Lecture 1. 3

Interaction by Contact

INTERACTION BY CONTACT

< THERMAL INTERACTION >

Interaction brought about by contact & prevented when the objects are separated by an evacuated space.

Change brought about → object warms up or cools down as perceived by sensory touch or some other secondary gadgets called thermometers.

'Force' responsible for this change is called : Temperature

INTERACTION BY CONTACT

Temperature is the 'gen. force' but what is the gen-coordinate?

Object1 Warms up $T' < T''$	$dx' > 0$, $dx'' < 0$
Object1 Cools down $T' > T''$	$dx' < 0$, $dx'' > 0$
No change $T' = T''$	$dx' = 0$, $dx'' = 0$

in thermal interaction

≡ thermal equilibrium.

$x' = ?$

Not possible to identify

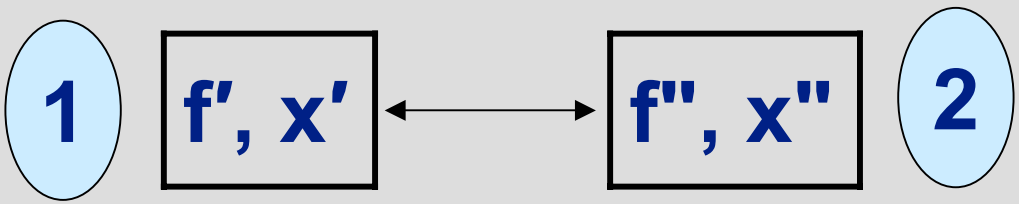
INTERACTION BY CONTACT

Thermal Interaction

Condition of Interaction

$$T'_{final} = T''_{final}$$

Combined Thermal + 'other' Interaction



INTERACTION BY CONTACT

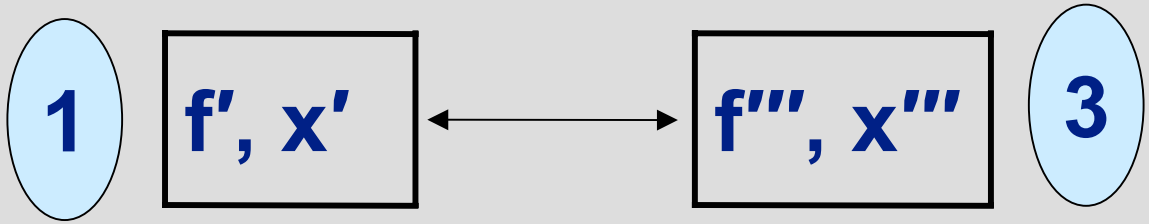
Thermal equilibrium.

$$f_{12}(x', f'; x'', f'') = 0 \text{ ---------- } (\alpha)$$

e.g. if 1 & 2 consist of gases trapped inside cyls., obeying Boyle's law, the above relationship would be

