Lecture 2-1

Question of the Day: Consider two 100 g cups of water. One is heated by blending, the other in a microwave. Both go from 25 to 30°C, and press. is const. Is there a difference in internal E of the cups at 30°C?

Review: 2° and 3° structure? Difference between nucleotide/nucleoside?

(slide) Thought experiment: Blending water

→ there is a physical relationship between work, heat, and temperature

- Early scientists wanted to study this relationship (1700s-1800s)
  - → no molecular theory
  - → basic measurements: T, P, electrical work, mechanical work
- From physics: Energy is conserved (neither gained nor lost)
  - → [redacted] but how is it converted

Thermodynamics: how energy is converted
→ (slide) examples
→ relevant to all natural sciences

- (slide) why discuss molecules (when the original thermodynamicists didn't know details)?

- (slide) Definitions: system/surroundings
  → can't talk about energy xfer w/o these

~~Work~~

Physics Review: Work

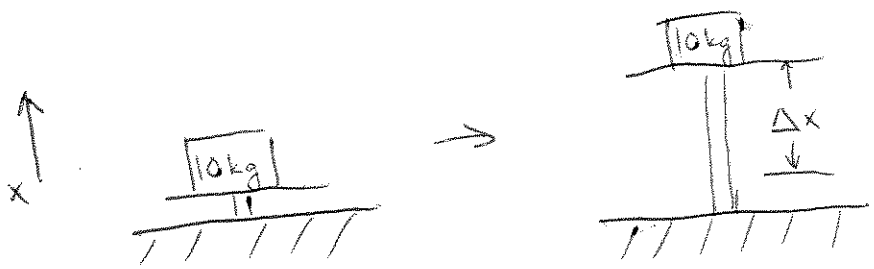
- convention (important) work done <u>to</u> system is positive, work done <u>by</u> system is negative

$$w = \int_{\text{(one dimension)}} F(x)\,dx \quad \text{or} \quad \underset{\substack{\uparrow \\ \text{const} \\ \text{force}}}{F} \cdot \underset{\substack{\uparrow \\ \text{displacement}}}{\Delta x}$$

  → in 3D, must use a path, not displacement (more advanced than we will do)

- ~~Example:~~

• Example: Piston lifts a 10 kg mass 10 m.



$\Delta x = 10\ m$

$F = -mg$

$= -98.0\ kg\,m/s^2$

$= -98\ N$

$|W| = F\,\Delta x = 980\ N \cdot m = 980\ J$

→ what is the sign? Depends on the system!

→ if system is mass, work is done to system (+)

→ if system " piston, " " " by system.

• Example: Gas expanding in cyllinder (constant external P_{ex}) What is work? (System is gas)

$P_{ex} = \frac{F_{ex}}{A}$, so

$F_{ex} = P_{ex} \cdot A$ (force points ↓)

$\Delta x \cdot A = \Delta V$, so $\Delta x = \frac{\Delta V}{A}$ (Δx is positive here)

$$\Delta W = -F_{ex} \cdot \Delta x = -(P_{ex} \cdot A)\left(\frac{\Delta V}{A}\right) = -P_{ex}\,\Delta V$$

↑ (points down, so negative)

→ for a very small ΔV, ΔW, we can sum up small changes to get total work

$$dW = -P_{ex}\,dV \Rightarrow W = -\int_{V_1}^{V_2} P_{ex}\,dV$$

Heat (Chemistry Review)

- Historically heat was postulated as a means of relating temperature and energy → absorbing heat leads to increase in temperature
- convention (important): heat is positive if <u>absorbed by</u> system, negative if <u>lost by</u> system (T↓)
- <u>Zeroth law</u>: all heat is the same
- Heat and temperature are related by heat capacity (C)

→ proportionality at either const P or V.

$$\Delta q = C\,\Delta T, \text{ or}$$

$$C = \frac{\Delta q}{\Delta T} \quad \text{ack! Calculus} \quad C = \frac{dq}{dT}$$

→ (slide) heat capacity is like a buffering capacity for heat / Temp

→ (slide) Calculus: If you plot q vs. T, heat capacity is the slope

- ~~IVE~~ Strictly speaking

$$\Delta q = \int_{T_1}^{T_2} C(T)\, dT$$

↑ either P, V

But if $C \approx$ constant over a temp range

$$\Delta q = C_{(P,V)} (T_2 - T_1)$$

↑

look familiar? where is m? or # of moles? what are units of C if q has units of J?

- (Slide) Question: what has higher heat capacity - 100 g or 500 g of water (think definition, what can absorb more heat before ↑T)

→ the absolute heat capacity C depends on the amount of water, but it makes sense that C/#moles or C/mass does not.

- Convention molar and specific values

$\bar{C}_v$ - heat capacity per mole (const V)

C_v^* - heat capacity per gram (const V)

$$\Delta q = n C_p^{\circ} (T_2 - T_1) \quad \text{or} \quad \Delta q = n \bar{C}_p (T_2 - T_1)$$

- (Slide) Intensive vs. extensive
  - → lots of quantities share the behavior of heat capacity
- Heat capacity of materials (slide)

First Law of Thermo

- Empirical: after many experiments, scientists come up with this "law" - its not derived from any thing else
- (Slide) First law and consequences
- (Slide) Significance of E, what are implications for QOTD?