JRG College of Pharmacy

# JRG COLLEGE OF PHARMACY

# UNIVERSITY SOLVED QUESTION

# WITH ANSWER

**Year** : 2022-2023

**Subject** : Pharmaceutical Engineering

**Subject Code** : BP304T

**Subject In-Charge** : Kiranmayee Bhatra

Registration No : | | | | | | | | | | |

Total Number of Pages : 02

B.Pharm
BP304T

**3rd Semester Regular/Back Examination: 2022-23**
**SUBJECT: PHARMACEUTICAL ENGINEERING**
**BRANCH: B.Pharma**
**Time : 3 Hour**
**Max Marks : 75**
**Q. Code : L700**

**Answer Question No.1 (Part-1) which is compulsory, any seven from Part-II and any two from Part-III.**
**The figures in the right hand margin indicate marks.**

## Part-I

**Q1** **Answer the following questions :** **(2 x 10)**

a) Differentiate between drying and evaporation.
b) Discuss about azeotropic mixtures with example.
c) Define thermal conductivity. Mention its SI unit.
d) Differentiate between laminar and turbulent flow.
e) What is the difference between sedimentation and elutriation?
f) Explain the principle behind centrifugal separation.
g) What is Reynolds number and how is it dimensionless?
h) What are filter aids? Give two examples.
i) What are the different types of glasses used in pharmaceutical industries?
j) What are 'Grey bodies'? How do they radiate heat?

## Part-II

**Q2** **Focused-Short Answer Type Questions- (Answer Any Seven)** **(5 × 7)**

a) Enumerate the differences between orifice and venturimeter.
b) Describe bag filter and what is its use in pharmaceutical industry?
c) Explain various factors influencing evaporation.
d) Explain principle, construction and uses of planetary mixer.
e) Describe construction and working of ball mill.
f) How multiple effect evaporators are more economical?
g) What kind of energy losses a fluid experiences during its flow through a pipe?
h) What are the differences between simple and fractional distillation?
i) What are the drawbacks and remedies of vortex formation?

## Part-III

**Long Answer Type Questions (Answer Any Two)**

**Q3** With the neat sketch, describe principle, construction, working, advantages and disadvantages of rotary drum filter. **(10)**

**Q4** Describe the principle, construction, working, advantages and disadvantages of multi-pass heater. **(10)**

**Q5** Write in detail on principle, construction, working, advantages and disadvantages of freeze dryer. **(10)**

**Q6** What is corrosion? Mention its types. How can it be prevented? **(10)**

# Pharmaceutical Engineering
## 2022-2023

2 marks

1a) Differentiate between drying and evaporation?

| Evaporation | Drying |
|---|---|
| Definition:- The process in which a liquid changes into vapor at the surface below its boiling point. | Definition:- The process of removing moisture (usually water) from a solid material |
| Nature:- A natural physical process. | Nature:- An application of evaporation (or other methods like absorption, heating or centrifugal force) to achieve moisture removal |
| Conditions:- Happens at any temperature (through faster at higher temperatures with airflow, or lower humidity) | Conditions:- Often involves heat airflow or desiccants to speed up moisture removal. |
| Example:- Water in a bowl left outside gradually evaporates into the air | Example:- Clothes drying in the sun involves water evaporating from the fabric and being carried away by air |

b) Discuss about azeotropic mixtures with example?

Ans An azeotropic mixture is a special type of liquid mixture that boils at a constant temperature and retains the same composition in both the liquid and vapour phases.

→ This happens because the vapour has the same proportion of components as the liquid, so it cannot be separated completely into its components by simple fractional distillation.

c) Define thermal conductivity. Mention its SI unit.

Ans Thermal conductivity is a physical property of a material that measures its ability to conduct heat.

→ It is defined as the amount of heat transferred per unit time through a unit area of the material with a temperature gradient of one kelvin per unit distance.

Mathematically, It appears in Fourier's law of heat conduction.

$$q = -K \frac{dT}{dx}$$

where, q = heat flux
K = Thermal conductivity of the material
$\frac{dT}{dx}$ = temperature gradient

→ The S.I unit of Thermal conductivity is watt per meter-kelvin (W/(m-K))

d) Differentiate between Laminar and Turbulent flow?

| Laminar Flow | Turbulent Flow |
|---|---|
| Ans i) Nature of flow | Nature of flow |
| → fluid particles moves in smooth, orderly, parallel layers (streamlines). | → fluid particles move in random, zigzag direction. |
| ii) velocity distribution | ii) velocity distribution |
| → velocity is highest at the center and decreases smoothly toward the boundaries. | → velocity distribution is flatter across the section due to intense mixing. |
| iii) Reynolds number | iii) Reynolds number |
| occurs when Re < 2000. | occurs when Re > 4000 |
| iv) Energy loss | iv) ~~Turbulent~~ Energy loss |
| → less energy loss due to smooth motion. | → Higher energy loss due to friction. |
| v) examples | v) example |
| → flow of blood in fine capillaries. | → water flow in rivers. |

e) What is the Difference between sedimentation and Elutriation?

| Sedimentation | Elutriation |
|---|---|
| Defn:- The process by which solid particles settle out of a liquid due to gravity. | Defn:- A process in which particles are separated by a rising fluid that flows upward through them. |
| Principle:- Heavier particles move downward faster than lighter or smaller particles. | Principle:- Lighter or smaller particles are carried upward by the fluid stream, while heavier or larger ones remain behind. |
| Direction of force:- Gravity (downward). | Direction of force:- upward flow of fluid (opposing gravity) |
| Results:- particles separate into layer heavier particles accumulate at the bottom, while lighter ones remains suspended or rise | Results:- fine particles are washed away and coarser particles are left behind. |
| Examples:- i) settling of sand in water ii) Laboratory centrifugation | Examples - i) separation of fine dust from crushed ore. ii) soil particle size analysis |

f) Explain the principle behind centrifugal separation

Ans centrifugation play a vital role in pharmaceutical process, especially for separation, purification & concentration of substances.