$$P' V' - P'' V'' = 0$$

INTERACTION BY CONTACT



Thermal eqlbm

$$f_{13}(x', f';\ x''', f''') = 0 \text{ ---------- } (\beta)$$

Since thermal eqlbm. is achieved when the temperatures of two objects equalize

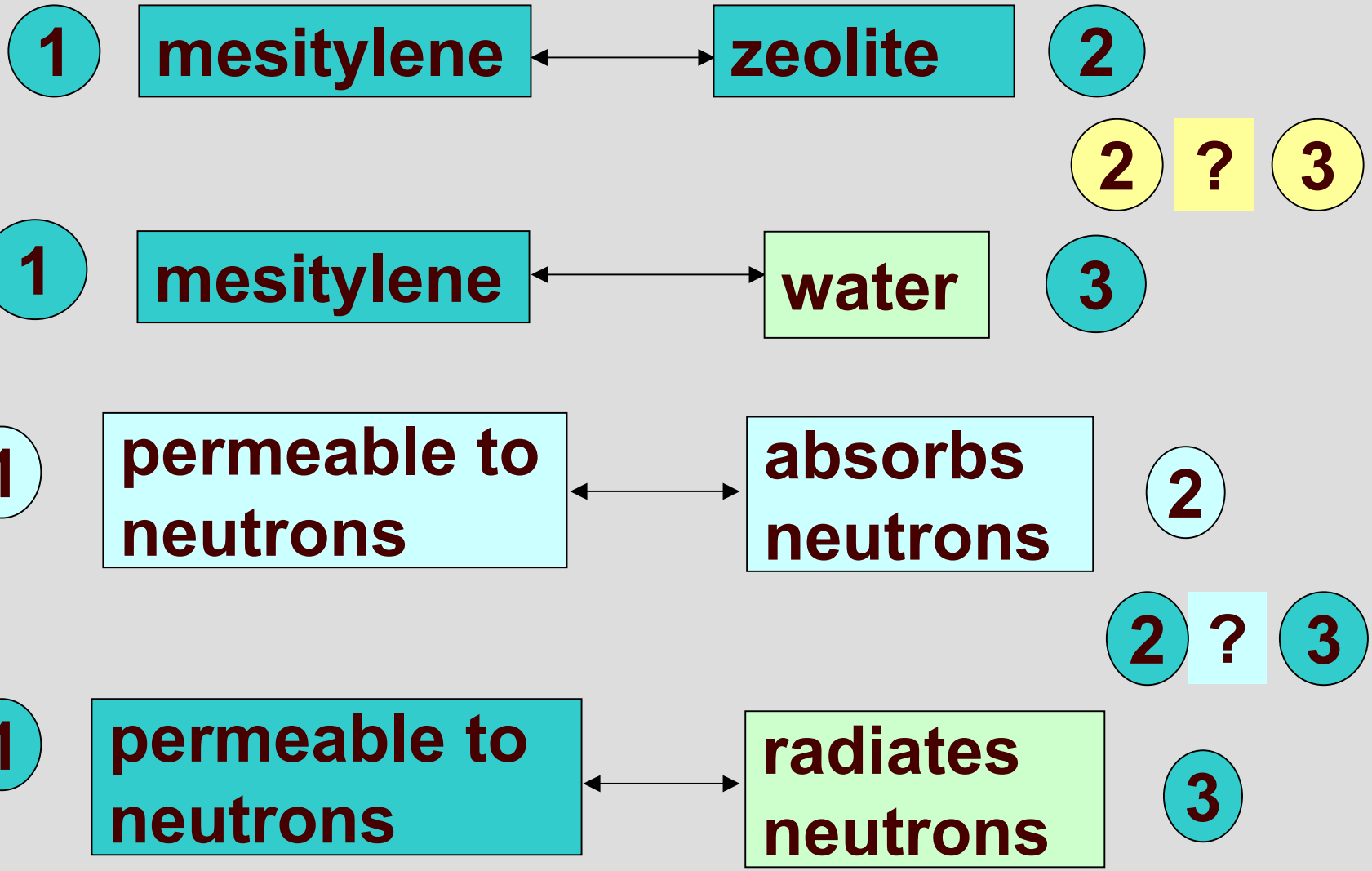
$$T' = T'', \quad T''' = T'$$

$$\Rightarrow T'' = T'''$$

Principle of Transitivity (~ Zeroth law)
Constraints under which it is true need to be noted!

INTERACTION BY CONTACT

Counter examples of zeroth law



INTERACTION BY CONTACT

Zeroth Law :

If an object 1 is separately in thermal eqlbm with objects 2 & 3, then objects 2 & 3 would also be in thermal eqlbm with each other provided the non-thermal modes of interaction possible between 2 & 3 are the same as those between 1 & 2 and 1 & 3.

Mathematically $\rightarrow$ Eqs. α & β =>

$$f_{23}(x'', f''; x''', f''')=0 \quad \text{-----(r)}$$

INTERACTION BY CONTACT

IMPLICATIONS

Solve α, β for f′

$f' = g_{12}(x' ; x'', f'')$

$f' = g_{13}(x' ; x''', f''')$

or $g_{12}(x' ; x'', f'') = g_{13}(x' ; x''', f''')$

From Zeroth Law, above eq. should imply eq (r).

INTERACTION BY CONTACT

Since eq. r contains variables pertaining to objects 2 & 3 only, it follows that extraneous variable x′ in above eq. should cancel out.

Accordingly we re-write it as

$$h_2 (x'', f'') = h_3 (x''', f''')$$

Applying the same arguments to objects 1 & 2 separately in thermal eqlbm with 3, we get for 3 objects in thermal eqlbm.

$h_2(x'', f'') = h_3 (x''', f''') = h_1 (x', f') = T$, the empirical temperature

OTHER CHARACTERISTICS OF OBJECT

Intensive Properties :-those, which are the same as for any of its subsystems i.e. $p=p_i$

&

Extensive Properties :-those, whose values for the systems is equal to the sum of their values for its various subsystems i.e. $p = \Sigma p_i$

OTHER CHARACTERISTICS OF OBJECT

N.B. :- The distinction is <u>not</u> FUNDAMENTAL

e.g. V of batteries; if put in parallel, V=Vi

if put in series; V = Σ Vi

- **It is not correct to say : Extensive prop. are proportional to mass.**

e.g. surface area of Hg. in a beaker.

OTHER CHARACTERISTICS OF OBJECT

PHASE : The total material of a system that has the same intensive prop.

COMPONENTS : Set of independent substances (chemicals) necessary & sufficient to build up the system.

The amount of a component i present in a phase is expressed in terms of number of moles n_i which are generalized coordinates --- how ?

OTHER CHARACTERISTICS OF OBJECT

STATE POSTULATE :

The number of independent thermo-dynamic properties required to uniquely specify the thermodynamic state of a system = 1 + No. of permissible interactions.

SIMPLE SYSTEMS ≡ those with one interaction need 2 independent prop. to define the state.