THERMAL PHYSICS 1/8/09

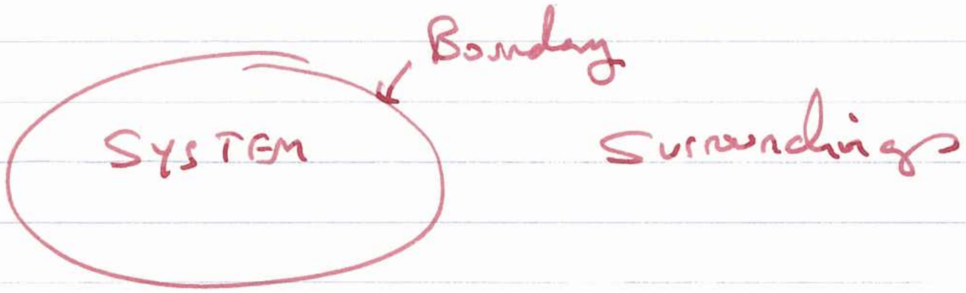
LECTURE 2

CONCEPTS & DEFINITIONS

Classical Thermodynamics

- Deal mainly with reversible processes & Eqm States

SYSTEM



SYSTEM + SURROUNDINGS = UNIVERSE

TYPES of SYSTEM

- OPEN / CLOSED : matter does / does not cross boundary
- ISOLATED : No ENERGY EXCHANGE Across bdry.

BOUNDARY

- can be physical or conceptual/virtual

Adiabatic wall

- PERMITS NO <u>Heat</u> interaction with surroundings

"Styrofoam box" • Thermal INSULATION

Diathermal Wall

• free exchange of heat between system & surrounding

"metal box"

• heat conducting wall

EQUILIBRIUM STATES

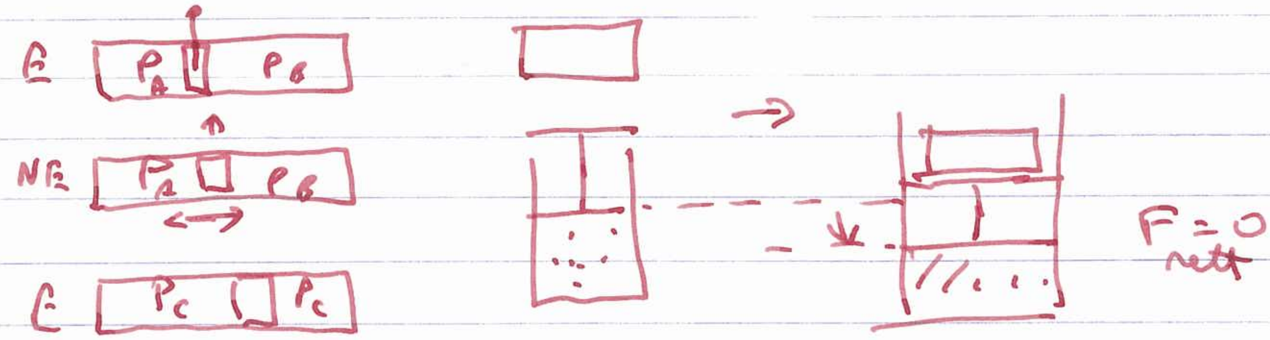
- Properties uniform throughout system
- Do not change with time unless acted upon by external influences.
- Indept of thermal history
- Just defined by "state variables"
- closed, isolated system → eqm over t.

NON - EQM STATES

- ∃ gradients, change with time
  - ocean, atmosphere
  - living cell, organism.

Types of EQM

Mechanical EQM:



