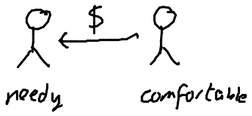
money ⟷ energy

happiness ⟷ entropy

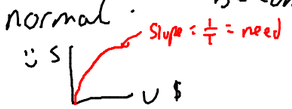
need: $\frac{dU}{d\$} \leftrightarrow \frac{1}{T} = \frac{dS}{dU}$

comfort: $\frac{1}{need} \leftrightarrow T$



normal: become more comfortable as they become wealthier (get more money)

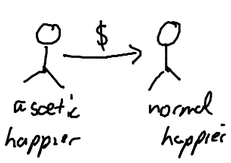
$U \sim T$



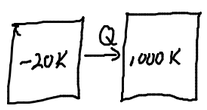
miserly: becomes needier with wealth (eg. planet around sun)

ascetic: (Zen): becomes happier when they lose money

$\frac{dU}{d\$} < 0 \rightarrow \frac{1}{T} < 0$

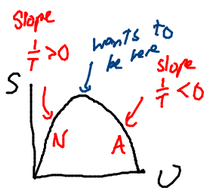


Ascetics will always give money to normal people (or misers)

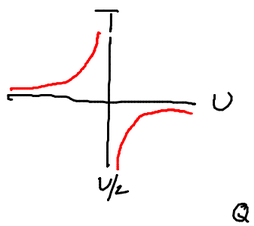


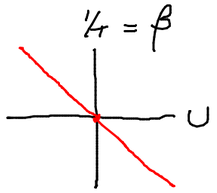
Negative temperatures are hotter than positive temperatures!

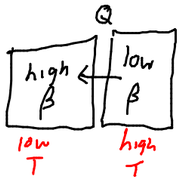
eg. Paramagnet



ascetic phases appear when energy is bounded







Heat flows from low β to high β and negative β is lower than positive β.

	−1 K	vs − 100 K
$\beta \propto \frac{1}{T}$	−1/K	−0.01/K
	lower β hotter	colder

Chapter 5

U is internal energy of system
but it's not the only energy associated w/ systems.

eg. System in air is holding back the surrounding air
- if system vanished suddenly, air would rush back in

potential energy : PV

$$H = U + PV \quad \text{enthalpy of system}$$

e.g. ideal gas

$$H = N\tfrac{f}{2}kT + NkT = \tfrac{f+2}{2}NkT$$

$$\Delta H = \Delta U + \Delta(PV)$$

At constant pressure, $W_c = -P\Delta V$

$$\Delta H = \Delta U + P\Delta V$$
$$= Q + W_c + W_{other} + P\Delta V$$
$$\Delta H = Q + W_{other} \quad \text{at constant } P$$

W_{other}: friction, microwave oven, etc

$W_{other} = 0$

$$C_p = \frac{Q}{\Delta T} = \frac{\Delta H}{\Delta T} = \left(\frac{\partial H}{\partial T}\right)_p \qquad C_V = \left(\frac{\partial U}{\partial T}\right)_V$$

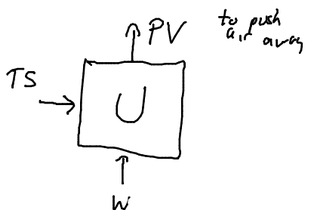
H at const P is analogous to U at const V.

When system is annihilated (ignoring $E=mc^2$)
H is total energy released
Some can be used as work, but not all

Why? System had some entropy which can't be destroyed.
Heat must flow out $Q = TS$.
$H - TS$ can be used as work if you choose
"free energy"

$F = U - TS$ Helmholtz free energy
$G = H - TS$ Gibbs free energy

In reverse situation: if a system is created,
F or G must be supplied as work
but TS can be drawn from environment



$$H = U + PV$$
$$F = U - TS$$
$$G = H - TS = F + PV$$