TECHNOCRATS

Lab Work Book of

Pharmaceutical Engineering

(BP- 308 P)

Department of Pharmacy

Lab Manual of

Pharmaceutical Engineering

(BP- 308P)

Price : ₹ ...../-

Edition :

Disclaimer
Every possible effort has been made to bring out this book accurately to fullfill aspirations of all readers. The publisher and their associates do not make any warranty with respect to accuracy, completeness of the book and hence can not be held liable in any way for the loss or damage whatsoever.

Printed & Published by :

TECHNOCRATS
PUBLICATIONS

Arera Colony, Bhopal.
e-mail : technocratspublications@gmail.com

TECHNOCRATS
PUBLICATIONS

Lab Work Book
of

PHARMACEUTICAL ENGINEERING

(BP-308P)

Name : .....

Enrollment No. : .....

Institute : .....

Academic Session : .....

Department of Pharmacy

TECHNOCRATS
PUBLICATIONS

Vision of the Institute

To grow as an institute of Excellence for Pharmacy Education and Research and to serve the humanity by sowing the seeds of intellectual, cultural, ethical, and humane sensitivities in the students to develop a scientific temper, and to promote professional and technological expertise.

Mission of the Institute

M 1: To inculcate ethical, moral, cultural and professional values in students

M 2: To provide state of art infrastructure facilities to the staff and students so as to enable them to learn latest technological advancements

M 3: State of art learning of professionalism by the faculty and students

M 4: To produce well learned, devoted and proficient pharmacists

M 5: To make the students competent to meet the professional challenges of future

M 6: To develop entrepreneurship qualities and abilities in the students

PROGRAM OUTCOMES (POs)

1. **Pharmacy Knowledge:** Possess knowledge and comprehension of the core and basic knowledge associated with the profession of pharmacy, including biomedical sciences; pharmaceutical sciences; behavioral, social, and administrative pharmacy sciences; and manufacturing practices.
2. **Planning Abilities:** Demonstrate effective planning abilities including time management, resource management, delegation skills and organizational skills. Develop and implement plans and organize work to meet deadlines.
3. **Problem analysis:** Utilize the principles of scientific enquiry, thinking analytically, clearly and critically, while solving problems and making decisions during daily practice. Find, analyze, evaluate and apply information systematically and shall make defensible decisions.
4. **Modern tool usage:** Learn, select, and apply appropriate methods and procedures, resources, and modern pharmacy-related computing tools with an understanding of thelimitations.
5. **Leadership skills:** Understand and consider the human reaction to change, motivationissues, leadership and team-building when planning changes required for fulfillment of practice, professional and societal responsibilities. Assume participatory roles as responsible citizens or leadership roles when appropriate to facilitate improvement in health and well- being.
6. **Professional Identity:** Understand, analyze and communicate the value of their professional roles in society (e.g. health care professionals, promoters of health, educators, managers, employers, employees).
7. **Pharmaceutical Ethics:** Honour personal values and apply ethical principles in professional and social contexts. Demonstrate behavior that recognizes cultural and personal variability in values, communication and lifestyles. Use ethical frameworks; apply ethical principles while making decisions and take responsibility for the outcomes associated with the decisions.
8. **Communication:** Communicate effectively with the pharmacy community and with society at large, such as, being able to comprehend and write effective reports, make effective presentations and documentation, and give and receive clear instructions.
9. **The Pharmacist and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety and legal issues and the consequent responsibilities relevant to the professional pharmacy practice.
10. **Environment and sustainability:** Understand the impact of the professional pharmacy solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
11. **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change. Self-assess and use feedback effectively from others to identify learning needs and to satisfy these needs on an ongoing basis.

PEOs

PEO 1: To inculcate quality pharmacy education and training through innovative Teaching Learning Process.

PEO 2: To promote professionalism, team spirit, social and ethical commitment with effective interpersonal communication skills to boost leadership role assisting improvement in healthcare sector.

PEO 3: To enhance Industry-Institute-Interaction for industry oriented education and research, which will overcome healthcare problems of the society.

PEO 4: To adapt and implement best practices in the profession by enrichment of knowledge and skills in research and critical thinking

PEO 5: To generate potential knowledge pools with interpersonal and collaborative skills to identify, assess and formulate problems and execute the solution in closely related pharmaceutical industries and to nurture striving desire in students for higher education and career growth.

Course Outcomes (COs):

Student will be able to:

- CO1: Explain Size Analysis by Sieving, Size Reduction Using Ball Mill, Mixing, Distillation.
- CO2: Determine Construction Working and Application Of Pharmaceutical Machinery.
- CO3: Calculate The Efficiency of Steam Distillation And Uniformity Index For Given Sample.
- CO4: Evaluate Materials Used for Mixing, Drying, Filtration, Centrifugation.
- CO5: Demonstration Of Colloid Mill, Planetary Mixer, Fluidized Bed Dryer, Freeze Dryer And Such Other Major Equipment.

Index

Experiment No. -1

OBJECT:

To determine the overall heat transfer coefficient.

REFERENCE:

C. V. S. Subrahmanyam, J. T. Setty, V. Kusumdevi and S. Suresh. Laboratory manual of pharmaceutical engineering, published by Vallabh publication, Delhi, first edition 2006, page 15-21.

REQUIREMENT:

Steam generator, thermometer, water condenser insulated and non insulated, bent tube, burner, cork, match box etc.

THEORY:

The overall heat transfer coefficient is influenced by the thickness and thermal conductivity of the mediums through which heat is transferred. The larger the coefficient, the easier heat is transferred from its source to the product being heated. In a heat exchanger, the relationship between the overall heat transfer coefficient (U) and the heat transfer rate (Q) can be demonstrated by the following equation:

$$Q = UA\Delta T_{LM}$$

where

Q = heat transfer rate, W=J/s [btu/hr]

A = heat transfer surface area, m^2 [ft^2]

U = overall heat transfer coefficient, W/(m^2°C) [Btu/(hr-ft^2°F)]

ΔT_{LM} = logarithmic mean temperature difference, °C [°F]

From this equation we can see that the U value is directly proportional to Q, the heat transfer rate. Assuming the heat transfer surface and temperature difference remain unchanged, the greater the U value, the greater the heat transfer rate. In other words, this means that for a same kettle and product, a higher U value could lead to shorter batch times.

Several equations can be used to determine the U value, one of which is:

$$\frac{1}{U} = \frac{1}{h_1} + \frac{L}{\lambda} + \frac{1}{h_2}$$

where

h = convective heat transfer coefficient, W/(m^2°C) [Btu/(hr-ft^2°F)]

L = thickness of the wall, m [ft]

λ = thermal conductivity, W/(m°C) [Btu/(hr-ft°F)]

The overall heat transfer coefficient, or U-value, refers to how well heat is conducted over a series of mediums. Its units are the W/(m²°C) [Btu/(hr-ft²°F)].

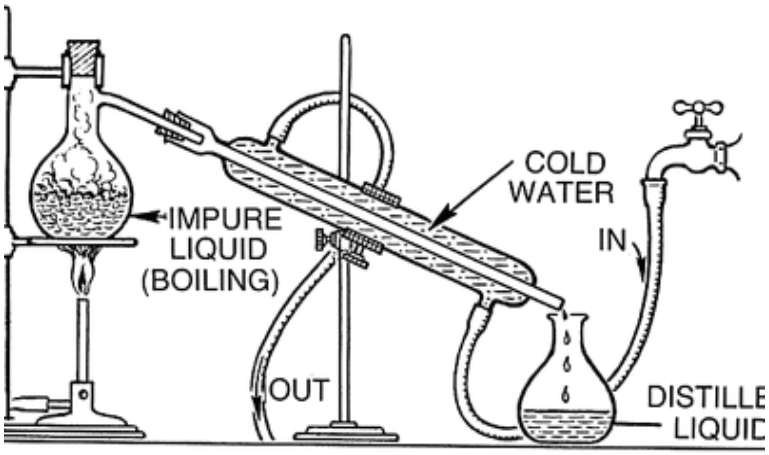


Figure: Distillation assembly

PROCEDURE

The assembly of apparatus is shown in the above figure.