-) It is widely used in drug manufacturing, Biotechnology laboratory research & even waste water Treatment.

principle

-> when a mixture is rotated at high speed, particles in the mixture experience, a force that move them away from the centre of rotation.

-> This centrifugal force is stronger on heavier or denser particles, causing them to move outward & settle at the bottom of the container.

→ Lighter particles remain near the top, forming layer.

Q) What is Reynolds number and how is it dimensionless?

→ Reynold's number is nothing but the summarised form of reynold's experiment.

→ In Reynold's experiment, the flow conditions are mainly observed by following four factors

1) Diameter of the pipe (D)
2) Average velocity of flow (v)
3) Density of liquid (ρ)
4) viscocity of fluid (η)

→ After combining the above 4 factors, we get reynold's number as;

$$Re = \frac{D v \rho}{\eta}$$

Yes All the fundamental units (mass, length, time) cancel out, leaving a pure number meaning it's dimensionless.

→ In other words It can also

→ In other words It can also be defined as ratio of Inertial forces to viscous forces.

$$Re = \frac{\text{Inertial forces}}{\text{viscous forces}}$$

Now, if

Re < 2000 :- Flow will be Laminar
Re > 4000 :- Flow will be Turbulent
2000 < Re < 4000 :- Flow will be transition

b) What are filter aids? Give two examples?

Ans filter aids are Inert, porous & Insoluble material added to the liquid before or during filtration to Improve flow rate and prevent clogging

Ex
1) Kieselguhr (diatomaceous earth)
2) Asbestos fibers
3) perlite
4) Cellulose

1) What are the different types of glasses used in pharmaceutical Industries? 5

Ans Glasses are classified into 5 type

1) TYPE-I → Borosilicate glass → used in All parenteral & sensitive products
2) TYPE-2 → treated sodal lime → used Acidic / neutra parenteral
3) TYPE-3 → sodalime → use oral / non-aqueous preparations
4) TYPE-4 → General sodalime → External use / non parenteral
5) Neutral glass (TYPE-1-equivalent) used in sensitive product

2) What are Grey bodies? How do they radiate heat?

Ans Grey bodies

- Grey bodies emits less radiation than a black body at the same temperature.
- Emissivity: $0 < \varepsilon < 1$.
- The key assumption:- emissivity is constant for all wavelengths (that's why makes it gray):- It's equally efficient across the spectrum).

How Grey bodies radiate heat

- Grey bodies emits radiation according to a modified form of the Stefan-Boltzmann law:

$$E = \varepsilon \sigma T^4$$

where:

$E$ = total radiant energy emitted per unit area
$\varepsilon$ = emissivity of the surface
$\sigma$ = Stefan-Boltzmann constant
$T$ = absolute temperature of the body.

29) Enumerate the difference between orificemeter and venturimeter?

| Ans parameter | orificemeter | Venturimeter |
|---|---|---|
| Basic principle | i) Based on Bernoulli's equation and continuity measures pressure drop across an orific plate | Also based on Bernoulli's equation measures pressure drop between converging and diverging sections |
| construction | ii) Has a thin plate with a sharp edged hole (orifice) fitted in the pipe. | Has a smooth convergent cone, throat and divergent cone section. |
| Flow Area change | iii) Sudden contraction at orifice → causes large energy losses. | Gradual contraction and expansion → minimal energy loss |
| Accuracy | iv) Lower due to turbulence and sharp edges. | Higher due to smooth flow transitions |
| Cost | v) Cheaper and easy to Install. | Expensive & bulky |
| Space requirement | vi) compact - occupies less space. | Requires more length due to convergent divergent sections |
| Applications | vii) used where low cost and compactness are important | used where high accuracy and low energy loss are essential |

4) Describe bag filter and what is its use in pharmaceutical industry. 7

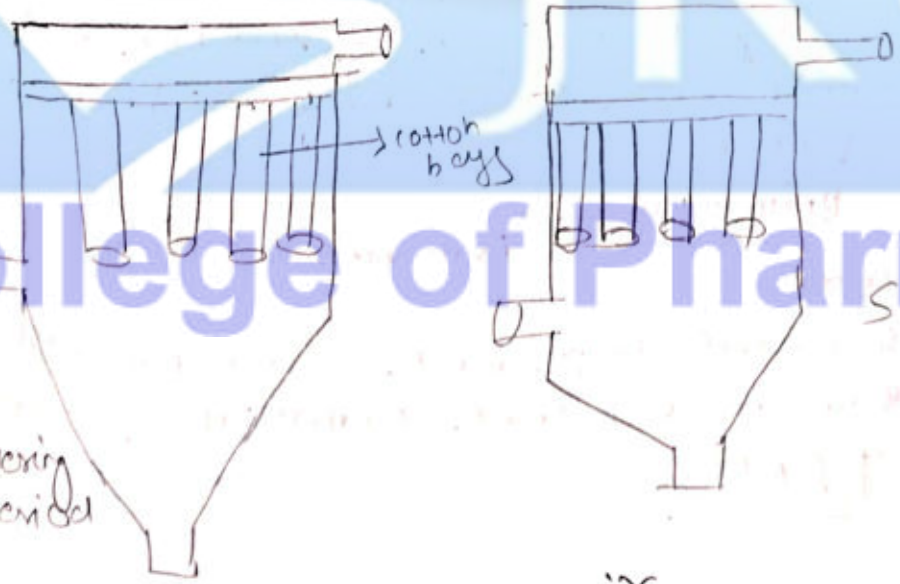
Ans Bag filters are mainly used for remove big dust particles filtration of air.

