APSC - ~~III~~ 132 January 10th 2022

Gibbs energy & chemical equilibrium

Define → appropriate system boundary
↳ thermodynamic processes
↳ gibbs energy

- how we define the systems matters
- by looking at only 1 part, we can miss changes in others

Equilibrium Thermodynamics
- At a given pressure and temp, what state(s) is the ~~solid~~ system

Systems & Surroundings
↳ quantity of matter
or
↳ Region in space

↳ everything outside of the system
if it's not part of the system, it's part of the surroundings

lack of concern for surroundings has caused issues
e.g. climate change, ozone depletion, environmental microplastics

Physically Bounded Systems → obvious boundaries

Control Volumes → often defined when dealing with flows that enter and exit a ~~system~~ region of interest

Hilroy

Types of Systems — most common

Open System → Can exchange energy and matter with the surroundings

Closed Systems → Can exchange energy but not matter

Isolated Systems → No transfer of any kind

Intensive properties → independent of the amount of water
e.g. pressure, surface tension, viscosity, refractive index

Extensive properties → are additive, the system property is the sum of the values of the parts
Internal energy (U), entropy (S), enthalpy (H)

Specific/Molar property: Normalizing an extensive ~~property~~ quantity by the amount of matter (E_i/m) yields an intensive property

Specific enthalpy, → J/kg ; molar volume → m^3/mol

$$\boxed{\Delta U = q + w}$$

heat — work

thermodynamics is only concerned with internal energy

Example:
Consider hydrogen in a fuel cell vehicle storage tank. Closed system. 5kg @ 500 atm & 20°C.
Find the change in energy for:
(a) acceleration from 0–100 km/h
(b) travelling up a hill, (100m)
(c) inc in temp to 35°C at constant volume

(a) $\Delta E_K = \frac{1}{2}mv^2 = \frac{1}{2}(5kg)(v^2) = 1929\ J$

(b) $\Delta E_P = mg\Delta h = (5kg)(9.8\ m/s^2)(100m)$
$= 4905\ J$

(c) $\Delta U = q + \cancel{w}^{0} = mC_v\Delta T;\ C_v = 10183\ J/kg\cdot K$
$= 763725\ J$

Entropy
↳ state function

$$\Delta S_{system} + \Delta S_{surroundings} \geq 0$$

example continued
(d) what is the change in entropy for (c)
given: $\Delta S = m(C_v + R)\ln\left(\frac{T_2}{T_1}\right) - mR\ln\left(\frac{P_2}{P_1}\right)$
- find P_2 by ideal gas law: $\frac{nR}{V} = \frac{P_1}{T_1} = \frac{P_2}{T_2}$
- change units on R for H_2
$R = 8.314 \frac{J}{mol \cdot k} = 4124 \frac{J}{kg \cdot k}$

$\therefore P_2 = \frac{P_1 T_2}{T_1} = 526$ atm

$\Delta S = (5kg)(10183 + 4124 \frac{J}{kg \cdot k})\ln\left(\frac{308}{293}\right)$
$- 5kg(4124 \ J/kgk)\ln\left(\frac{526}{500}\right)$

Equillibrium

Gibbs energy combines properties

$G \equiv U + PV - TS \equiv H - TS$, where H is enthalpy
spontaneous → $\Delta G < 0$

Molar Gibbs energy and phase behaviour

A system at equillibrium will follow Gibbs energy
solid-liquid=m Vapoor-liquid=m
minimization

Nilroy