Today

I. Last Time
II. Wrap up Kinetics, Equipartition, Temperature
III. Quick Survey on Kinetics, 1st Guest Lecture Volunteer
IV. Heat, Work, and Important Conventions

I. Introduced the "Sackur-Tetrode" equation as an example of the fundamental equation. Introduced the idea of an equation of state, e.g. the Ideal Gas law:

$$PV = NkT = nRT.$$

Discussed kinetic theory, which connects the microscopic motions of the atoms or molecules to the macroscopic observables. :

$$NkT = \frac{1}{3}Nm\overline{v^2} \implies T = \frac{2}{3}\frac{\overline{E}}{k} \implies \overline{E} = \frac{3}{2}kT.$$

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II. Wrap up

Let's introduce the notion of "internal energy" U. The total internal energy includes all forms of energy in the system including chemical bonding and rest energy of the particles. Here we've tracked the motional energy, which is more related to temperature

$$U_{\text{thermal}} = \frac{3}{2}NkT\,.$$

This also motivates talking about changes in energy ΔU.

II. Wrap up

This also motivates talking about changes in energy ΔU.

<u>Equipartition</u>: In the kinetic theory argument we just gave wee only tracked *translational* kinetic energy. In fact, in our initial argument the average energy of one particle. The Equipartition theorem states that:

At temperature T, the average energy of any quadratic degree of freedom is $\frac{1}{2}kT$.

In the case we've just done each particle has three quadratic degrees of freedom and we get 3N total degrees of freedom. More examples would be: $\frac{1}{2}I\omega_x^2, \frac{p_x^2}{2m}, \frac{1}{2}k_s x^2$. In general we call the number of such freedoms for a single particle f. Then,

$$U_{\text{thermal}} = \frac{1}{2}NfkT$$

II. Wrap up

The Equipartition theorem states that:

At temperature T, the average energy of any quadratic degree of freedom is $\frac{1}{2}kT$.

~~Sometimes you will hear people say that this shows that temperature is about the average motional energy in a system.~~

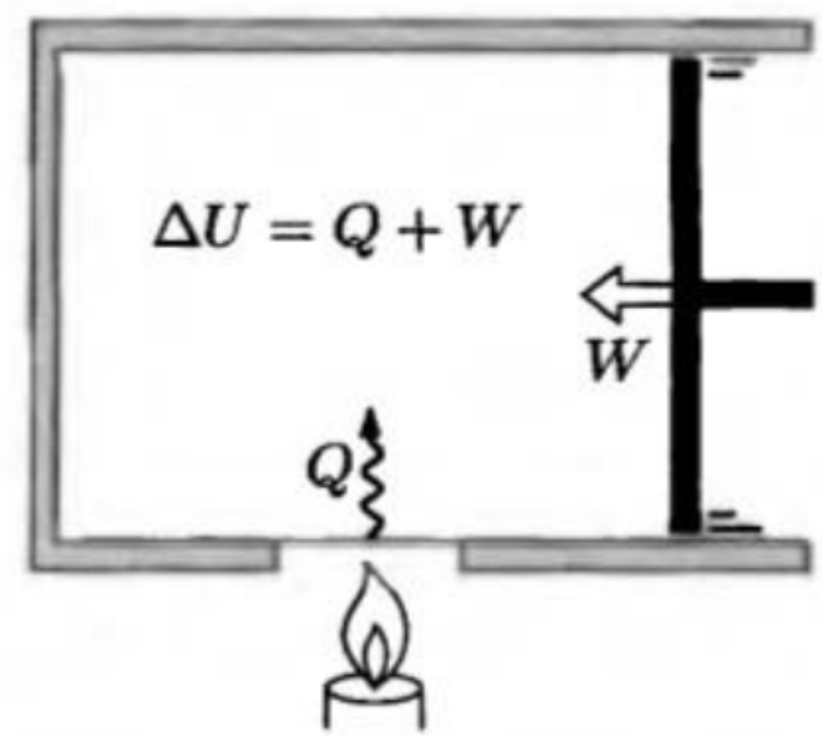
Temperature is a measure of the tendency of an object to spontaneously give up energy to its surroundings.

III. Heat, Work, and Important Conventions

Heat is energy transferred spontaneously between two systems atat different temperatures.

Work is energy transferred to a system directly by mechanical or other means and done so intentionally.

IV. Heat, Work, and Important Conventions



Both heat and work are energy in transition!

(Frankly, I don't think the difference between heat and work is perfectly well defined, e.g. in Special Relativity.)

In our course, we will always consider heat *added to the system* as positive. Similarly, we say that work done *on the system* is positive work.