Principle

- The bag filter works on two steps principle.
- In the first step the gas containing the dust is passed through a bag (cloth) by applying suction because of this separation occurs.
- In the next step bags are shaken by applying pressure so that powders attached with the bags falls & collected from bags.

Construction & working

- It consist of series of bags made of cotton or wool.
- A hopper is arranged at the bottom of the filter to receive feed working consist of two steps.
- First feed is separated from air by passing it through cloth bags.
- In next step the bags are shaken to collect the fine particles that are adhers to the bags.




Uses

- It is used to purify the air.
- It is used along with cyclone separator

Advantages

- It can be used to removing dust.
- It is cost effective.

Disadvantages

-) It requires long time.
-) It is not pure size separation equipment.

C) Explain various factors Influencing evaporation.

Factors affecting evaporation

-) There are those factors which affect the rate of evaporation.
-) Rate of evaporation is the speed of converting liquid into vapour of any material.
-) It is depends on following factors.

1) Boiling point
2) Temperature
3) Surface area
4) Vapour pressure
5) Humidity

1) Boiling point

-) It is the temperature for a particle (liquid) at which liquid starts to boil and converts into vapour.
-) It is different for different liquids
   eg water boil at 100°C.
-) It is inversely proportional as solution with high boiling point evaporate slower and lower boiling rate evaporate faster.

$$\text{Boiling point} \propto \frac{1}{\text{Evaporation}}$$

2) Surface area

-) It is also directly proportionale to evaporation Increased surface area Increase evaporation rate

| S.A ∝ E |

3) Humidity

-) It is inversely proportional to evaporation. As the humidity in atmosphere Increases. the rate of evaporation decreases.

$$H \propto \frac{1}{E}$$

4) vapour pressure

-) It is directly proportional to evaporation. As the vapour pressure Increases, the rate of evaporation Increases. N·p d F

5) wind speed

-) It is directly proportional to evaporation. Increase in wind speed results in Increased evaporation.

W·s d E

Q) Explain principle, construction and use of Planetary mixer?

Ans principle

-) The planetary mixer works on the principle of planetary motion. The mixing head equipped with blades, rotates on its own axis while simultaneously orbiting around the centre of mixing bowl.

construction

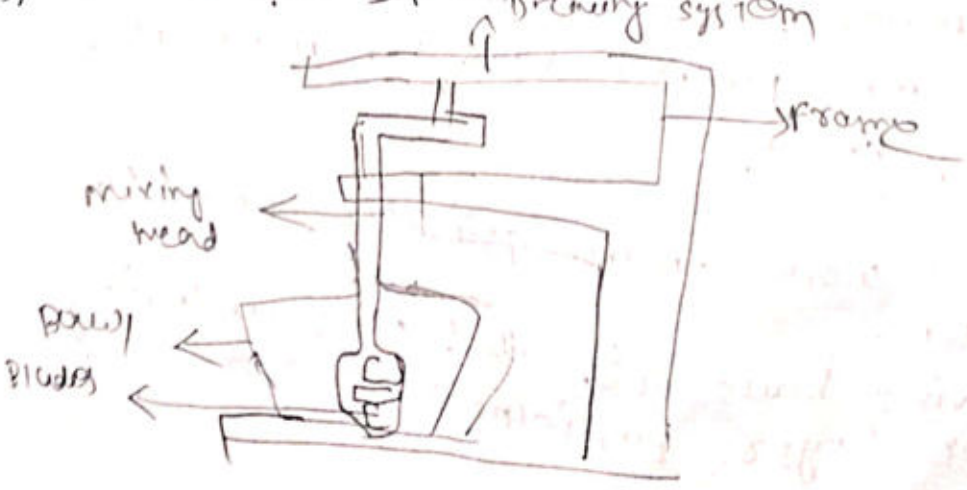
1) mixing bowl :- A stationary, cylindrical bowl that holds material to be mixed, generally made up of stainless steel.

2) mixing head :- A central mixing head that rotates on its own axis.

3) Blades :- various types of blades can be attached to the mixing head.

4) Driving system :- A motor & gearbox to power the mixing heads rotation and orbit.

5) frame :- A frame to support bowl & mixing head



Working

-) The Ingredients are first placed in bowl
-) The mixing head rotates on the own axis while simultaneously orbiting around the centre of the bowl.
-) This creates a powerful mixing action that incorporate all Ingredient thoroughly.
-) once the mixing is complete, the mixed material can be removed from the bowl.

Advantages

-) speed of rotation can be varried as needed
-) more useful for wet granulation.
-) NO dead space (unmixing space)

Disadvantages

-) It require high power
-) It has limited size and is useful for batch work only.

Use:

-) low speeds are used for dry mixing
-) fast speeds in wet granulation.
-) steam jacketed bowl are used in the manufacture of sustained release product / ointment
-) mixing ointments, creams.
-) mixing paints / Adhesives.

