Physics

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Early Kinematics

SDR and Galilean relativity

Late Kinematics

Special Relativity

Thermodynamics

"It's no use going back to yesterday, because I was a different person then."
— Alice, Alice in Wonderland

The zeroth law of thermodynamics

Macrostates and Microstates

A Macrostate is a macroscopic description of a system using the 4 main thermo-dynamic variables pressure (p), temperature (T), volume (V), and number of particles (N). These variables are averages e.g the pressure of a gas is the average force per unit area exerted by particles, temperature reflects the average kinetic energy of particles. A Microstate is a complete, detailed description of every particle in the system, including their positions and momenta. MICROSTATES WILL NOT BE COVERED.

The zeroth law

"If A, B and C are different thermodynamical systems and A is in thermodynamical equilibrium with B, and B is in thermodynamical

equilibrium with, then A is in the themodynamical equilibrium with C"

The first law

"The internal energy of an isolated system is conserved under any thermodynamical change"

The second law
Under any thermodynamical change:

$$\Delta U = Q + W$$

And in differential form using inexact derivatives

$$dU = đQ + đW$$

-This will be explained further on.

Work

Work is energy being transferred between one system. Due to this it cannot be tied to a thermodynamical process, and therefore is a function of path. A system doesn't store work, therefore it cant be measured in the exact differential equation at the start or end of a reaction. This is why it is represented in a inexact differential written as đX, which allows us to show work transforming over time.

Work can be defined as:

$$dW = \vec{F} \times \vec{dh} \tag{1}$$

For the first law of thermodynamics, W > 0 if work is done on the system, such as compression and W < 0 work done by the system, usually expansion.

Pressure and Work. If work is done by the system us negative F, if instead its work done on the system the F is positive.

$$dW = \pm F dh$$

Force in terms of pressure is determined by:

$$F = p_{surr} \times A$$

Where A is the relevant surface area

To represent the change in volume

$$dV = A \times dh \implies dh = \frac{dV}{A}$$

Now when we substitute F and dh

$$dW = \pm(p_{surr} \times A)\left(\frac{dV}{A}\right)$$

$$dW = -p_{surr}dV$$

Therefore the total work is the integral of dW:

$$W = \int_{V_i}^{V_f} \pm p_{surr}dV$$

Heat

Heat is calculated in a much easier manner. Using the second law of thermodynamics:

$$\Delta U = Q + W$$

Solve for Q

$$Q = \Delta U - W$$

Keep in mind that this is only valid for closed systems.

Heat capacity at a constant volume (C_V). For context the internal energy for ideal gas is:

$$U = \frac{3}{2}nRT$$

I will explain this better later, but for reference n is number of moles and R is the gas constant.

Lets take the first law, where đW is 0 because the volume is constant.

$$dU = đQ + đW\!\!\nearrow^{0}$$

$$C_V = \left(\frac{\partial Q}{\partial T}\right)_V = \left(\frac{\partial U}{\partial T}\right)_V$$

$$C_V = \frac{\partial}{\partial T}\left(\frac{3}{2}nRT\right)_V$$

$$C_V = \frac{3}{2}nR$$

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Heat capacity at a constant pressure (C_P). For this problem work is done because gas can expand. Since $dW = pdV$

$$dU = dQ + dW \nearrow^{pdV}$$

$$C_p = \left(\frac{\partial Q}{\partial T}\right)_p = \left(\frac{\partial U}{\partial T}\right)_p + p\left(\frac{\partial V}{\partial T}\right)_p$$

Because we are working with a ideal gas, U is dependent on only T so we can simplify it C_V.

THIS SECTION NEEDS WORK, MISSING A LOT OF CRITICAL STEPS

$$V = \frac{nRT}{p}$$

$$\left(\frac{\partial V}{\partial T}\right)_p = \frac{nR}{p}$$

$$C_P = C_V + p\left(\frac{nR}{p}\right)$$

$$C_p = C_V + nR$$

$$C_p = \frac{3}{2}nR + nR$$

$$C_p = \frac{5}{2}nR$$

Internal Energy

Thermodynamic processes