

SEPARATION TECHNIQUES SUMMARY

TYPES of SEPARATIONS :

Gas - Solid

Liquid - Solid

Solid - Solid

Gas - Liquid

Liquid - Liquid

Gas - Gas

GAS - SOLID Separations

<u>Concept</u>	<u>Principle</u>
primarily for 'small' particles in a gas stream :	
1. Filtration = Baghouse	Size of Particle to filter pore size.
2. Cyclone	Inertial Impaction mass = size * density
3. Impingement = Baffled	"
Particle Beds	"
4. Gravity Settling Chamber	Density difference
5. Electrostatic Precipitator	Particle Charge
Magnetic Precipitator	Magnetic attraction
6. Wet Scrubbers	Inertial Impingement
Spray towers	Drop Coalescence
Tray or packed towers	Particle wettability
Venturi	Solid Solubility
Bubbler (or pool impingement)	
primarily for 'large' porous solid with gas in pores :	
7. Vacuum	Concentration gradient diffusion
8. Wash displacement	= immiscible liquid displacement
9. Chemical reaction	

GAS - GAS Separations

<u>Concept</u>	<u>Principle</u>
1. Phase alteration	Temperature & pressure
a) Cryogenic distillation	boiling point
b) Desublimation	freezing/sublimation point
2. Absorption	Preferential solubility
3. Adsorption	Surface attraction potentials
Chromatography	Surface attraction or size exclusion
4. Gas permeation	Diffusivity through membranes
5. Diffusion	
a) Gaseous	Knudsen diffusion through porous media
b) Sweep	Diffusion against cross flowing vapor
c) Thermal	Thermal effects on diffusivity
d) Nozzle	Outward transport in jet issuing from a nozzle
6. Cyclone	Density differences
7. Chemical reaction	Conversion of component to a separable component in different phase state
8. Mass Spectrometry	Charges per unit mass
9. Electromagnetic	'mass spectroscopy'
10. Clathration	Molecular shape 'adsorption' lattice CO ₂ into H ₂ O
11. Oscillating Flow	Diffusion momentum

SEPARATION TECHNIQUES SUMMARY

SOLID - SOLID Separations

<u>Concept</u>	<u>Principle</u>
1. Screening	Size difference
2. Sink-Float	Density difference
3. Flotation	Surface Character (wettability)
4. Air separation	Density difference
5. Magnetic	Magnetic vs. non-magnetic attraction
6. Leaching	Solubility
7. Jigging & Tabling	Mass
Panning (for Gold), Sluice Box	Density difference
8. Centrifuge	Mass
9. Electrostatic	Particle Charge
10. Optical = Hand pick	Color, transmittance
Mechanical or hydraulic pick	size, shape
11. Cone	Size & density difference
12. Sublimation	Evaporation
13. Chemical Reaction	
14. Melt	Heat of fusion, melting point
15. Solids Gun	Mass kinetic energy

LIQUID - LIQUID Separations

<u>Concept</u>	<u>Principle</u>
1. Distillation	Boiling point, relative volatility
2. Liquid-liquid extraction	Solubility difference in immiscible phase co-ordination compound chemical complex
3. Decantation	Insolubility and density difference
4. Centrifuge	"
5. Ion exchange	Ion affinity
6. Adsorption on packing	Adsorption of selected species
Activated Carbon	"
7. Molecular sieve	Molecular weight difference
8. Chromatography	Molecular weight or size or adsorption
9. Crystallization	Solubility difference, freezing point
10. Super critical extraction	Difference in critical points
11. Membrane separation/Osmosis	Molecular size difference
12. Dialysis & electro dialysis	Particle charge
13. Chemical Reaction = combustion, precipitation = produce phase change	
14. Biological metabolism	"
15. Gas stripping	Solubility in gas
16. Magnetic	Magnetic vs. non-magnetic attraction
17. Coalescence	Insolubility and surface tension
18. Foam fractionation	Surface tension
19. Thermal Diffusion	Temperature gradient causes concentration gradient
? . Parametric pumping	

SEPARATION TECHNIQUES SUMMARY

GAS - LIQUID Separations

<u>Concept</u>	<u>Principle</u>
1. Adsorption	Chemical reaction & physical attraction Activated aluminas; molecular sieves; Silica gel; activated carbons; spray towers
2. Gravity settling chambers	Density difference
3. Cyclone	Centrifugal force, mass difference
4. Impingement	Direct impact and particle inertial force difference Karbate line, multiple tube banks; Packed beds; wire mesh demisters
5. Electrostatic precipitators	Particle charge
6. Foam separators	Surface tension; thermal, mechanical pressure and acoustic, electrical, chemical
7. Gas permeation / filtration	Diffusivity through membranes
8. Super critical extraction	Solubility enhancement
9. Pressure change	

LIQUID - SOLID Separations

<u>Concept</u>	<u>Principle</u>
1. Filtration Screening	Size of Particle to filter pore size.
2. Hydroclone	Inertial Impaction $\text{mass} = \text{size} * \text{density}$
3. Centrifuge	Density
4. Gravity Settling Basin Clarifiers, Thickeners	Density difference
5. Drying	Evaporation of liquid
6. Expression Screw press	Mechanical squeeze
7. Foam fractionation	Surface tension
8. Electrostatic	Particle Charge
9. Magnetic	
10. Optical = Hand pick Mechanical or hydraulic pick	Color, transmittance size, shape
11. Chemical Reaction Crystalize liquid & use solid-solid	Dissolve solid & use liquid-liquid
12. Melt & use Liquid-liquid	Heat of fusion, melting point
13. Absorb liquid onto a solid;	example = cotton swab or sponge
14. Wash displacement	= gas or immiscible liquid displacement
15. Vibration/ultrasonic vibration	= break solid particles to release trapped liquid
16. Flocculation	= add chemical surfactants, agglomerate fine particles
17. Laser extraction	= lasers move solid particles to interface
? . Nanobots	= micron sized robots programmed to retrieve solid particles.