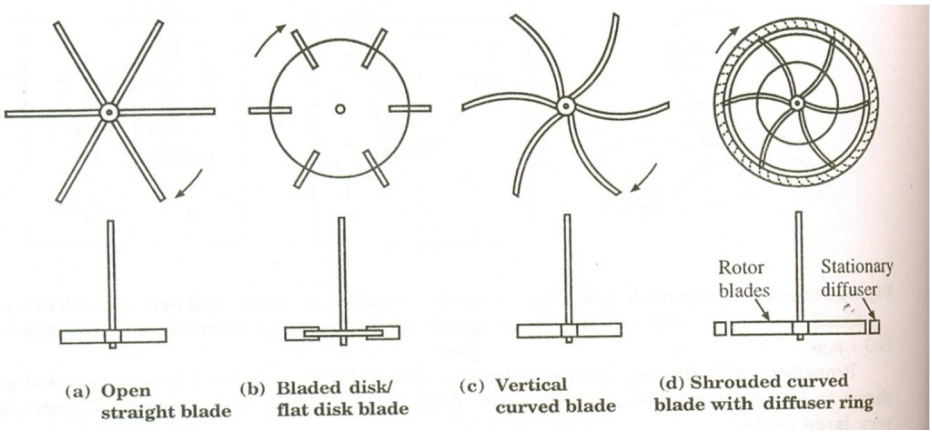
SUMMER-14 EXAMINATION

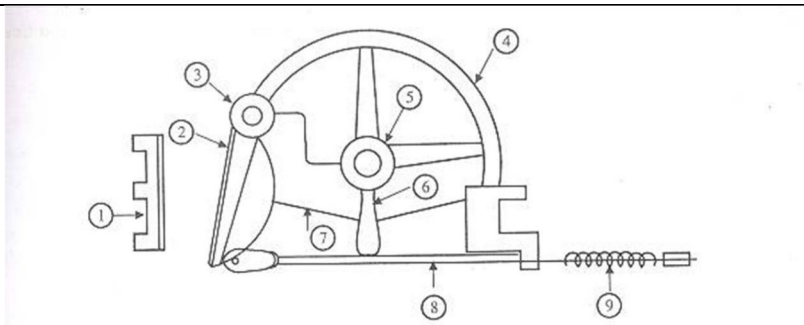
Model Answer

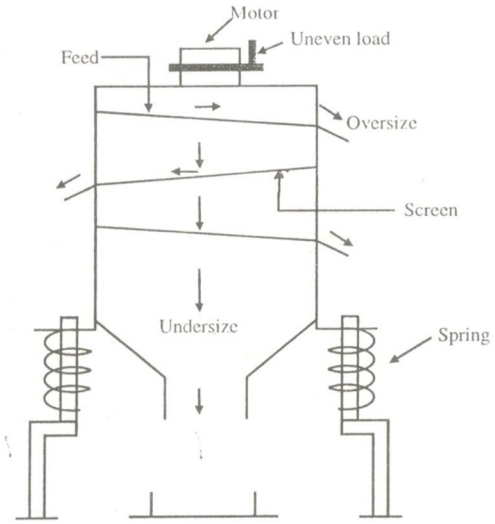
Important Instructions to examiners:

1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling errors should not be given more Importance (Not applicable for subject English and Communication Skills.
4) While assessing figures, examiner may give credit for principal components indicated in the figure. The figures drawn by candidate and model answer may vary. The examiner may give credit for any equivalent figure drawn.
5) Credits may be given step wise for numerical problems. In some cases, the assumed constant values may vary and there may be some difference in the candidate's answers and model answer.
6) In case of some questions credit may be given by judgement on part of examiner of relevant answer based on candidate's understanding.
7) For programming language papers, credit may be given to any other program based on equivalent concept.

Q No.	Answer	marks	Total marks
1a-i	**Concept of size reduction:** Many solid particles exist in sizes that are too large to be used directly. Such materials must be reduced in size before use. The term size reduction is applied to all the ways in which particles of solid are cut or broken into smaller pieces.	2	2
1a-ii	**Kick's law:** Kick's law states that the work required for crushing a given mass of material is the log of ratio of initial particle size to final particle size. **Mathematical statement** $\frac{P}{\dot{m}} = K_k \ln \frac{\bar{D}_{sa}}{\bar{D}_{sb}}$	1 1	2
1a-iii	**Oversize material:** Oversize materials are particles whose sizes are greater than the opening of the screen. **Undersize material** Undersize materials are particles whose sizes are smaller than the opening of the screen.	1 1	2
1a-iv	**Mesh:** It is the number of openings per linear inch counting from the center of any wire to a point exactly one inch distant. **Screen aperture**: Minimum clear space between edges of openings in the screening surface is termed as screen aperture.	1 1	2
1a-v	**Four classifiers used for size separation.** 1. Cone classifier 2. Double cone classifier 3. Rake classifier 4. Spiral classifier	½ mark each.	2