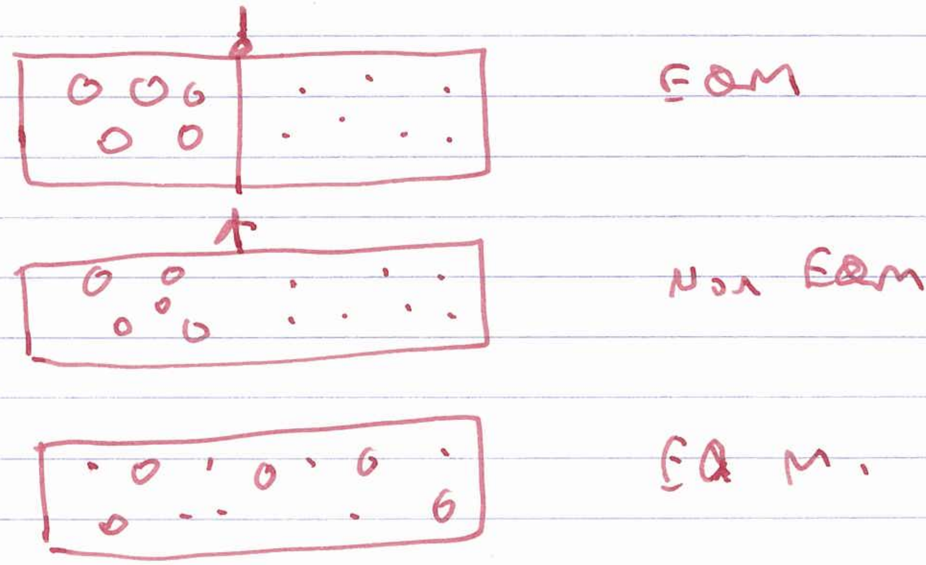
Applied Pressure = Internal Pressure.

Chemical EQM:

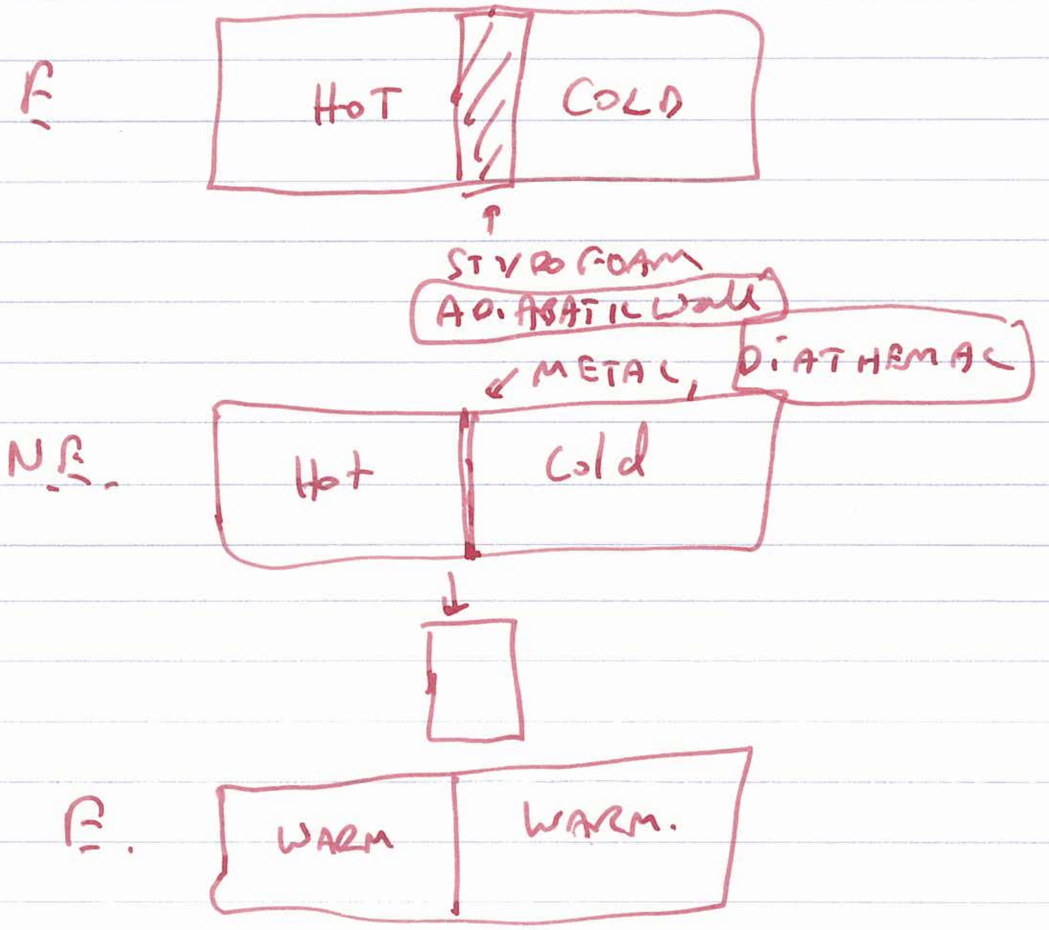
Mix A + B - Non - EQM

→ $A + B \rightleftharpoons AB$

Eqm const: $K_D = \frac{[A][B]}{[AB]}$ - EQM.



