Breakup: L –T –P –C

3 –1 –0 –4

MASS TRANSFER II

What is mass transfer?

Ability of certain component(s) to move in molecular scale within a phase or from one phase to another under the influence of a concentration gradient, this is known as mass transfer.

Frequently, these mass transfer operations are used for the separation of a product from the by-product formed and also from the unreacted materials. This separation technique plays a vital role in fixing the cost of final product.

Mass transfer may be of two types

— **Diffusional mass transfer**

Diffusional mass transfer occurs in the absence of any macroscopic motion of the medium through which such transfer takes place. As a result, diffusional mass transfer is a very slow process.

Example:

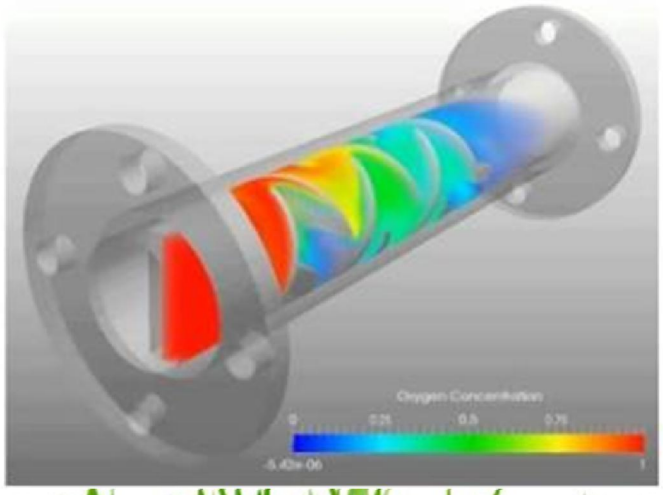
The movement of moisture within a grain during drying

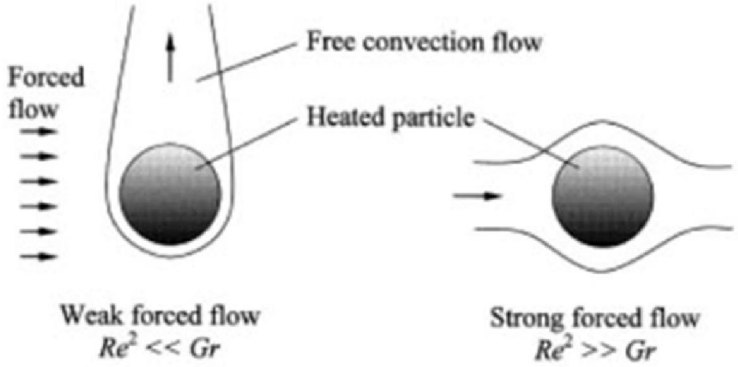
or

The transports of a reactant or a product through the pores of a catalyst pellet

Diffusional mass transfer occurs in quiescent fluids, in fluids moving in laminar motion in a direction perpendicular to the direction of transfer or through microspores of solids.

— **Convective mass transfer**





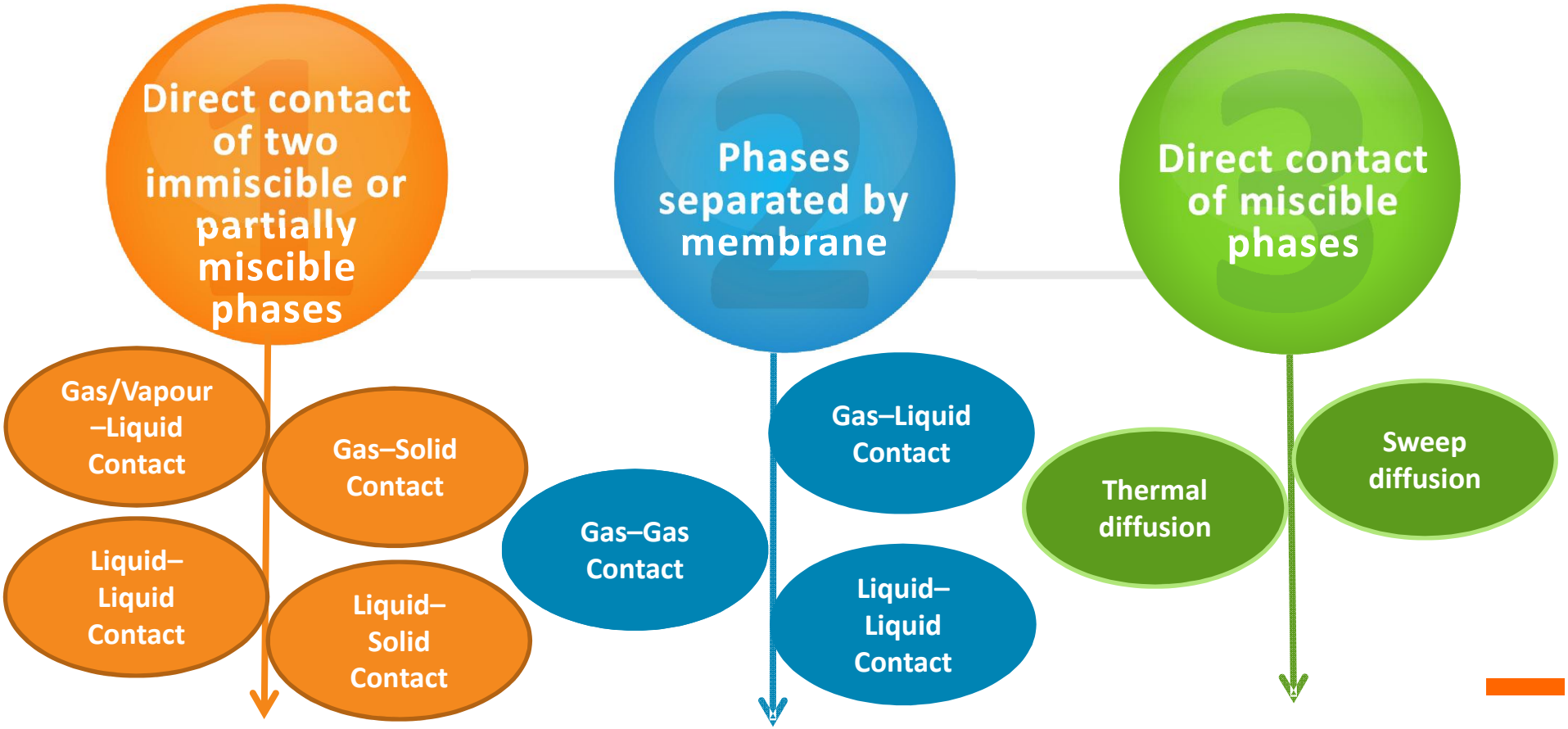
Convective mass transfer occurs through a fluid which is in turbulent motion or subject to stirring so that bulk motion of the medium takes place. As a result, the rate of transfer increases several times.