1a-vi	**Hindered settling**: If the settling of particle is affected by other particles and by the boundary of the container, then it is known as hindered settling.	2	2
1a-vii	**Prevention of Swirling and Vortex Formation:** There are four methods of prevention of swirling and vortex formation a) Off-center mounting of the impeller. b) Use of Baffles c) Use of diffuser ring with turbines d) Angular entry of agitators.	1 mark each for any two methods	2
1a-viii	**Turbine impeller.** 	2 marks for any one diagram	2
1b-i	**Labeled diagram of blake jaw crusher**	2 marks	4

	 (1) Fixed jaw, (2) Movable jaw, (3) Shaft, (4) Fly wheel, (5) Eccentric, (6) Pitman, (7) Toggle, (8) Tie rod, (9) Spring	for diagram and 2 marks for labeling.	
1b-ii	**Differentiate crushing and grinding:** Crushing | Grinding 1.Size reduction by compression | Size reduction by impact and attrition 2. Breaks large pieces of solid materials into small lumps. | Reduces crushed feed to powder.	2 marks each	4
1b-iii	**Factors affecting performance of screen.** 1) Method of feeding Particles should approach the screening surface in a direction parallel to the longitudinal axis (perpendicular) of the screen. Particles should be fed at as low velocity as possible. 2) Screen slope As the slope increases, the rate at which the materials travels over the screening surface increases thereby reducing bed thickness and allowing the fines to come in contact with the screening surface. But if the slope is increased too much, the material will travel down the screen very fast without getting properly screened 3.Screening Surface Material should be spread evenly on the full screening surface so that all	1 mark each for any four points	4

	particles will come in contact with the screening surface 4.Vibration amplitude &frequency Proper amplitude of vibration is selected to prevent binding of screen. 5. Moisture in the feed Moisture in the feed adversely affects screening operation & should be removed.		
2-a	**Importance of size reduction** 1. To increase the surface area thereby increasing the effective contacting which is essential for physical and chemical process . 2. To effect the separation of two constituents when one is dispersed in small isolated pockets. 3. To increase the effective mixing between components. 4. To meet stringent specification regarding the size of commercial products. 5. To improve dissolution rate, solubility, dispersion properties etc	1 mark each for any four points	4
2-b	**Diagram and working of vibrating screen**  	2	4

<table>
<tr>
<td></td>
<td>Working:
The screens are vibrated mechanically or electrically with a frequency of 1800 to 3600 per minute. Mechanical vibrations are transmitted from the high speed eccentrics to casing & from there to screens so that the whole assembly is vibrated. In electrically vibrated screens, vibrations are transmitted from heavy duty solenoids directly to the screens.</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>2-c</td>
<td>Comparison of grizzlies and trammels
<table>
<tr><td></td><td>Grizzlies</td><td>Trommel</td></tr>
<tr><td>1.Screen arrangement</td><td>Stationary inclined screen. Screen is a grid of parallel metal bar</td><td>Revolving screens. Screen is perforated cylinder.</td></tr>
<tr><td>2.Openings in screen small/large</td><td>large</td><td>small</td></tr>
<tr><td>3.Size of feed handled</td><td>Large size feed</td><td>Small size feed</td></tr>
<tr><td>4.Capacity</td><td>large</td><td>small</td></tr>
</table></td>
<td>1 mark each</td>
<td>4</td>
</tr>
<tr>
<td>2-d</td>
<td>Gravity settling tank</td>
<td>2 marks for diagram</td>
<td>4</td>
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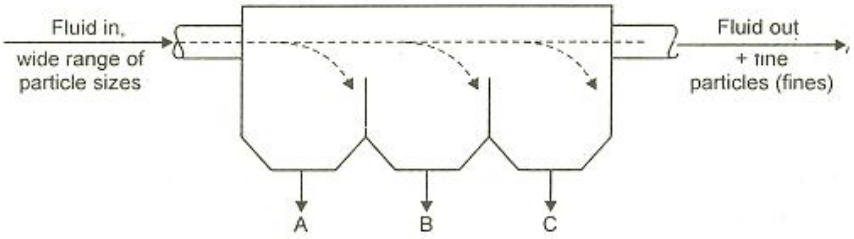
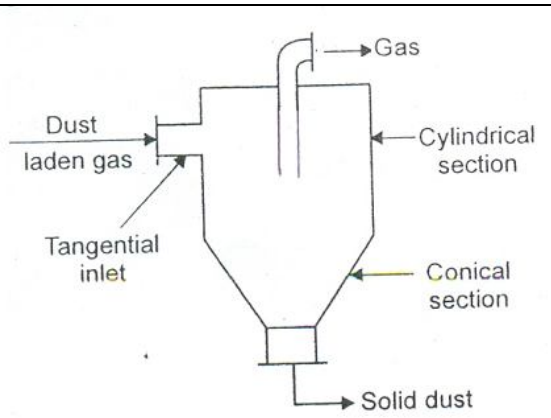
	 A = Coarse particles B = Intermediate particles C = Small particles	and 2 marks for labeling	
2-e	**Constant pressure filtration and constant rate filtration** **Constant Pressure Filtration:** The filtration in which the pressure drop over the filter is held constant throughout the run so that the rate of filtration is maximum at the start of filtration and decreases continuously towards the end of the filtration is called constant pressure filtration **2. Constant rate Filtration:** The filtration in which the pressure drop is varied usually from minimum at the start of filtration to a maximum at the end of filtration so that the rate of filtration is constant throughout the run is called constant rate filtration.	2 2	4
2-f	**Labeled diagram of Cyclone separator**	2 marks for diagram	4

