CEN 207 Physical Chemistry

Text book:

Atkins' Physical Chemistry, Peter Atkins, Julio de Paula, James Keeler, 11th Edition, Oxford University Press.

Reference books

. Physical Chemistry, Robert J. Silbey, Robert A. Alberty, Moungi G. Bawendi

. Physical Chemistry, Ira N. Levine

C. Real gases

Real gases do not obey the perfect gas law exactly in the limit of p→0
Real gases show deviations from the perfect gas law because molecules interact with one another.

The compression factor (at the same pressure and temperature)

$$Z = \frac{V_m}{V_m^o} = \frac{molar\ volume\ of\ gas}{molar\ volume\ of\ perfect\ gas}$$ Compression factor (definition)

$pV_m = ZRT$ for real gas

Virial equation of state:

$$pV_m = RT\left(1 + \frac{B}{V_m} + \frac{C}{V_m^2} + \cdots\right) \rightarrow Z = \frac{pV_m}{RT} = \overbrace{\left(1 + \frac{B}{V_m} + \frac{C}{V_m^2} + \cdots\right)}^{Z}$$ Virial equation of state

The coefficients B, C, …., which depend on temperature, are the second, third, … virial coefficients; the first virial coefficient is 1.

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C. Real gases

van der Waals equation of state

$$p + a\frac{n^2}{V^2} = \frac{nRT}{V-nb} \rightarrow p = \frac{nRT}{V-nb} - a\frac{n^2}{V^2}$$

van der Waals equation of state

a and **b** are called the van der Waals coefficients

a: the strength of attractive interactions

b: the repulsive interaction between molecules

The First Law

Energy; 1. Heat, 2. Work, 3. Chemical reaction, 4……

Internal energy

Enthalpy

Thermochemistry

State functions and exact differentials

Adiabatic changes

System and Surroundings (outside of the system)

System: a part volume in the space/world, reaction vessel, electrochemical cell

Open system,

Closed system,

Isolated system.

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The First Law

Work, heat and energy

Work is done to achieve motion against an opposing force.

The energy of a system is its capacity to do work.

Heat is a kind of energy and can be converted to the work.

Kinetic energy (E_k) of a body is the energy possesses as a result of its motion ($E_k = ½ mv^2$).

Potential energy is the position energy

$$E_p = -F_x dx \rightarrow F_x = -\frac{dE_p}{dx}$$

The gravitational potential energy: $E_p(h) = E_p(0) + mgh$ E(0) The zero of potential energy is arbitrary. The

$E=E_k+E_p$

Exothermic process: energy releases as heat

Endothermic process: energy required as heat

The First Law

Internal energy

In the thermodynamics, the total energy of a system is called its internal energy (U).

U: a state function and an extensive property of a system (depends only amount of substance).

$$\overbrace{U_m}^{intensive} = \frac{\overbrace{U}^{extensive}}{n}$$