

I) REVIEW OF MACROSCOPIC THERMO

A) FOCUS ON ISOLATED SYSTEM SUBJECT

TO HEAT TRANSFER AND/OR WORK

AC1001: MAIRO THERMO REVIEW

~~REVIEW~~ A) 1st LAW THERMO

$$\boxed{du = dq - dw} \quad (1.1)$$

$du = 0$ in system's
internal en. / mass
during process

$dq = (d.f.t.t.)$ heat addition ($dq > 0$)
or removal from system
($dq < 0$)

during given process (per unit mass)

dw represents differential

work done on (to get
system

physics right, must choose

$dw < 0$, i.e., a dreaded 'sign
convention') or by system
choose

($dw > 0$ in order to reduce du)

the
for process
involving a
non-equilibrium
~~non~~
single phase
multi

a) $[u]$ represents / captures all of
the molecular-scale energy w/in
your ^{chosen} system. Much of this

course is devoted to modeling / figuring out /
guessing at ~~what~~ these molecular-scale
energy modes.

b) dq captures: i) conduction heat-xfer
to / from system during
given process
ii) radiation " " same..
iii) electrically-induced
heat-xfer during process

c) dq can also or be used to
represent / capture heat-evolution
or loss associated w/ phase
change and/or chemical reaction
(e.g., combustion). For now, we
focus on processes not involving
these two.

c) dq can also capture frictional heating,
when applicable.

c) $d_{friction} \geq 0$ Always; (macro thermal contr.)
LI Spgls (3)

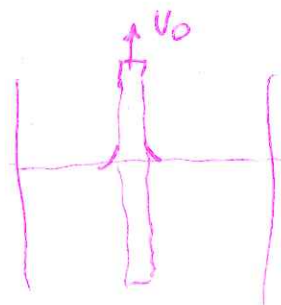
d) dW captures (different) work associated with:

i) Compression or expansion at the material within your system (i.e., PdV work)

ii) work transferred to/from System by ~~shear~~ shear work = shaft work produced at ~~moving~~ solid surfaces ~~or~~ having a tangential velocity component relative to the system.

iii) work transferred to/from System via surface tension forces.

EX. : pull a cylinder out of a beaker of water (= system)



↑ z



$$\sigma R d\theta \cos \theta_c = dF_{sr_z}$$

$$\Rightarrow F_{sr_z, \text{normal}} = \sigma R \cos \theta_c 2\pi$$

$\theta_c = \text{dynamic contact angle}$

$dl = R d\theta$



$\sigma = \text{surf. tens. coeff.}$

$R = \text{cyl. radius}$

$$\Rightarrow \left[\begin{aligned} dW_{sr} &= \sigma F_{sr_z} dz \\ &= \sigma R \cos \theta_c 2\pi dz \end{aligned} \right]$$

(+) this is an energy loss

iv) other work modes, including elastic and/or plastic expansion or ~~contraction~~ compression of solid.

v) work is also often done by a gravitational, electromagnetic force fields.

B) DEFINITIONS

a) system = chosen^{CONSTANT MASS} collection of molecules / atoms.

i) examples: a car, a human,
a glass of H_2O , a
the steam and water
w/in a steam turbine
a ^{single} ~~PRO~~ H_2 molecule,
etc. etc.

ii) when we want to figure
out / model the thermodynamics
(either micro or macro),
we have to first clearly
decide on the system
we want to model

b) thermodynamic process = any
event or series of events
which causes a ~~a~~ our chosen

System to move from one equilibrium state to another.

macroscopic

c) A thermodynamic state $\Rightarrow$ well

THINK OF THE MACROSCOPIC STATE AS

THAT ASSOCIATED WITH ANY THE

SET OF THERMODYNAMIC STATE

VARIABLES: $\boxed{h, u, s, g, a, T, P}$

i) $g \equiv$ Helmholtz Free energy/mass
 $\equiv u - Ts$ ~~free~~

ii) $G \equiv$ GIBBS Free energy/mass
 $\equiv h - Ts$

iii) For a non-reacting, single phase system, the complete equilibrium thermo state $\equiv$ {the above set of variables}.
IS DETERMINED / KNOWN IF
ANY 2 OF THESE VARIABLES
ARE KNOWN.

DEFN'S CONNO

LI SPG IS ④

iv) For MULTI-COMPONENT and/or MULTI-PHASE SYSTEMS, use

GIBBS PHASE RULE TO DETERMINE

THE NUMBER OF ~~VAR~~ (NUMBER)

STATE VARIABLES REQ TO

SPECIFY THE SYSTEM'S EQUILIBRIUM STATE;

$$F = C - P + 2$$

C = no. of components (e.g. solid copper
⊕
solid Al.)

P = no. of Phases

(solid, liquid, gas).

F = no. of ~~all~~ state vbls
req. to determine
state.

D) MATH PROPS OF STATE VBLS

~~BY~~ BY CONSTRUCTION (GIBBS), ~~THE~~

ALL STATE VBLS ARE

POINT FUNCTIONS, i.e., THEY'RE

MANY PROPS STATE FNS LI SFG 15
VALUES ONLY DEPEND ON WHICH ③
THEY ARE EVALUATED W/IN A
GIVEN THERMODYNAMIC STATE SPACE.

i) FOR NON-ROTATING, SINGLE-PHASE
SYSTEMS

$$f = f(x, y)$$

where $f = u, h, s, g, a, T, P$ or ρ
and where

x, y = any other two state vars

(MATH STATEMENT THAT ONLY
2 VARS NEEDED TO DETERMINE
THE MACROSCOPIC STATE)

ii) STATE FUNCTIONS / POINT FNS
ARE PATH INDEPENDENT; ~~is~~
PHYSICS - THE CHANGE IN
ANY STATE VAR ONLY DURING A PROCESS
DEPENDS ON THE
BEGINNING AND ENDING

RN. VALUES:

$\Delta f = \Delta$ in ^{state} vbl f during /
associated w/ any
given thermo process

or $\Delta f = f_{\text{ending}} - f_{\text{beginning}}$ (vers. 1)

or $\Delta f = f(x_{\text{end}}, y_{\text{end}}) - f(x_{\text{beg}}, y_{\text{beg}})$ (vers. 2)

iii) POINT / STATE FNS ~~ALL~~ ~~ALL~~ ~~ALL~~
HAVE EXACT DIFFERENTIALS:

$$\Delta f = df = \left. \frac{\partial f}{\partial x} \right|_y dx + \left. \frac{\partial f}{\partial y} \right|_x dy$$

= exact result

$dx = \Delta$ in vbl x during
process

$dy =$ " " " y "
process

iv) POINT / STATE FUNCTIONS ALSO
HAVE FOLLOWING PROPS

a) express df as

$$df = M(x,y)dx + N(x,y)dy$$

$$\left(\text{where } M = \frac{\partial f}{\partial x} \Big|_y, N = \frac{\partial f}{\partial y} \Big|_x \right)$$

then

$$\left[\frac{\partial M}{\partial y} \Big|_x = \frac{\partial N}{\partial x} \Big|_y \right]$$

(10.1)