1. The length and diameter of the plain water condenser is determined and reported in the observations. Based on these values, surface area of the condenser is estimated.
2. Using the plain water condenser, the distillation apparatus is assembled as shown in the figure
3. The inlet of water condenser is connected to the tap. The outlet of the condenser is placed in the beaker [2 liter beaker].
4. The temperature of water at the inlet of condenser is noted. This will be same as the temperature of the tap water. The temperature is reported in Table.
5. The steam generator is heated so that steam will be generated. After some time, the thermometer shows constant temperature. The temperature is noted [Table] and experiment is started from the point. The steam passes through the water condensed gets condensed in the condenser due to circulation of water in the jacket.
6. The condensate gets collected into the beaker [two liter].
7. Allow the experiment for 2 minutes [after attaining constant temperature of steam].
8. The quantity of condensate water is collected and its temperature is noted.
9. The quantity of circulated water is collected at the outlet of condenser and its temperature is noted [Table].

10. The entire experiment is repeated by replacing the plain water condenser with insulated water condenser and its temperature is noted [Table].

Observation and Calculation

Observation with plain water condenser

Diameter of the condenser, d = cm= m

Radius of the condenser, r = cm= m

Length of the condenser, l= cm = m

Area of the condenser, a = $2\pi rl$

Latent heat of vaporization of water, l =226.1 J\kg.

Specific heat of steam, s = 4190 J\kg .K

The following calculation are been made.

Heat loss by steam, $Q_1 = M_1.L+M_1.s.\ \Delta t_1$

Heat gain by tap water, $Q_2= M_{2s.}\Delta t_2$

M_1= Mass of condensed steam Kg

M_2= Mass of circulating water Kg

S= specific heat of steam J/kg.K

L= latent heat of vaporization of water, J/kg

t_1= temperature drop on steam K

t_2= temperature rise on the circulating side of water K

$$\text{Heat transferred, } Q = \frac{Q1+Q2}{2}$$

$$U=\frac{Q}{A*\Delta tav}$$

Where Q = amount of heat transferred, W (J/s)

A= Surface area of the glass tube, m^2

Δtav= Temperature gradient, K

U = Overall heat transfer coefficient, $w/m^2.K$

Similar observations can be obtained by conducting the experiment using insulated water jacket condenser

TABLE: PARAMETER FOR COUNTERCURRENT FLOW

	Water condenser circulating water		**On steam side of condenser**	
	Tape water	**Water outlet**	**Steam**	**condensate**
Temperature ^{o}C				
Temperature K				
Difference in temperature	Δt_1		Δt_2	
Average temperature Δtav				
Volume of water in two minutes	**-**	**M_2**	**-**	**M_1**
Mass of water in 2 minutes kg				
Mass of water per second kg/s				

REPORT:

Overall heat transfer coefficient of plain glass tube (water condenser)=

Overall heat transfer coefficient of insulated glass tube =

RESULT:

Ans- .....

.....

.....

.....

The overall heat transfer coefficient of the insulated glass tube is higher /lower than the plain glass tube=

VIVA QUESTIONS

Q.1. What is overall heat transfer coefficient?

Ans- .....

.....

.....

.....

Q.2. What is significance of overall heat transfer coefficient?

Ans- .....

.....

.....

.....

Q.3. What is the application of overall heat transfer coefficient in pharmacy?

Ans- .....

.....

.....

.....

Q.4. What are the precautions to remember during this experiment?

Ans- .....

.....

.....

.....

Q.5. What are the factor associated with heat transfer coefficient?

Ans- .....

.....

.....

.....

Experiment No. 2

OBJECT:

To determine the radiation constant of the given metal cylinder.

REFERENCE:

C. V. S. Subrahmanyam, J. T. Setty, V. Kusumdevi and S. Suresh. Laboratory manual of pharmaceutical engineering, published by Vallabh publication, Delhi, first edition 2006, page 1-8.

REQUIREMENT:

Metal cylinder, thermometer, glass, tripod stand, thread, burner, cork, match box etc.

THEORY:

A freely suspended hot body looses heat by conduction, convection, and radiation, until it reaches the room temperature. This is an equilibrium condition. In this system, the heat loss through convection is neglected, since movement of particles in negligible. As the metal cylinder freely suspended without any contact with metal [of high thermal conductivity] the loss through conduction is considered minimum. For this reason, the metal cylinder is placed on a glass tripod stand figure. Thus the heat loss by radiation is highlighted.

If tow adjacent surfaces are at different temperatures, the hotter body radiates more than it receives and its temperature falls. The cooler surface receives more energy than it emits and its temperature rises. Ultimately thermal equilibrium is reached. Stefan Boltzmann law gives the total amount of radiation emitted by a body.

$$q = bAT^4$$

Where q= energy radiated per second, W [or J\s]

A = area of radiation surface, m^2

T = absolute temperature of radiating surface, K

B= constant, $W\backslash m^2.K$

According to table 1 the rate of heating depends upon the temperature and surface area of the emitter. At the same time, it also depends upon absorption capacity of the material to be heated this characteristic is evaluated.

The difference in the temperature of the hot body and the ambient is the temperature gradient for the heat loss by radiation. The radiation constant [α] is calculated using the following equation.

$$Ms\frac{dq}{dt} = \alpha A\left(\left[\frac{T_1}{100}\right]^4 - \left[\frac{T_2}{100}\right]^4\right) + \beta A(T_1 - T_2)^{1.23}$$

Where m = mass of the metal cylinder, w g

S = specific heat of metal, J\Kg. K

[dq/dt] = rate of the loss by the metal cylinder, W/s

T_1= temperature of the metal body, K

T_2= temperature of the ambient [room temperature], K

α = convection factor

A= surface area of the heat transferred, m^2

The parameters mentioned in an equation 2 are evaluated by different methods and substituted for calculating α.

