermodynamics - relationships among the various equilibrium properties of a system**
- **Quantum mechanics - new set of laws which govern motions of molecules, atoms, electrons and nuclei. The study of spectroscopy is derived from this.**

- **Statistical mechanics - relates the macroscopic to the microscopic. Allows the calculation of macro properties from the micro.**
- **Kinetics - study of reaction rate, uses parts of thermo, quantum mechanics and stat mech**

II. Some meanings of the term state

- A. States of matter (solid, liquid, gas) or
- B. A description of a sample of matter in terms of macroscopic variables V, P, T and n
 - 1. volume - m^3 , ft^3 , liters, ml
 - 2. pressure (Force/area)
 - direct \Rightarrow lb/in^2 , N/m^2 or Pa, bar (1 bar = 10^5 Pa)
 - indirect \Rightarrow Atmosphere, mm Hg or torr, in of Hg

Conversions	Old Standard Pressure
14.7 lb/in^2	760. mm Hg or torr
101.3 kPa	1.013 bar
1.00 Atm	29.9 in of Hg

New definition of standard pressure is exactly 1 bar

3. Temperature - measure of average KE

Gives an indication of energy flow - no energy flow means thermal equilibrium (same temp)

Celsius

Fahrenheit

Kelvin

Rankine

$$K = C + 273$$

$$R = F + 460.$$

$$C = 5/9 (F - 32)$$

$$F = 9/5 C + 32$$

4. Number of particles - the mole

1 mole = 6.02×10^{23} particles

allows conversions g → moles → molecules

C. Equations of state

- 1. V, P, T and n are not independent
Once we specify 3 - the other is already determined.
The equation of state relates these variables**
- 2. The equation of state is not known for most
substances because of complicated interactions but the
equation for low pressure gases is.**

III. Kinetic Theory and the Ideal gas law

A. Assumptions

- Matter made of particles
- Particles are in constant motion
- Particles collide elastically unless they react
- All particles of the same substance and at the same temperature don't have the same kinetic energy

B. Ideal gas - particles are very far apart and their size is negligible compared to the distance they travel between collisions

C. Equation of state for an ideal gas

- Boyle's Law

Pressure and volume are inversely proportional provided temperature and number of particles are held constant.

- **Charles' Law**

Volume and temperature are directly proportional provided pressure and the number of particles are held constant

- **Avogadro's principle**

At same T and P equal volumes of gases contain equal numbers of particles.

D. Ideal or perfect gas law

$PV = nRT$	Equation of state
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$D = \frac{PM}{RT} \quad \mathbf{D = density}$
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R is the gas constant (8.314 J/mole K or kPa-L/ mole K ; 62.4 L-Torr/mole K; 0.0821atm L/mole k)

If the conditions of the gas change then

$$\frac{P_1 V_1}{P_2 V_2} = \frac{n_1 T_1}{n_2 T_2}$$

E. Dalton's Law of Partial Pressures

Total pressure is the sum of partial pressures

$$\mathbf{P_T = P_A + P_B + P_C + \dots}$$

but $V_T = V_A = V_B = V_C$ and $n_T = ?$

Derive to get

$$\mathbf{P_T = X_A P_T + X_B P_T + X_C P_T + \dots}$$

where $X_A = n_A / n_T$ the mole fraction

This of course means that P_A must equal $X_A P_T$