THERMAL EQM:



THERMODYNAMIC EQM

MECHANICAL, CHEMICAL &

Thermal EQM

– all three.

DESCRIBING EQM STATES

SIMPLEST SYSTEM: <u>HOMOGENEOUS FLUID</u>

STATE VARIABLES: "properties whose differential is EXACT"

- Describe EQM SYSTEM:

MECHANICAL :	P , V	Pressure volume
CHEMICAL :	μ , N	CHEMICAL POTENTIAL NUMBER of Particles
THERMAL :	T , S	TEMPERATURE ENTROPY
OVERALL :	U	INTERNAL ENERGY

~~EXTENSIVE ~~VARIABLE~~ PARAMETER~~

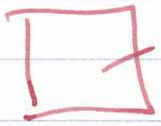
~~EXPANSIVE VARIABLE is Proportional to mass~~

~~EXTENSIVE PARAMETER is additive where subsystems combine to give composite system:~~

~~V, N, S, U EXTENSIVE~~

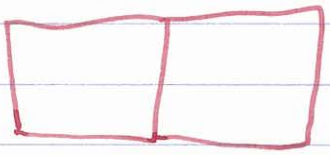
Look at Doubling System

One system in EQM



u, V, P, N, μ, S, T

MAKE 2 identical copies. ~~Since~~



Remove wall

SYSTEM already in EQM, since two subsystems identical

$u', V', P', N', \mu', S', T'$

$U' = 2U$ — since cons of Energy

$V' = 2V$ but $P' = P$!

(since eqm)

$N' = 2N$ but $\mu' = \mu$

$S' = 2S$ but $T' = T$

later

⇒ two types of State Parameters:

EXTENSIVE PARAMETERS

Extensive parameter is additive on combination of ~~identical~~ subsystems

$$U_T = \Sigma U_i$$
$$V_T = \Sigma V_i$$
$$N_T = \Sigma N_i$$
$$S_T = \Sigma S_i$$

] EXTENSIVE PARAMETERS

INTENSIVE PARAMETERS

Remain unchanged when identical subsystems are combined

→ T, P, μ

CONJUGATE PAIRS of Intensive + Extensive PARAMS

Extensive	Intensive
V	P
N	μ
S	T

- like classical mechanics:

$q_i \rightarrow p_i$

Gen. Coord — Gen conjugate Momentum

DESCRIBING EQM STATE

FORMALLY:

∃ FUNDAMENTAL EQN

$$U = U(S, V, N_1 \ldots N_r)$$

- ENERGY as Fn of EXTENSIVE PARAMETERS
(FIRST-ORDER HOMOGENEOUS EQN)

→ ENERGY REPRESENTATION

OR EQUIVALENTLY:

$$S = S(U, V, N_1, \ldots N_r)$$

ENTROPY as fn of EXTENSIVE PARAMS
(FIRST-ORDER HOMOGENEOUS EQN

→ ENTROPY REPRESENTN

- COME BACK to THIS LATER.

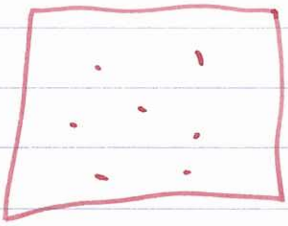
- THESE FUNDAMENTAL EQN are complete ~~des~~ thermodynamic description of eqm system !

Fundamental Eqns not so easy to get. INSTEAD:

EQUATIONS of STATE

- FUNCTIONAL Relationships between state variables
- set of such eqns
- need to worry about
  - dept / indept params
  - thermodynamic degrees of freedom.

EXAMPLE: Ideal, monatomic gas



STATE PARAMS:

P, V, T, N, U

– obvious

but also S, μ

EQNS of STATE

$$PV = NRT$$

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

write them as Intensive params

as fn of EXTENSIVES:

$$\frac{P}{T} = NR\frac{1}{V}$$

$$\frac{1}{T} = \frac{3}{2}NR\frac{1}{U}$$

From this, get complete

thermodynamic description of

ideal monatomic gas.