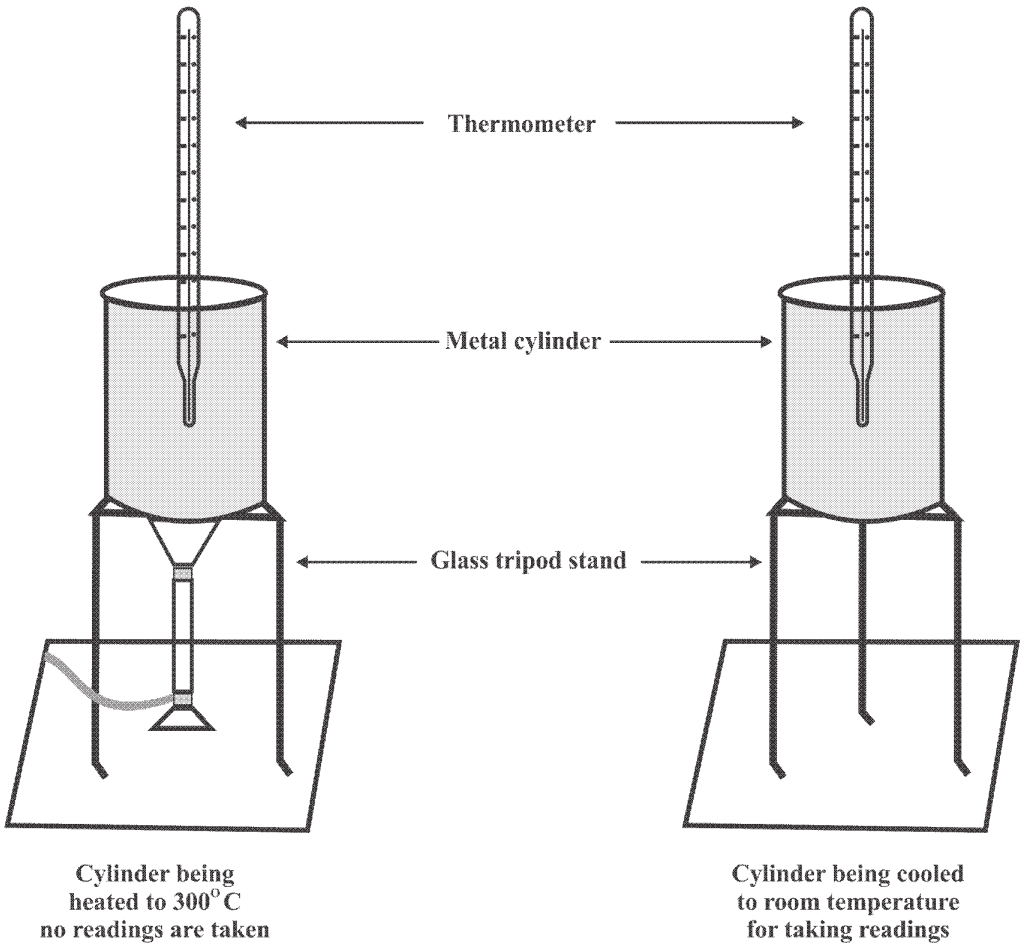


Figure 1. Arrangement of apparatus for the determination of radiation constant of metal.

PROCEDURE:

Arrangement of apparatus for the determination of radiation constant of metal cylinder is shown in figure 1.

A metal iron cylinder is cleaned and weighed [w g] thrice. The average is noted in the table 1-1.

The diameter and height of the cylinder are measured thrice. The average values are calculated. The surface area of the cylinder is calculated and recorded in table 1-1.

The metal cylinder is heated using a Bunsen burner.

After reaching a constant maximum temperature the hot body [metal cylinder] is transferred to the glass tripod stand using long tongs.

the thermometer [360^0 C] is placed in central hole of the cylinder and fixed to a stand using a thread [figure 1].

Slowly the temperature of the hot body decreases. The decrease in temperature is noted every 5 minute interval. The data are recorded in the table 1-1.

A graph is plotted taking time [mins] on x-axis and temperature [^{0}C] on y-axis. Normally, a curve is observed.

Depending on the temperature at which the radiation constant is to be determined, a tangent is drawn at that temperature. The slope of the tangent is calculated, which represents the rate of fall of temperature. This parameter is related to the rate of loss of heat[dq/dt] by the hot body.

Radiation constant α is determined at that temperature [figure given in example].

OBSERVATION AND CALCULATION:

At room temperature: wet bulb temperature = …….^{o}C……K

Dry bulb temperature = …….^{o}C……K

Table 1

Parameters of the metal cylinder

S. No.	Parameter of the metal cylinder	Trial			Average in cgs system	Average in SI system
		1	2	3		
1	Weight, w g					
2	Diameter, d cm					
3	Radius r cm					
4	Height h cm					
5	Surface area, A					

Heat loss by convection β = 0

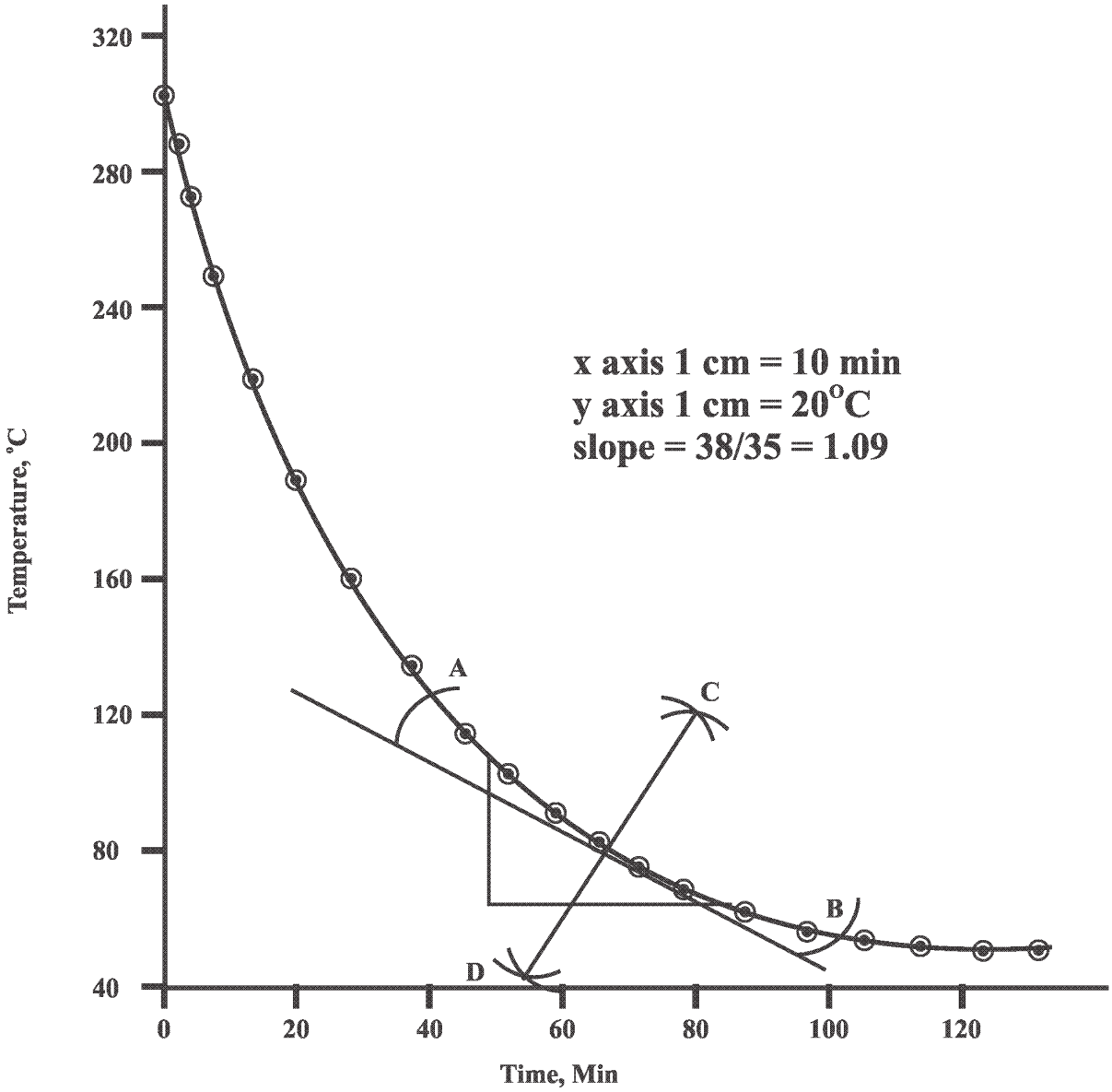
Specific heat the of metal=

Iron s = 106 J/Kg.K

Copper s = 385 J/Kg.K

Brass s = 370 J/Kg.K

Aluminium s = 913 J/Kg.K



Figure, Time-temperature profile for calculating the slope of the tangent.

TABLE 2

Radiation constant of a metal- time Vs. temperature plot data

Time in min.	Temp ^{o}C	Time in min	Temp ^{o}C	Time in min	Temp ^{o}C	Time in min	Temp ^{o}C

Result: Radiation constant of metal. A =

VIVA QUESTIONS

Q.1. Explain Stefan Boltzmann' s law

Ans- .....

.....

.....

.....

Q.2. Define radiation

Ans- .....

.....

.....

.....

Q.3. Explain different model of heat transfer

Ans- .....

.....

.....

.....

Q.4. Explain principal involved in determination of radiation constant

Ans- .....

.....

.....

.....

Q.5. Why different metal have different radiation constant

Ans- .....

.....

.....

.....