For increasing the rate of transfer, for reducing the size of equipment and for minimizing the cost, most industrial operations are carried out by convective mass transfer.

However, within a narrow region near the phase boundary, the transfer takes place by diffusional process resulting in a very low rate of transfer and this rate then becomes the controlling rate.

Therefore, in the design of mass transfer equipment all possible measures should be taken to minimize the role of diffusional mass transfer near the phase boundary.

Mass transfer operations are broadly classified into three categories



Processes will be discussed in MTO II

Absorption:

Transfer of a solute from gas mixture to a solvent is known as absorption.

For Example: (i) removal of ammonia gas from by product coke ovens using water. (ii) removal of H2S from naturally occurring hydrocarbon gases by alkali solutions.

Desorption:

This is reverse of absorption, i.e. removal of a solute in a solution using a gas.

For Example: removal of NH3 from NH3-water solution using air.

Drying:

Drying refers to the removal of moisture from a substance.

For Example: (i) removal of water from cloth, wood, or paper (ii) removal of water from solution (manufacture of spray dried milk).

Humidification:

Transfer of a liquid to a gas phase containing one or more components by contacting dry gas with pure liquid is known as humidification.

Dehumidification:

Transfer of a vapor component from a gas-vapor mixture to a liquid phase by contacting them is known as dehumidification.

For example: transferring water vapor from air-water vapor mixture to liquid water.

Adsorption:

Adsorption involves contact of solid with either a liquid or a gaseous mixture in which a specific substance from the mixture concentrates on the solid surface.

For Example: (i) removal of colour from solutions using activated carbon, (ii) removal of moisture from air by silica gel.

Desorption:

It is reverse of adsorption operation.

Mass Transfer II

Molecular diffusion:

Diffusivity
Steady state diffusion in fluid at rest and laminar flow,
Molecular diffusion in gases
Pseudo steady state diffusion
Steady state diffusion in multicomponent mixtures,
Molecular diffusion in liquid,
Diffusion in solids

Mass transfer coefficient:

Mass transfer from a gas into a falling liquid film,
Eddy diffusion,
Prandtl mixing length;
Film theory: Lewis, Penetration and Surface Renewal theory;
Dimensionless numbers
Interphase mass transfer
Combination of resistances
overall coefficient, correction applied to individual coefficient,
Heat, mass and momentum transfer analogies, j_H and j_D factor

Mass Transfer II

Gas Absorption:

Packed towers,
pressure drop and flooding in packed towers,
Design of packed towers,
Height of Transfer Unit, concept of Ht_G, Ht_L , Ht_{OG} and Ht_{OL},
Desorption,
Mass transfer coefficient in packed beds

Drying:

Drying operation, Rate of batch drying,
constant and falling rate, mechanism of batch drying,
tray drying with varying air conditions
continuous dryers,
Introduction to rotary dryers, rotary drum dryers and spray dryers

Humidification and Dehumidification:

Psychrometric chart,
wet bulb and adiabatic saturation temperation,
design of cooling towers and dehumidifiers

Adsorption:

Adsorption in continuous column,
breakthrough curve