		and 2 marks for labeling	
3-a	**Open-circuit grinding**: It is the grinding system in which material passes through the grinder without classification of product and without recycle of oversize lumps.. **Advantages**:Simplicity of operation,minimum equipment requirement **Examples** : Ball mill,Rod mill **Closed-circuit grinding**:If the partially ground material from the size reduction machine is sent to a size separation unit, from where the undersize is withdrawn as the product & the oversize material is returned to the machine for reground ,the process is called as closed-circuit grinding. **Advantages**: Higher capacity, lower power consumption per ton of product,eliminate overgrinding by removing fines early **Examples**: Ball mill &classifier,Rod mill & classifier	2 2	4
3-b	**Effectiveness of a screen**: Let feed consists of material A &B,where A is the oversize & B is the undersize material.Let *F*, *D*, and *B* be the mass flow rates of feed, overflow, and underflow, respectively, and x_F, x_D, and x_B be the mass fractions of material A in the streams. The mass fractions of material B in the feed, overflow, and underflow are 1- x_F, 1- x_D, and 1- x_B.		4

Overall material balance:

Feed = Overflow + Underflow

$F = D + B$ *eq. 1*

1

Material balance of A over a screen

$Fx_F = Dx_D + Bx_B$ *eq.2*

As $F-B = D$ *eq.3*

Putting value of D from eq.3 into eq.2,we get

$Fx_F = (F-B)x_D + Bx_B$

$Fx_F = Fx_D - Bx_D + Bx_B$

$(x_D - x_F)F = (x_D - x_B)B$

$B/F = (x_D-x_F) / (x_D - x_B)$

1

Elimination of *B* from the above equations gives

$D/F = (x_F - x_B)/ (x_D-x_B)$

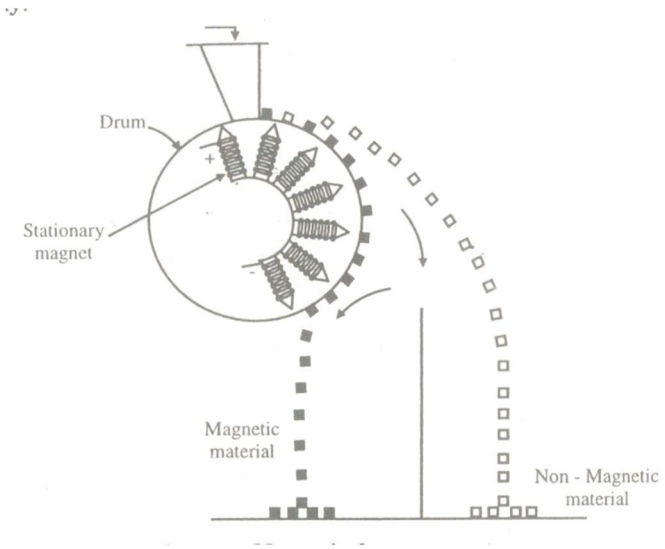
Screen effectiveness

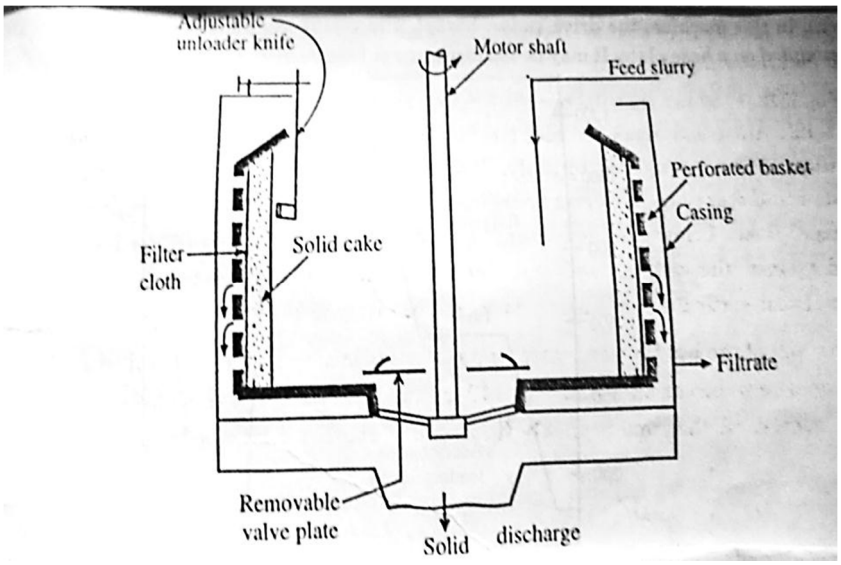
A common measure of screen effectiveness is the ratio of oversize material A that is actually in the overflow to the amount of A entering with the feed. These quantities are Dx_D and Fx_F respectively. Thus

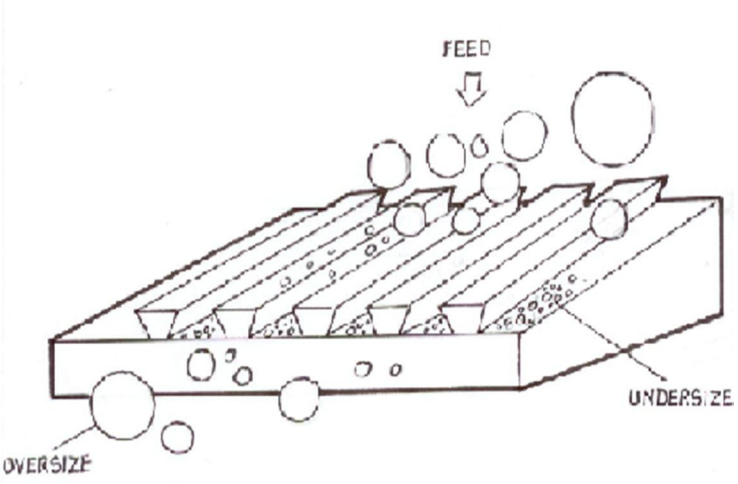