Experiment No. 3

OBJECT:

To dry calcium carbonate slurry and plot the rate of drying curve.

REFERENCE:

C. V. S. Subrahmanyam, J. T. Setty, V. Kusumdevi and S. Suresh. Laboratory manual of pharmaceutical engineering, published by Vallabh publication, Delhi, first edition 2006, page 132-137.

REQUIREMENT:

Dryer [hot air oven], Balance [triple beam], Stainless steel plate, Beaker 100 ml, glass rod, Calcium carbonate etc.

THEORY:

Rate relationship can be studied considering a simple model, which mimics the conditions of a dryer. In this model, the wet slab to be dried is placed in a tray whose bottom and sides are insulated. The air is blown over the solid under the constant drying conditions. The superficial water diffuses through the surrounding air film and is carried away rapidly by the moving air stream. Then water diffuses from the interior of the solid to the surface. This process continues until bound water gets evaporated. Then the material attains equilibrium moisture content.

Rate of drying of this process can be determined by periodically weighing the calcium carbonate slurry. The difference in the weights of two successive weighings gives the loss of moisture content, i.e. , amount dried. The following equation is used to calculate rate of drying:

$$\text{Rate of drying} = \frac{weightofwaterremoved}{weightofdrypowderXtimeofdryingXsurfacearea\,\exp osed}$$

Unit of drying = $g/ghcm^2$

A graph is plotted by taking FMC on x-axis and drying rate on y-axis. The curve so obtained is called drying rate curve. It represents different changes occurring during drying, where AB is constant rate period, BC is first falling rate period, CD is second falling rate period. The FMNC at the end of constant rate period is known as critical moisture content.

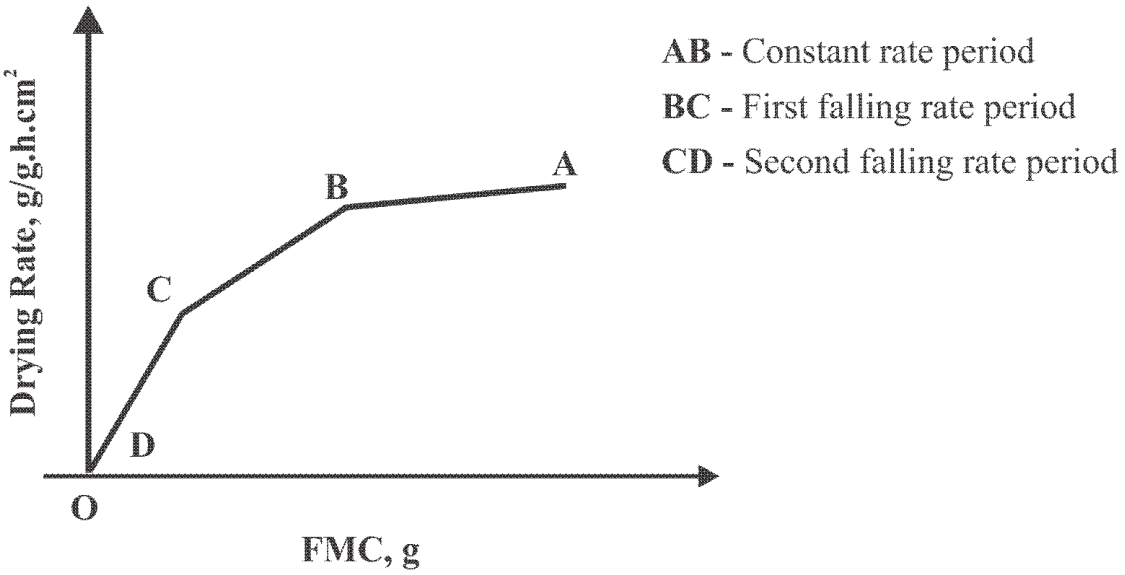


Figure: Drying curve

PROCEDURE:

1. The stainless steel plate is weighed and weight is recorded as w1.
2. 15.0g of calcium carbonate is transferred into a beaker. Water is added slowly to prepare slurry.
3. The calcium carbonate slurry is transferred into the stainless steel plate.
4. Filling must be done in such a way that $^{3}/_{4}$th of the volumes of the stainless steel plate is filled with slurry.
5. The weight of steel plate plus slurry is taken and recorded as w2.
6. Plate containing slurry is placed in hot air oven, whose temperature must be maintained 60^{0} C.
7. The time is noted soon after placing plate containing slurry in hot air oven.
8. After 15 minutes, the weight of plate with slurry is taken. The weight is recorded in column 3 of the table.
9. Again the steel plate containing slurry is placed the dryer. [Steel plate should be immediately placed back into the dryer, otherwise temperature decreases enormously and results will be erroneous].
10. Step 8 and 9 are repeated until constant weight is obtained.
11. The rate of drying is calculated.
12. A graph is potted by taking free moisture content [weight of water column 5 on x-axis and rate of drying on y-axis].

OBSERVATIONS AND CALCULATIONS

1. Weight of empty stainless steel plate w1=…….g
2. Weight of stainless steel plate + sample slurry w2=…….g
3. Weight of sample slurry w3= w2-w1= …….g
4. 45 g of sample slurry contains 15 g of calcium carbonate w3 g of sample slurry contains

   …….g of calcium carbonate

$$\frac{15 X w3}{45} = \text{g of calcium carbonate}$$

5. Weight of total water contant (TWC), w5= (w3-w4)= ……g
6. Diameter of stainless steel plate d= …….cm
7. Radius of stainless steel plate r= (d/2)= ……cm
8. Area of stainless steel plate A= πr2 = ……cm2
9. Moisture content removed from the sample =w2- last weight of steel plate taken with sample +water (if any)

RESULT:

Drying rate curve is plotted by taking FMC on x axis and rate of drying on y axis

Total moisture content removed from calcium carbonate slurry ……g

VIVA QUESTIONS

Q.1. What is drying?

Ans- .....

.....

.....

.....

Q.2. What are different methods of drying?

Ans- .....

.....

.....

.....

Q.3. What are applications of drying in pharmacy?

Ans- .....

.....

.....

.....

Q.4. Define equilibrium moisture content?

Ans- .....

.....

.....

.....

Q.5. What is bound and unbound water?

Ans- .....

.....

.....

.....

Experiment no. 4

OBJECT:

To determine the humidity and relative humidity of the ambient environment using psychrometer.

REFERENCE:

C. V. S. Subrahmanyam, J. T. Setty, V. Kusumdevi and S. Suresh. Laboratory manual of pharmaceutical engineering, published by Vallabh publication, Delhi, first edition 2006, page 138-143.

REQUIREMENT:

Sling psychrometer containing wet bulb and dry bulb thermometer, psychrometer chart.

THEORY:

Humidity is the amount of water vapor present in the air. Water vapor is the gaseous state of water and is invisible to the human eye. Humidity indicates the likelihood of precipitation, dew, or fog. Higher humidity reduces the effectiveness of sweating in cooling the body by reducing the rate of evaporation of moisture from the skin. This effect is calculated in a heat index table or humidex. The amount of water vapor that is needed to achieve saturation increases as the temperature increases. As the temperature of a parcel of water becomes lower it will eventually not reach the point of saturation without adding or losing water mass. The differences in the amount of water vapor in a parcel of air can be quite large. For example, a parcel of air that is near saturation may contain 28 grams of water per cubic meter of air at 30 °C, but only 8 grams of water per cubic meter of air at 8 °C.

There are three main measurements of humidity: absolute, relative and specific. Absolute humidity is the water content of air expressed in gram per cubic meter. Relative humidity, expressed as a percent, measures the current absolute humidity *relative* to the maximum (highest point) for that temperature. Specific humidity is the ratio of the mass of water vapor to the total mass of the moist air parcel.