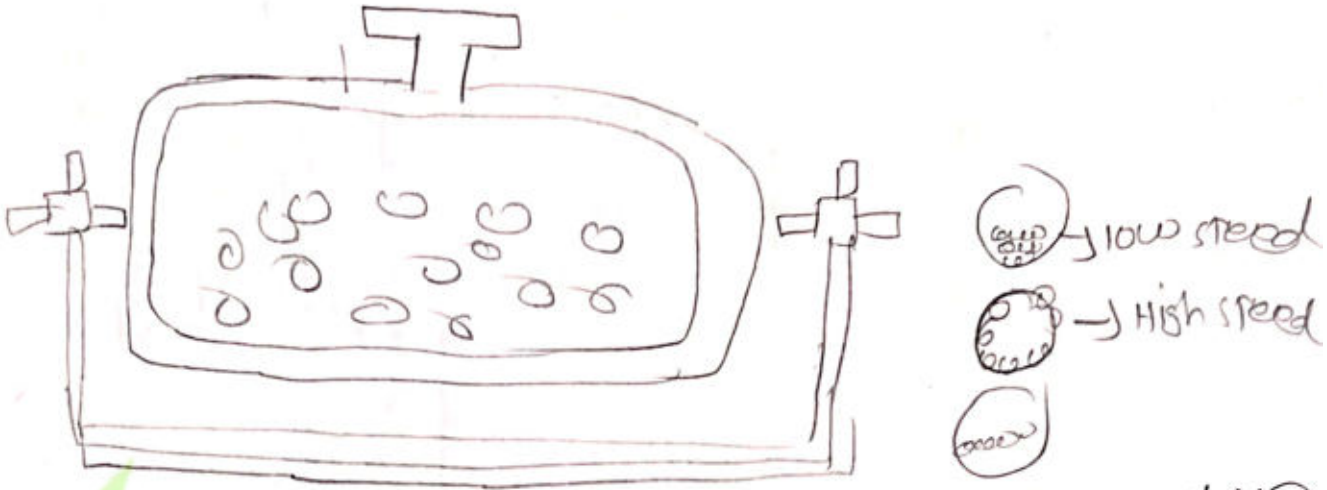
e) Describe construction and working of ball mill

Ans Ball mill one of the type of grinder used to grind or blend materials into super fine powders.
-) These powders are further used in mineral, dressings, paints & ceramics.

principle

-) The ball mill works on the principle of combined impact & Attrition.
-) Rapidly moving balls are used for reducing the size of larger particles.

## Construction & working




- The ball mill consist of a hollow cylinder mounted on a shaft & rotating about it's horizontal axis.
- The cylinder contains balls generally made of metals that occupies 30-50% volume of the cylinder.
- The drug to be ground is placed inside the cylinder along with balls to about 60% volume of the cylinder.
- The mill is allowed to rotate on a correct speed.

**Uses**

- used for production of opthalmic & parental products
- used for both dry & wet grinding.
- used for production of fine powders without dust.

**Advantages**

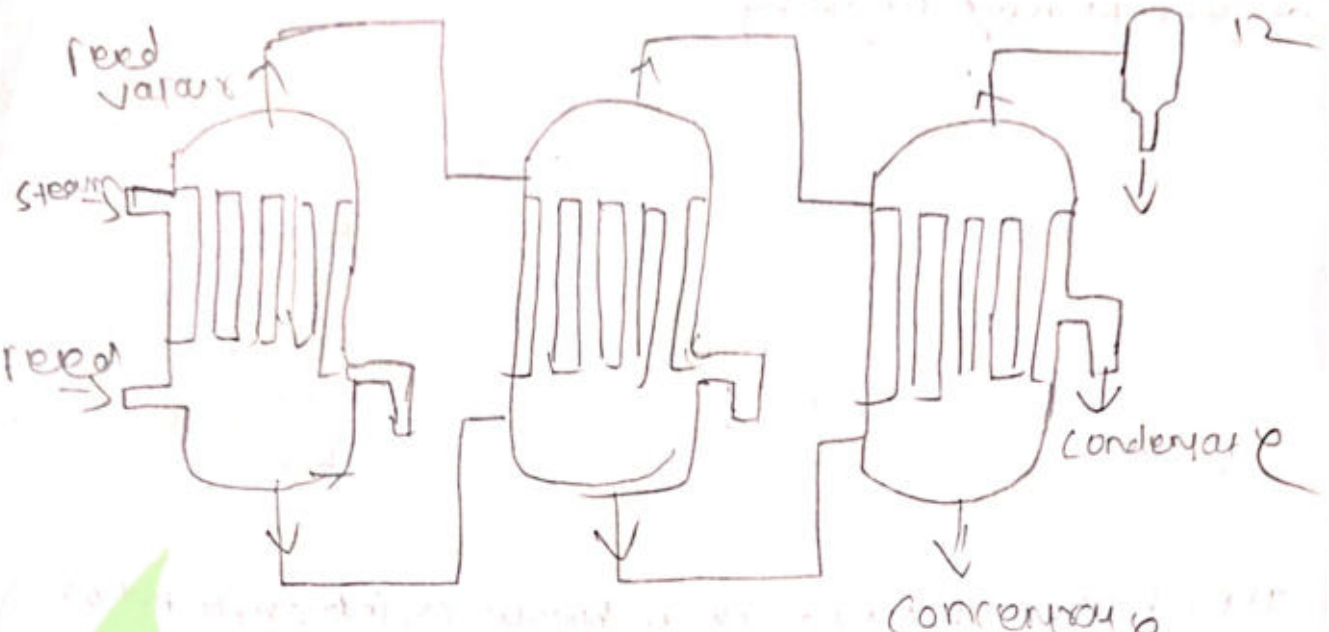
- very fine powders can be obtained.
- suitable for both wet & dry grinding.
- low production & Instalation cost.