Sling thermometer gives wet and dry bulb temperatures. The weight bulb temperature is a function of temperature and humidity of air used for evaporation. The difference between the wet and dry bulb temperature are used for calculating the per cent relative humidity and humidity of air.

$$\frac{humidityofair}{humidityofsaturatedair} = \text{per cent relative humidity}$$

The intersection point is identified at which the saturated curve crossed the wet bulb temperature. From this point, the horizontal line towards the y axis (humidity scale) is drawn and humidity values are noted.

PROCEDURE:

1. The sling psychrometer is taken and verified for the dry bulb and wet bulb thermometer.
2. The sling psychrometer is whirled in the air of laboratory.
3. Dry bulb and wet bulb temperature are noted at 5 minute interval. Once the temperature remained constant, these are considered as dry bulb and wet bulb temperature for calculation.
4. The humidity and relative humidity are determined using humidity charts.

OBSERVATIONS AND CALCULATIONS:

Table

Dry bulb and wet bulb temperature at different locations

S no.	Location	Average dry bulb temperature		Average wet bulb temperature		Humidity	Per cent relative humidity
		^oC	^oK	^oC	^oK		
1							
2							
		Average humidity					

RESULT:

Humidity of the air =

Per cent relative humidity =

VIVA QUESTIONS

Q.1. What is humidity?

Ans- .....

.....

.....

.....

Q.2. What is relative humidity?

Ans- .....

.....

.....

.....

Q.3. What is absolute humidity?

Ans- .....

.....

.....

.....

Q.4. What is specific humidity?

Ans- .....

.....

.....

.....

Q.5. What is wet bulb and dry bulb temperature?

Ans- .....

.....

.....

.....

Experiment no. 5

OBJECT:

To determine the humidity of the air by dew point method.

REFERENCE:

C. V. S. Subrahmanyam, J. T. Setty, V. Kusumdevi and S. Suresh. Laboratory manual of pharmaceutical engineering, published by Vallabh publication, Delhi, first edition 2006, page 144-147.

REQUIREMENT:

Round bottom long neck flask 100 ml, thermometer, tripod stand, water, ice etc.

THEORY:

Dew point is defined as the temperature to which a mixture of air-water vapour must be cooled (at constant humidity) to become saturated (i.e. to be in equilibrium with liquid).

Formation of mist and disappearance of mist are considered and dew point is determined. Dew point temperature is noted on the temperature axis (x-axis) and moved vertically on the psychrometric chart. The intersect point at saturated curve (100%) is identified. The coordinates of the point (temperature, K, humidity) are noted. The y-axis point is the humidity of air. These values are substituted in the equation.

Per cent relative humidity = (humidity of air/humidity of saturated air)*100

Percent relative humidity can be directly read from the psychrometric chart.

The cooled and polished disk is placed in a vessel. The vessel is cooled gradually. At a particular temperature, the mist begins to form and this temperature is noted. It is the dew point. Alternatively, dew point can be determined using a round bottom flask. The arrangement of apparatus is shown in Figure.

PROCEDURE:

The assembly of apparatus for determining dew point is shown in Figure.

1. Around bottom long neck flask (100 ml) is thoroughly cleaned and dried the external surface.
2. Water is filled into the flask upto 2/3rd volume.
3. The above flask is kept on a glass tripod stand.
4. A thermometer (110 degree C) is dipped in the water (Figure).
5. Crushed ice is slowly added to the water (in the flask) and stirred thoroughly with the help of a glass rod.
6. As the temperature of water (in the flask) is lowered, mist begins to forms on the outer bottom surface of the flask. At this point, the temperature is noted. This is the dew point (temperature).

7. In psychrometric chart, from the temperature (x – axis) moved vertically up until the saturation curve and identified the intersecting point. The coordinates of the (temperature, humidity) intersecting point are noted. The y coordinate is the humidity.

OBSERVATIONS AND CALCULATIONS

Trials	Dew point, C degree		Humidity
	Mist appear-ance	Average value	

From humidity chart, humidity of saturated air dew point = ……kg water/kg dry air.

$$\text{Percentage relative humidity} = \frac{Humidity of air}{Humidity of saturated air} 100$$

VIVA QUESTIONS

Q.1. What is psychrometric chart?

Ans- .....

.....

.....

.....

Q.2. What is dew point?

Ans- .....

.....

.....

.....

Q.3. What is humidity chart?

Ans- .....

.....

.....

.....

Q.4. What is importance of humidity?

Ans- .....

.....

.....

.....

Q.5. How humidity affect stability of pharmaceutical product?

Ans- .....

.....

.....

.....

Experiment No. - 6

OBJECT:

To determine the particle size distribution of powder by sieving method.

REFERENCE:

C. V. S. Subrahmanyam, J. T. Setty, V. Kusumdevi and S. Suresh. Laboratory manual of pharmaceutical engineering, published by Vallabh publication, Delhi, first edition 2006, page 27-34.

REQUIREMENTS:

Sieve set (sieve no. 30, 45, 60, 100, 140, and 200), electrical sieve shaker, weighing balance, calcium carbonate or any other substances etc.

THEORY:

Many natural and manufactured materials occur in a disperse form, which means that they consist of differently shaped and sized particles. The particle size distribution, i.e. the number of particles of different sizes, is responsible for important physical and chemical properties such as:

- Mechanical bulk behavior
- Surface reaction
- Taste
- Miscibility
- Filtration properties
- Conductivity

This list could be continued at great length. The examples clearly show how important it is to have knowledge of the particle distribution, particularly within the context of quality assurance in the production of bulk goods. If the particle distribution changes during the manufacturing process then the quality of the finished product will also change. Only a continuous monitoring of the particle size distribution can guarantee a constant product quality.

During sieving the sample is subjected to horizontal or vertical movement in accordance with the chosen method. This causes a relative movement between the particles and the sieve; depending on their size the individual particles either pass through the sieve mesh or are retained on the sieve surface. The likelihood of a particle passing through the sieve mesh is determined by the ratio of the particle size to the sieve openings, the orientation of the particle and the number of encounters between the particle and the mesh openings. As explained later, the likelihood of passage and therefore the associated quality of the sieved sample also depends on the sieve movement parameters and the sieving time.

PROCEDURE:

1. Arrange set of sieves in the descending order.

2. Weighed amount of sample is placed in the sieve at the top of the sieve set.
3. Start the sieving machine. The duration of time and speed of vibration can be controlled by semiautomatic attachment in the machine.
4. Collect the powder material retained on the various sieves.
5. Weigh the powder material retained on the sieves.
6. Calculate percent frequency of each size of particle and plot the graphs.
7. Determine the geometric mean weight diameter and geometrical standard deviation.

OBSERVATIONS:

(a) Weight of substance = W 1 g

(b)Time of shaking = t min

(c) Speed of electrical shaker = rpm

S. no.	Sieve number (passed/retained)	Arithmetic Mean size of opening (μm)	Weight Retained on a sieve (g)	Percent Weight Retained (undersize)	Cumulative Percent Retained
1	30/45				
2	45/60				
3	60/80				
4	80/100				
5	100/140				
6	140/200				

CALCULATION:

Calculation of percent weight retained on screen.

1. Plot frequency distribution curve taking particle size on X axis and percent weight retained on the screen on Y axis.
2. The logarithm of the particle size is plotted against the cumulative percent frequency on a probability scale. It showed a linear relationship.
3. The geometrical mean weight diameter dg and geometrical standard deviation can be obtained from the straight line.

RESULT:

The geometrical mean weight diameter (dg) is ……and geometric standard deviation is ……..

VIVA QUESTIONS

Q.1. What is the importance of particle size in pharmacy?

Ans- .....

.....

.....

.....

Q.2. What are different methods of determination?

Ans- .....

.....

.....

.....

Q.3. What is IP sieve standard?

Ans- .....

.....

.....

.....

Q.4. What are the drawbacks of sieving method?

Ans- .....

.....

.....

.....

Q.5. What is average particle size?

Ans- .....

.....

.....

.....

Experiment No. -7

OBJECT:

To determine the moisture content and loss on drying of given sample.

REFERENCE:

C. V. S. Subrahmanyam, J. T. Setty, V. Kusumdevi and S. Suresh. Laboratory manual of pharmaceutical engineering, published by Vallabh publication, Delhi, first edition 2006, page 126-131.

REQUIREMENTS:

Theory:

Moisture analysis covers a variety of methods for measuring moisture content in both high level and trace amounts in solids, liquids, or gases. Moisture in percentage amounts is monitored as a specification in commercial food production. There are many applications where trace moisture measurements are necessary for manufacturing and process quality assurance. Trace moisture in solids must be controlled for plastics, pharmaceuticals and heat treatment processes. Gas or liquid measurement applications include dry air, hydrocarbon processing, pure semiconductor gases, and bulk pure gases, dielectric gases such as those in transformers and power plants, and natural gas pipeline transport.

LOSS ON DRYING:

The classic laboratory method of measuring high level moisture in solid or semi-solid materials is loss on drying (LOD). In this technique a sample of material is weighed, heated in an oven for an appropriate period, cooled in the dry atmosphere of a desiccators, and then reweighed. If the volatile content of the solid is primarily water, the LOD technique gives a good measure of moisture content. Because the manual laboratory method is relatively slow, automated moisture analyzers have been developed that can reduce the time necessary for a test from a couple hours to just a few minutes. These analyzers incorporate an electronic balance with a sample tray and surrounding heating element. Under microprocessor control the sample can be heated rapidly and a result computed prior to the completion of the process, based on the moisture loss rate, known as a drying curve.

Loss on drying measures all weight loss after heating to a specific temperature for a specific time. This value will include moisture as well as any volatile components or solvents that may be present. Moisture content is only a measure of the water present.

Often the two values are identical, if water is the only component that is lost, but if you are measuring loss on drying, you can not verify how much of the loss is caused by water.

PROCEDURE:

1. Take the given sample to be dry on petri disc and weigh accurately.
2. Placed the given sample in an oven at 100 ^{O}C for one hour to dry.
3. After complete drying again weigh the sample and take the difference.

4. The difference can be termed as moisture content and loss on drying.
5. Report the value as result for drying.

OBSERVATION AND CALCULATION:

Take empty weight of petri disc= w1=

Take weight of petri disc + sample before drying= w2=

Take weight of petri disc + sample after drying=w3=

Weight of sample= w2 - w1=……..g

Weight of sample after drying = w3 – w1= …….g

Moisture content or loss on drying= w3 – w2= ……..g

RESULT:

The moisture content or loss on drying of given sample was found……g

VIVA QUESTIONS

Q.1. What is moisture content and equilibrium moisture content?

Ans- .....

.....

.....

.....

Q.2. What is loss on drying?

Ans- .....

.....

.....

.....

Q.3. What are the different methods used for drying of pharmaceutical sample?

Ans- .....

.....

.....

.....

Q.4. What is the importance of drying?

Ans- .....

.....

.....

.....

Q.5. What is the use of desiccators in drying?

Ans- .....

.....

.....

.....

Experiment No. - 8

OBJECT:

To study the effect of diameter of balls, no. of balls and volume of feed amount on particle size reduction using a ball mill.

APPARATUS/CHEMICALS REQUIRED:

Ball mill, Balls (different sizes), material used to be reduce the size, Sieves, Tray, and Sample Bags.

THEORY:

A ball mill consists of a hollow cylindrical shell rotating about its axis. The axis of the shell may be either horizontal or at a small angle to the horizontal. It is partially filled with balls. The grinding media is the balls, which may be made of steel, chrome steel, stainless steel or rubber. The inner surface of the cylindrical shell is usually lined with an abrasion-resistant material such as manganese steel or rubber. Less wear takes place in rubber lined mills, such as the Sepro tyre drive Grinding Mill. The length of the mill is approximately equal to its diameter. Ball mill works on the principle of impact between the rapidly moving balls and the material. It involves the determination of mean particle size of the material before and after size reduction. The ball mill is used for grinding materials such as coal, pigments, and felspar for pottery. Grinding can be carried out either wet or dry but the former is performed at low speed. Blending of explosives is an example of an application for rubber balls.

PROCEDURE:

1. The cleaned metal chamber (of ball mill) is taken with sufficient number of balls of similar size and 100 gm of material.
2. The ball mill is operated for 10 min.
3. The product is unloaded on to tray and subjected for sieve analysis
4. Repeat the experiment taking same amount of sample and same number of balls of different size.
5. The ball mill is operated for 10 min, after which the feed is unloaded and subjected to particle size determination.
6. The ball mill is operated for 10 minutes taking 100 gram of sample and using 02 balls of same size, sample is unloaded and taken for particle size determination
7. The experiment is repeated using 04, 06, 08 and 10 balls of similar size and particle size of each sample is determined after completing each experiment
8. 100 gram of sample is taken in the ball mill and it is operated using 10 balls of similar size, after 10 minutes sample is taken out and subjected to particle size determination.
9. The experiment is repeated taking 200 gram of sample with same number of balls of same size as used in (8). Particle size is determined using sieving method.

OBSERVATION TABLE 1

Sieve number	Nominal mesh aperture size, um	Aperture size (passed / retained), um	Mean size of opening d, um	Before size reduction	After size reduction

OBSERVATION TABLE 2

S.N.	Initial Average Particle Size of sample	Average Particle size after size reduction	
		Diameter of ball (d_1)	Diameter of ball (d_2)

OBSERVATION TABLE 3

S.N.	Initial Average Particle Size of sample	Average Particle size after size reduction	
		Using 100 g Sample	Using 200 g Sample

RESULT AND DISCUSSION:

VIVA QUESTIONS

Q.1. What is the significance of ball mill?

Ans- .....

.....

.....

.....

Q.2. Discuss the principle behind ball milling.

Ans- .....

.....

.....

.....

Q.3. Explain role of balls and its diameter in size reduction of material.

Ans- .....

.....

.....

.....

Q.4. What is size reduction?

Ans- .....

.....

.....

.....

Q.5. How you will determine average particle size?

Ans- .....

.....

.....

.....

Experiment No. - 9

OBJECT:

To calculate energy requirement (Rittinger's law) for powder milling

APPARATUS/CHEMICALS REQUIRED:

Ball mill, Balls (different sizes), material used to be reduce the size, Sieves, Tray, and Sample Bags.

THEORY:

Size reduction leads to increase of surface area,which has several advantages

The rate of dissolution of solid drug particles increases many folds after size reduction. Griseofulvin, an antifungal drug, when administered in its micronized form shows around five times better absorption. Size reduction produces particles in narrow size range. Mixing of powders with narrow size range is easier

The absorptive power of charcoal and kaolin increases after size reduction due to increase in surface area.

Rittinger's law, which assumes that the energy consumed is proportional to the newly generated surface area; Since the specific surface area is inversely proportional

to the particle size, Rittinger's hypothesis can be written in the following form:

$$E = K_R\left(\frac{1}{d_2} - \frac{1}{d_1}\right)$$

where,

E(J.kg-1) = the energy required per mass of feed (W/(kg/s))

KR = Rittinger's constant,

d1 (m) = the average initial size of pieces,

d2 (m) = the average size of milled particles.

PROCEDURE:

1. Take the initial reading of energy meter as N1
2. The cleaned metal chamber (of ball mill) is taken with sufficient number of balls.
3. The ball mill is operated without load for 10 min.

4. The reading (revolutions) in energy metal is noted down Let it is N2. The difference N2 – N1 = N3 give the energy required for running the ball mill without feed.
5. Hundred grams of sample is weighted and subjected to sieve analysis, and then transferred into the ball mill.
6. The ball mill is operated for 10 minutes.
7. The reading (revolution) is noted down as N4 the difference N4 – N2 = N5 give the energy required for running the ball mill for size reduction of the material.
8. The product is unloaded on to tray and subjected for sieve analysis.
9. The average particle size of the product after size reduction is determined.
10. The data is substituted in equations for obtaining Rittinger's constant.