**Disadvantages**

- It produce too much noise.
- Ball milling is a slow process.
- It consumes high unit electricity.

**f) How multiple effect evaporators are more economical**

A multiple effect evaporator (MEE) is a system used to increase evaporation efficiency by reusing steam multiple time.




**Principle**

→ It uses the vapours from one effect (stages) as the heating medium for the next, saving energy.

→ each effect operates at a lower pressure & temperature than the previous one.

**Construction**

→ Composed of 2-7 evaporators in series.
→ Steam is supplied to the first effect.
→ Vapour from one effect are used to heat the next.

**Working**

→ In multiple effect evaporator (MEE) steam is used more than once.
→ The vapours produced in the first effect is used to heat the second effect soon.
→ It's next effect works at a lower pressure, temperature, allowing reuse of the steam heat.

**Application**

→ used in sugar, pharmaceuticals & chemical Industry

**Advantages**

→ Reduce steam usage & fuel cost.
→ suitable for large-scale continuous operations

Disadvantages

- High Initial cost & complex control

Economy

- In a multiple effect evaporator, economy is a measure of how much water can be evaporated using a fixed amount of steam.

formula :- $\text{Economy} = \frac{\text{Kg of water evaporated}}{\text{Kg of steam used}}$

Why Is It Important

- It improves energy efficiency, as less steam is needed to evaporate more water.
- Reduce fuel / steam cost as In Industries where evaporation is done at large scale.
- commonly used In sugar Industry, salt production, papers Industries, Pharmaceutical Industries, dairy & food products.

What kind of energy losses a fluid experiences during Its flow through a pipe?

Ans When a fluid flows through a pipe, the fluid experience some resistance due to which part of the energy lost.

- This loss of energy is classified as;
  1) friction losses
  2) Losses in fitting
  3) Enlargement losses
  4) Contraction losses

1) Friction losses

- friction loss refers to resistance caused by fluid flowing through pumps, pipes & fittings
- The Resistance Results in decreased pumping pressure and decreased velocity, friction loss can be calculated by following formula

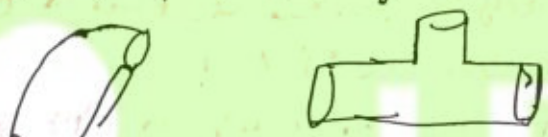
$$\Delta P_f = \frac{f l v^2}{2gD}$$

where, $\Delta P_f$ = loss in pressure due to friction
$f$ = friction factor
$l$ = length of pipe
$v$ = velocity of pipe
$g$ = Acceleration due to gravity
$D$ = Diameter of pipe.

2) Loss in fittings

-) Various types of fittings in a straight pipe, cause disturbance in the flow, which results in loss of energy.

-) Losses in fittings may be due to change in direction or change in type of the fittings such as Elbow fittings, T fittings etc.



-) pressure loss due to fitting's can be calculated by

$$\Delta H_L = \frac{kv^2}{2g}$$

Here, $\Delta HL$ = pressure head loss
$K$ = resistance coefficient due to fitting
$v$ = velocity of fluid
$g$ = Acceleration due to gravity.

3) Enlargment loss

-) if there is a sudden enlargement in pipe cross section, then it results into loss of pressure head across the fitting.

-) for sudden enlargement, loss is given by,

$$\Delta H_e = \frac{(v_1 - v_2)^2}{2g}$$

where $\Delta He$ = loss in pressure, head due to enlargement
$u_1$ = velocity of smaller cross section
$u_2$ = velocity of larger cross section
$g$ = Acceleration due to gravity

iv) Contraction loss

- When cross section of the pipe reduced suddenly energy is lost because flow of fluid get disturbed
- For sudden contraction loss is given by

$$\Delta Hc = \frac{Ku_2^2}{2g}$$

where; $\Delta Hc$ = loss due to contraction
$K$ = constant
$u_2$ = velocity of smaller cross section
$g$ = Acceleration due to gravity

h) What are the difference between simple and fractional distillation?

| feature | simple distillation | fractional distillation |
|---|---|---|
| purpose | used to separate liquids with large difference in boiling points ($\geq 25$-$30^\circ C$) | used to separate liquids with close close boiling point ($< 25^\circ C$ difference |
| Apparatus | uses a simple set up, distillation flask, condenser and receiver | Includes a fractionating column between the distillation flask and condenser. |
| fractionating column | Not used | used - It contains glass beads or plates to increase surface area for repeated condensation and vaporization |
| Efficiency | Less efficient | more efficient |
| Example uses | Separating salt water (to get pure water. | Refining crude oil into, petrol, diesel, kerosene. |
| purity of distillate | produces less pure separation. | produces more pure components |

Q) What are the drawbacks and remedies of Vortex formation?

Drawbacks of vortex formation

1) Increased Drag

Cause :- vortices create regions of low pressure and turbulence behind the object.

effect :- Increase pressure drag or form drag, reducing efficiency.

example :- Aircraft wings or car bodies experience higher fuel consumption due to vortex Induced drag.

2) Noise generation

Cause :- Rapid changes in pressure and turbulent flow due to vortices.

effect :- produces aerodynamic noise, especially in aircraft, fans or vehicles

Example :- whistling sound from wires or wind passing through obstacles.