OBSERVATION TABLE

Sieve number	Nominal mesh aperture size, um	Aperture size (passed / retained), um	Mean size of opening d, um	Before size reduction	After size reduction

OBSERVATION:

Result and Discussion:

VIVA QUESTIONS

Q.1. What is Rittinger's law?

Ans- .....

.....

.....

.....

Q.2. Explain role of balls in size reduction of material.

Ans- .....

.....

.....

.....

Q.3. Discuss significance of calculation of energy requirement calculation.

Ans- .....

.....

.....

.....

Q.4. What is Rittinger's constant?

Ans- .....

.....

.....

.....

Q.5. Discuss applicabilities of Rittinger's constant.

Ans- .....

.....

.....

.....

Experiment No.- 10

OBJECT:

To determine the particle size weight distribution of a given sample (powder or Granules) by sieving method.

APPARATUS/CHEMICALS REQUIRED:

Sieves of different sizes, Sample Bags, and Weighing balance.

THEORY:

A sieve analysis is a practice to assess the particle size distribution of a granular material. The size distribution is often of critical importance to the way the material performs in use. A sieve analysis can be performed on any type of non-organic or organic granular materials including sands, crushed rock, clays, granite, feldspars, coal, soil, a wide range of manufactured powders, grain and seeds, down to a minimum size depending on the exact method. Being such a simple technique of particle sizing, it is probably the most common. For coarse material, sizes that range down to #100 mesh (150μm), a sieve analysis and particle size distribution is accurate and consistent. However, for material that is finer than 100 mesh, dry sieving can be significantly less accurate. This is because the mechanical energy required to make particles pass through an opening and the surface attraction effects between the particles themselves and between particles and the screen increase as the particle size decreases.

PROCEDURE:

1. A standard sieve set is selected. This set consists of various sizes (10, 22, 44, 60, 85, 10, and sieves)
2. Sieves are arranged in such a manner that remains at the top and finest at the bottom .The pan is kept is below the sieves set.
3. Hundred grams of given sample (granules or powder) is weight.
4. The sample is placed on the coarsest sieve. The lid is placed.
5. The above sieve set is fixed on mechanical shaker and clamped tightly.
6. The timer is adjusted on the dial for 05 minutes and the mechanical shaker is switched on. (Each sieve shaker must be standardized for the time of shaking)
7. When the shaker automatically stops. The sample retained on each sieve is collected into a paper.
8. All the samples are weighed.
9. The weights retained on each sieve are recorded against the corresponding sieve number
10. The data is analyzed for normal weight distribution pattern. A plot is drawn by taking mean size of opening on x- axis and per cent weight retained on smaller sieve on y- axis.

11. The average particle size is calculated.

TABLE

Sieve number	Nominal mesh aperture size, um	Aperture size (passed/retained)um	Mean size of opening * d, um	Weight of powder undersize n, g	Pre cent weight retained on smaller sieve	Weight size n x d (4) x (6)

OBSERVATION:

Result and Discussion:

VIVA QUESTIONS

Q.1. What is the size range of the particles over which sieving is an effective method.

Ans- .....

.....

.....

.....

Q.2. What do you mean by percentage under size of the particles

Ans- .....

.....

.....

.....

Q.3. What do you mean by percentage over size of the particles.

Ans- .....

.....

.....

.....

Q.4. What is frequency distribution curve.

Ans- .....

.....

.....

.....

Q.5. What is the meaning of mesh number of the sieve.

Ans- .....

.....

.....

.....

Experiment No. -11

OBJECT:

To study the effect of concentration on the rate of filtration, using calcium carbonate suspension.

APPARATUS/CHEMICALS REQUIRED:

Pestle-Mortar, Sieves, Sample Bags, Weighing balance, Distilled water and Calcium carbonate.

THEORY:

Filtration is commonly the mechanical or physical operation which is used for the separation of solids from fluids, liquids or gases by interposing a medium through which only the fluid can pass. The fluid that passes through is called the filtrate. Oversize solids in the fluid are retained, but the separation is not complete; solids will be contaminated with some fluid and filtrate will contain fine particles depending on the pore size and filter thickness. Filtration is also used to describe some biological processes, especially in water treatment and sewage treatment in which undesirable constituents are removed by absorption into a biological film grown on or in the filter medium as in slow sand filtration. Thickness of the filter cake increases as the filtration progresses. Highly concentrated slurry is first decanted or strained to reduce the solid content and then it is filtered (this reduces the cake thickness). In a rotary drum filter cake is removed continuously so that the cake thickness is minimized.

PROCEDURE:

1. 5.0 g of calcium carbonate is weighed and transferred to a mortar. 50 ml of water is added and triturated to a get smooth paste. To contents are transferred into a measuring cylinder (100 ml). To mortar and pestle are washed with 10 ml water (2 or 3 time if necessary). The washing is transferred into the measuring cylinder. The volume is made up to the mark (100 ml) by adding water. The suspension is shaken is thoroughly.
2. The same procedure is repeated to prepare 10% and 15% suspensions using 10.0 and 15.0 g of calcium carbonate, respectively.
3. The apparatus is assembled.
4. The filter paper of appropriate size (10 cm diameter) is placed into the Buckner funnel.
5. 100 ml of 5% calcium carbonate suspension is poured over the Buckner funnel.
6. Time required to collect 50 ml of the filtrate is recorded and reported.
7. The experiment (steps 2 to 4) is repeated for the same concentration of calcium carbonate suspension for various prepared concentrations.
8. The time is recorded for other concentration also and processed.
9. A graph is plotted by taking concentration of calcium carbonate on x- axis and rate of filtration on y-axis.

OBSERVATION TABLE

S.N.	Time required to collect 50 ml of filtrate		
	5% $CaCo_3$ slurry	10% $CaCo_3$ slurry	15% $CaCo_3$ slurry

RESULT AND DISCUSSION:

VIVA QUESTIONS

Q.1. What are the factors which affect rate of filtration.

Ans- .....

.....

.....

.....

Q.2. How the concentration of solute affect rate of filtration.

Ans- .....

.....

.....

.....

Q.3. What is filter cake.

Ans- .....

.....

.....

.....

Q.4. What is filter media.

Ans- .....

.....

.....

.....

Q.5. What is sterile filtration.

Ans- .....

.....

.....

.....

Experiment No.- 12

OBJECT:

To study the effect of viscosity on the rate of filtration, using calcium carbonate Suspension.

APPARATUS/CHEMICALS REQUIRED:

Buckner funnel, Pestle-Mortar, Filter paper, Weighing balance, Distilled water and Calcium carbonate

THEORY:

Filtration may be defined as process of separation of solid from a liquid by passing the same through a process medium that retain the solid but allow the fluid to pass through . The suspension to be filtered is now as a slurry .The porous medium used to retain the solid is known as filter medium . The solid retained on the filter medium is known as filter cake and the clean fluid pass through is known as filtrate. Viscosity is one of the most significant variables both in filtration rate . Viscosity is closely related to temperature. As temperature is increased, viscosity is decreased resulting in a higher filter capacity and lower cake moisture. At the same time, increased vapor pressure will help reduce moisture. the rate of filtrate flow is inversely proportional to filtrate viscosity η. Therefore, in order to increase filter capacity it is advisable either to heat the suspension or to add substances to reduce η.

PROCEDURE:

1. 5.0 g of calcium carbonate is weighed and transferred to a mortar. 50 ml of water is added and triturated to a get smooth paste. The contents are transferred into a measuring cylinder (100 ml). To mortar and pestle are washed with 10 ml water (2 or 3 time if necessary). The washing is transferred into the measuring cylinder. The volume is made up to the mark (100 ml) by adding water. The suspension is shaken is thoroughly.
2. The filter paper of appropriate size (10 cm diameter) is placed into the Buckner funnel
3. 100 ml of calcium carbonate aqueous suspension is poured over the Buckner funnel.
4. Time required to collect 50 ml of the filtrate is repeated
5. The same procedure is repeated by adding 5% v/v glycerin to the calcium carbonate slurry used in step (3)
6. The experiment is repeated for suspension containing increased concentration of glycerin (different viscosities) also.

A graph is plotted by taking viscosity of vehicle of calcium carbonate suspension on x-axis and rate of filtration on y-axis

OBSERVATION TABLE

S.N.	Time required to collect 50 ml	
	$CaCO_3$ slurry alone	$CaCO_3$ slurry containing 5%v/v Glycerin

RESULT AND DISCUSSION:

VIVA QUESTIONS

Q.1. How viscosity of liquid affect rate of filtration.

Ans- .....

.....

.....

.....

Q.2. How the Pharmaceutical syrups are filtered.

Ans- .....

.....

.....

.....

Q.3. How will you filter an antibiotic solution.

Ans- .....

.....

.....

.....

Q.4. How the suspensions containing 25%w/v solute can be filtered

Ans- .....

.....

.....

.....

Experiment No. 13

OBJECT:

To study the effect of suspending agent on the rate of sedimentation of given sample.

APPARATUS/CHEMICALS REQUIRED:

Pestle-Mortar, Sieves, Sample Bags, Weighing balance, Distilled water and Calcium carbonate.

THEORY:

The rate of filtration in general depend on properties of filtrate, viscosity of medium particle characteristics their size and distribution. agglomeration by coagulation change of electrical separation forces, flocculation, filter aids which improve permeability of cakes and pressure drop that can make worse filterability of suspensions with compressible cakes. physicochemical phenomena like electrical double

layer at filtration of fine suspensions decrease diameter of pores. Filter Aids" is a group of inert materials that can be used in filtration pretreatment, to improve the flow rate by decreasing cake compressibility and increasing cake permeability. Materials commonly used as filter aid are suspending agents which are incompressible diatomaceous earth, or kieselguhr, which is composed primarily of silica. Also used are wood cellulose and other inert porous solids such as the cheaper and safer perlite.

PROCEDURE:

Preparation of calcium carbonate suspension:

1. 5.0 g of calcium carbonate is weighed and transfer to a mortar.
2. 50 ml of water is added and triturated to a get smooth paste.
3. The contents are transferred into a measuring cylinder (100 ml). The mortar and pestle are washed with 10 ml water (2 or 3 time if necessary). The washing is transferred into the measuring cylinder. The volume is made up to the mark (100 ml) by adding water. The suspension is shaken is thoroughly.
4. Place the measuring cylinder on a table and note the volume of sediment after an interval of each 1 second. A thin strip of graph paper can be stuck on measuring cylinder for noting sedimentation volume accurately
5. Repeat the experiment using 20% w/w bentonite as suspending agent
6. The same procedure is repeated to prepare 10% and 15% suspensions using 10.0 and 15.0 g of calcium carbonate, respectively each time using 20% w/w amount of bentonite.
7. Plot a graph between time and volume of sedimentation

OBSERVATION TABLE

S.N.	Time in Sec.	Volume of Sdimentation					
		5% $CaCO_3$ slurry	5% $CaCO_3$ slurry containing 20% w/w Bentonite	10% $CaCO_3$ slurry	10% $CaCO_3$ slurry containing 20% w/w Bentonite	15% $CaCO_3$ slurry	15% $CaCO_3$ slurry containing 20% w/w Bentonite

RESULT AND DISCUSSION:

VIVA QUESTIONS

Q.1. What are suspending agents

Ans- .....

.....

.....

.....

Q.2. How the suspending agents work.

Ans- .....

.....

.....

.....

Q.3. Write the name of natural suspending agents.

Ans- .....

.....

.....

.....

Q.4. How suspending agent can decrease rate of sedimentation of suspended particles.

Ans- .....

.....

.....

.....

Q.5. What is the difference in suspending agents and emulsifying agents.

Ans- .....

.....

.....

.....

Experiment No. -14

OBJECT :

To study the effect of surface area, concentration and temperature on rate of drying

APPARATUS/CHEMICALS REQUIRED:

Petridishes, Beakers, Distilled **w**ater, Starch, Thermometer and Balance

THEORY:

Drying is a complex operation involving transient transfer of heat and mass along with several rate processes, such as physical or chemical transformations, which, in turn, may cause changes in product quality as well as the mechanisms of heat and mass transfer. Physical changes that may occur include: shrinkage, puffing, crystallization, glass transitions. In some cases, desirable or undesirable chemical or biochemical reactions may occur leading to changes in color, texture, odor or other properties of the solid product. In the manufacture of catalysts, for example, drying conditions can yield significant differences in the activity of the catalyst by changing the internal surface area. The general methods of drying include

Application of hot air (convective or direct drying). Air heating increases the driving force for heat transfer and accelerates drying.

Dielectric drying It may be used to assist air drying or vacuum drying. Researchers have found that microwave finish drying speeds up the otherwise very low drying rate at the end of the classical drying methods. Freeze drying or lyophilization is a drying method where the solvent is frozen prior to drying and is then sublimed, i.e., passed to the gas phase directly from the solid phase, below the melting point of the solvent..

PROCEDURE:

To determine the effect of surface area on rate of drying:

1. Take petridishes of 3 different sizes and determine their surface area.
2. In each petridish place slurry of 10g of starch in water.
3. Weigh the petridishes and place inside the oven maintained at a temperature of 80°C for 30 min.
4. Take out the petridishes from oven and weigh again.
5. Repeat the process till constant weight of petridish obtained.
6. Calculate the rate of drying for each petridish.
7. Plot a graph by taking rate of drying on Y- axis and surface area on X-axis. Report the result.

To determine the effect of concentration on rate of drying :

1. Make slurry of 10, 20 and 30 gm of starch in water.
2. Take 3 petridishes of same size and determine their surface area.
3. Place equal volume of slurry in these petridishes respectively.
4. Weigh the petridishes and place inside the oven maintained at a temperature of 80°C for 30 min.
5. Take out the petridishes from oven and weigh again.
6. Repeat the process till constant weight of petridish obtained.
7. Calculate the rate of drying for each petridish.
8. Plot a graph by taking rate of drying on Y- axis and concentration on X-axis. Report the result.

To determine the effect of temperature on rate of drying:

1. Take 3 petridishes and determine their surface area.
2. In each petridish place slurry of 10g of starch in water.
3. Weigh the petridishes and place inside the oven maintained at a temperature of 60°C, 80°C and 100°C for 30 min.
4. Take out the petridishes from oven and weigh again.
5. Repeat the process till constant weight of petridish obtained.
6. Calculate the rate of drying for each petridish.
7. Plot a graph by taking rate of drying on Y- axis and temperature on X-axis. Report the result.

OBSERVATIONS:

To determine the effect of surface area on rate of drying:

S.No.	Surface area of petridish	Initial weight	Final weight	Remaining weight	Rate of drying
1					
2					
3					

To determine the effect of concentration on rate of drying :

S.No.	Concentration of slurry	Initial weight	Final weight	Remaining weight	Rate of drying
1					
2					
3					

To determine the effect of temperature on rate of drying:

S.No.	temperature	Initial weight	Final weight	Remaining weight	Rate of drying
1					
2					
3					

RESULT AND DISCUSSION :

VIVA QUESTIONS

Q.1. What is the boiling point diagram?

Ans- .....

.....

.....

.....

Q.2. Discuss dew-point.

Ans- .....

.....

.....

.....

Q.3. Define Supercritical drying.

Ans- .....

.....

.....

.....

Q.4. Explain bubble-point.

Ans- .....

.....

.....

.....

Q.5. Q.5 Discuss the importance of humidity measurement.

Ans- .....

.....

.....

.....