3) Energy losses

Cause :- Energy from the main flow is dissipated in swirling motions and turbulence.

effect :- Decrease overall efficiency of flow systems like turbines, pumps & ducts.

4) Flow separation and Instability

Cause :- strong vortices can disturb boundary layers.

effect :- causes unstable flow patterns, potential flow detachment or stalling.

example :- in aircraft wings, can lead to sudden loss of lift.

remedies / control methods for vortex formation

1) Flow straighteners and screens

method :- placed in ducts or tunnels to break up swirling flow and realign it.

effect :- Reduces downstream turbulence.

2) Optimized flow conditions

method :- Adjust flow speed, angle of attack or Reynolds number to reduce vortex intensity.

→ used in :- Experimental setups, cooling systems and hydraulic structures.

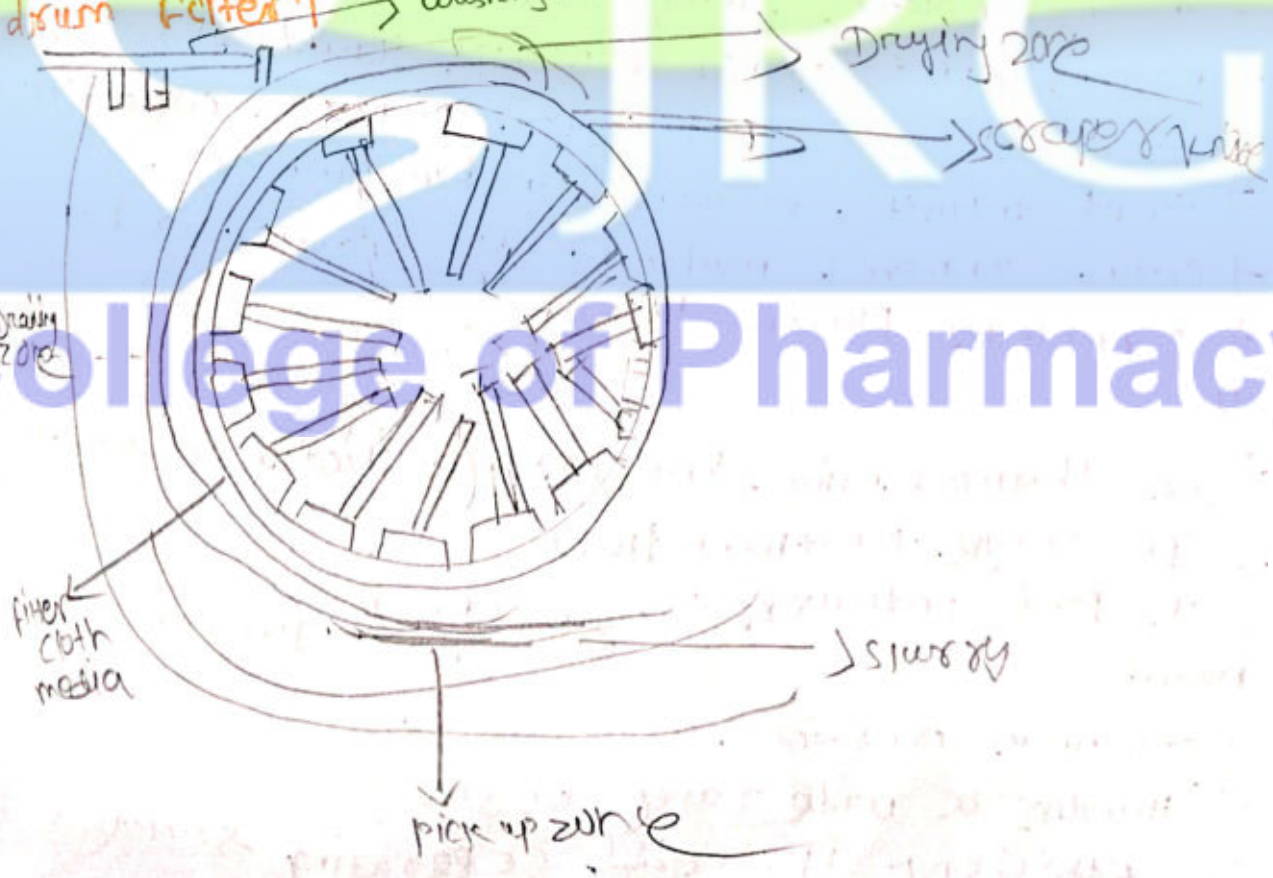
3) passive and Active flow control

passive :- use fixed geometric modifications (fins, grooves)

Active :- use plasma jets or feedback system to dynamically control vortex formation.

10-marks

1) write the neat sketch, describe principle, construction working, advantages & disadvantages of rotary drum filters



## Principle

→ The rotary drum filter operates on the principle of gravity filtration.
→ It uses a rotating drum, covered with a filter cloth/media, partially submerged in a slurry to separate solids from liquids.
→ As the drum rotates the slurry is fed on to the surface of the filter cloth.
→ The liquid passes through the cloth, leaving the solid trapped on the cloth surface forming a cake.

## Construction

1) drum
→ Typically made of stainless steel or synthetic material the drum is cylindrical in shape.

2) filter cloth
→ covers the drum allows liquid to pass through. while retaining solids.

## working

→ Drum rotates slowly in slurry.
→ vacuum applied → liquid passes Inside through filter cloth filtrate collected.
→ solid deposite as cake on drum surface.
→ cake removed machinary by scraper or belt.
→ continuous process repeats.

## Use

→ In Pharmaceutical Industries (antibiotics, fermentation products)
→ In sewage treatment Plant.
→ In food Industries (sugar, starch, juices)

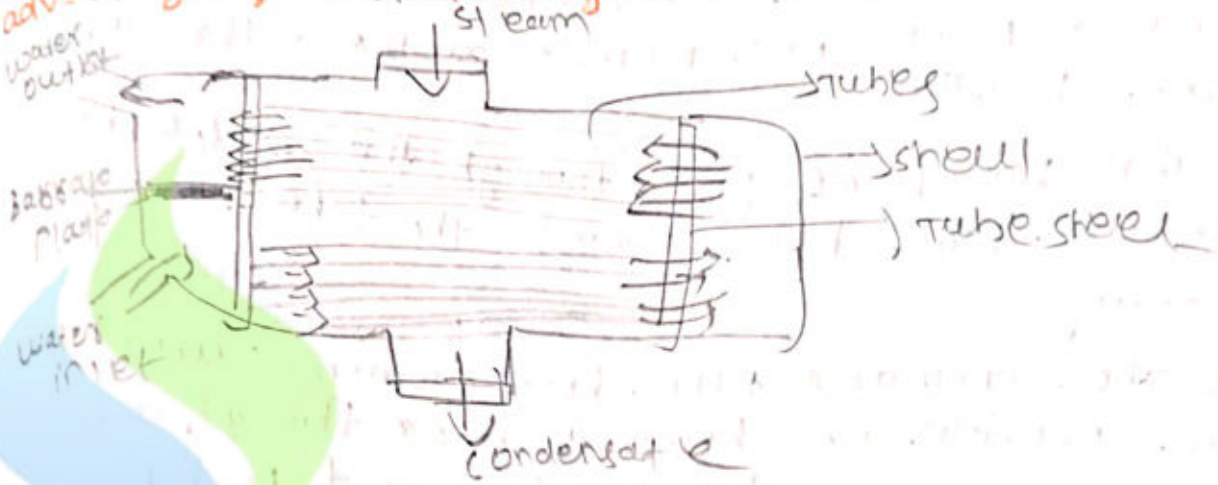
## merits

→ continuous operation.
→ Handles a wide range of slurry.
→ efficient in separating solid from liquid.

demerits

-) High cost & bulk design.
-) Not suitable for dilute suspension
-) Filter cloth requires frequent cleaning.
-) Not ideal for highly compressible solids

4) Describe the Principle, construction, working, advantages & disadvantages of multi-pass heater)




Definition:

-) A multipass heater is a type of heat exchanger where the fluid flows through the tube bundle multiple times before leaving the exchanger.

Eg: Shell and tube exchanger

-) It is also known as 2-4 shell and tube exchanger
-) It is one type of heat exchanger that consist of a series of tubes and shell which contain fluids that must either heated or cooled.
-) It is widely used in various Industrial applications due to its efficiency, reliability.

Construction

1) Shell

-) Cylindrical / rectangular shaped which contain hot liquid and have two openings i.e one for inlet and one for outlet.

2) Tube

-) These contain cold liquid, which have to be heated and these tubes are supported by tube sheet.

3) Baffles

-) It create turbulent in flow of fluid which helps to increase the heat transferred and also helps to holds tubes in position.

Principle

-) It is based on the principle that heat transfer from one fluid to another through a tube bundel.

-) The hot fluid flow through the shell, while the cold fluid flows through the tube.

Working

-) The shell and tube heat exchanger works on the principle of heat transfer through a solid way - from a hot fluid to cold fluid, without mixing them.

-) one fluid enters the tube side through an inlet and exist through an outlet.

-) The other fluid enters the shell side and flow around the tubes.

-) Heat ~~transfer~~ flows from the hot fluid to the cold fluid through the tube walls.

-) Then Baffles causes turbulence in the shell-side flow, improving heat transfer by forcing fluid to cross the tubes repeatedly.

-) Finally the hot fluid become cooler.

-) The cold fluid becomes warmer.

Merits

-) compact design / easily maintainance.

-) high heat transfer rates

-) suitable for high pressure applications.

De-merits

- Higher cost.
- difficult tube cleaning
- potential for corrosion.

Applications

- Helps in heat transfer between fluids.
- helps to control temperature during mixing & blending
- used to sterilize equipment & materials
- used to heat or cold liquids during formulation

Others

- Crude oil refining.
- Engine cooling system etc.

5] Write In detail on principle, construction, working, Advantages & disadvantages of freez dryer?

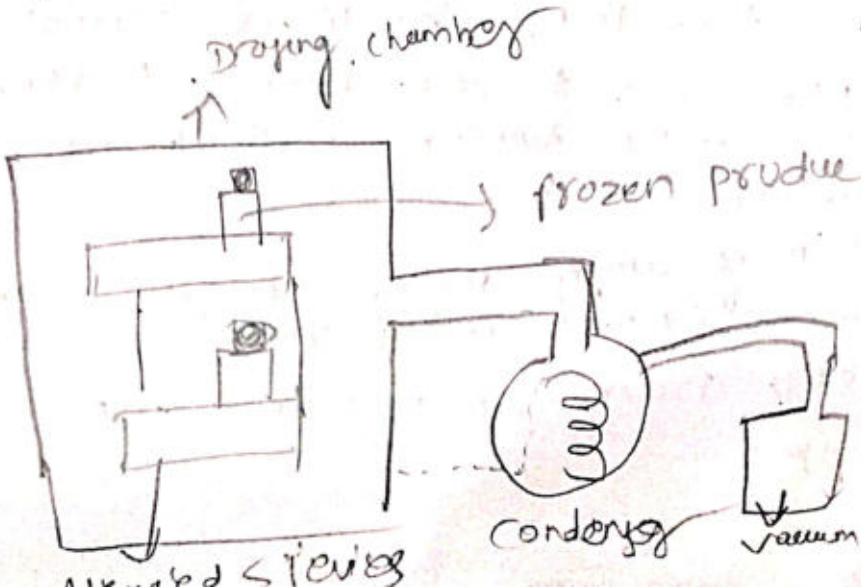
Ans Introduction

- A freeze dryer also known as a lyophilizer is a type of dryer that removes the water content from a material by freezing the water & then reducing the surrounding pressure to allow the frozen water to sublimate without going through liquid phase.

principle

- In freez dryer, water is removed from the frozen state by sublimate i.e direct change of water from solid into vapour without conversion to a liquid phase.

Construction.



Working

- It involves 5 stages.

1) preparation and pretreatment
2) prefreezing to solidify water
3) primary drying (sublimation step)
4) secondary drying (Removal of Residual moisture)
5) packing.

1) preparation & pretreatment

→ It is essential process, which reduces the actual drying by 8 – 10 times.

→ The solution is preconcentrated under normal trays drying, the final product becomes more porous

2) prefreezing to solidify water

→ In which the solution is packed are frozen in cold sievies. During this stage cabinet is maintained at low temperature and atmospheric pressure.

3) primary drying (sublimation step)

→ In this step the material to be dried is spread as much large surface as possible for sublimation

→ The temperature and pressure should be below the triple point of water i.e 0.0098°C & 0.533 kilopascal for the sublimation.

→ Vacuum is applied about 3mmHg on the frozen sample. The temperature is linearly Increased to about 30°C in a 2hrs.

→ All the things has to be controlled in such a manner so as to get highest possible water vapour at ice surface, without melting the material.

→ primary drying stages removes easily moisture (98 to 99% water is removed)

→ Still traces of moisture is present in the sample.

4) Secondary drying
- During this stage, traces of moisture is removed
- In this stage the rate of drying is very low
- It takes about 10-20 hours.

5) Packing
- After vacuum is replaced by inert gas, the bottles & vials are closed.

Uses
- It is most commonly used in the production of dosage forms, such as injection, solution & suspension
- It is used in Biotechnology Industry to freeze dried biological material such as tissues & cells
- It is also used in Aerospace Industry to freeze dried the foods for space mission.

Advantages
- Thermolabile material can be dried.
- Sterility can be maintained.
- easy to transport.
- stored for long periods without refrigeration
- helps preserve the nutrient & flavour of the material

Disadvantages
- Expensive to purchase & maintain,
- The period of drying is high.

6) What is corrosion? mention it's types, how can it be prevented?

Corrosion
- Corrosion is defined as the gradual deterioration of metals or alloys by chemical or electrochemical reaction with their environment.
- It leads to loss of mechanical strength, surface properties & economical value of material.
- common examples include rusting of Iron in moist air.
- Formation of green patina (layer) on copper

Types of corrosion

1) General corrosion
2) Localised corrosion
3) Structural corrosion
4) Biological corrosion

1) General corrosion (uniform corrosion)

- It is the most common form of corrosion.
- metal surface is uniformly attacks due to reaction with the environment.
- the thickness of the metal reduce evenly
- It is easy to detect, major & prevent compare to other types.
- usually controlled by coating or corrosion inhibitors.
  eg Rusting of Iron roofs & bridges expose to rain.

2) Localised Corrosion

- unlike general corrosion, Here the attack is limited to small areas.
- Dangerous because It may not be visible from the outside, but It weakens the metal leads to sudden failure.
- eg corrosion under washers & joints in ships.

3) Structural corrosion (mechanical + corrosion)

- caused by combine effect of mechanical force and corrosion.
- metal under stress, vibration or high velocity fluid are more prone
- weakens the structural Intergity of machines & pipe lines.
  eg Damage of Turbine blades in hydroelectric plants.

## Biological corrosion

- caused by the action of micro organism like bacteria, fungi etc.
- These organisms produce corrosive substances such as acids, hydrogen sulphide etc.
- common in pipe lines, water tanks & sewage system
- It is often difficult to detect in the early stage.

eg growth of Algae in putting trays used in production of steel.

## methods of preventing corrosion

### 1) painting & coating

- painting forms a protective film on metal surface & prevent direct contact with air, moisture and other corrosive gases.
- coating include enamel, plastic, galvanization (zinc coating) & Anodization (Aluminium oxide).

### 2) Alloying

- corrosion resistance is increased by forming alloys with suitable metals.

eg stainless steel (Iron + Chromium + nickel)

### 3) Cationic protection

- The metal to be protected is made a cathode of an electrochemical cell.
- used for pipelines, ships & other underground structures.

### 4) Design of equipment

- proper design reduce corrosion risk.
- Avoid sharp corner where moisture can collect
- Ensure smooth surface for easy cleaning.
- provide adequate drainage & ventilation.

### 5) Use of corrosion Inhibitors.

- chemicals added in small quantities to the environment reduce corrosion.
- different types of Inhibitors are chromate, phosphate, arsenic compounds etc to reduce hydrogen evolution. Also used in closed system like boilers