$E_A = D\ x_D / Fx_F$

where E_A is the screen effectiveness based on the oversize. Similarly, an effectiveness E_B based on the undersize materials is given by

1

	$E_B = \frac{B(1-x_B)}{F(1-x_F)}$ A combined overall effectiveness can be defined as the product of the two individual ratios. $E = E_A E_B = \frac{(x_F - x_B)(x_D - x_F)x_D(1-x_B)}{(x_D - x_B)^2(1-x_F)x_F}$	1	
3-c	**Magnetic Drum Separator**:  **Working:** The feed(mixture of magnetic & non-magnetic materials) is admitted at the top & is allowed to fall on the rotating drum. The non-magnetic material is discharged in a normal manner. The magnetic material adheres to the drum & falls off underside when the drum loses the contact of the magnet assembly.	2 2	4

3-d	**Characteristics of Filtre medium :(any4)** 1) It should retain solids to be filtered,giving clear filtrate. 2) It should not plug. 3)It should be mechanically strong to withstand process conditions. 4) It should offer little resistance to flow of filtrate. 5) It should be resistant to corrosive action to fluid. 6) It should possess ability to discharge cake easily & cleanly. 7) It should have acceptable resistance to mechanical wear. 8) It should be cheap & should have long life.	1 mark each	4
3-e	**Basket Centrifuge**:  	4	4
3-f	**Advantages of Plate & frame filter press(any2)** 1)It provides large filtering area per unit for floor space occupied 2)Low maintenance cost 3)It can be operated at higher pressures 4)Most joints are external ,so leakges can be easily identified.	1 mark each	4

	Disadvantages of Plate & frame filter press(any 2) 1)Labour requirement is more 2) Intermittant in operation & periodic manual dismantling tend to cause high wear on the cloths. 3)It frequently drip & leak ,making housekeeping difficult 4) Cake washing is impractical.	1 mark each	
4-a	**Construction of Grizzlies**: A grizzly is a grid of parallel metal bars set in an inclined stationary frame ,with a slope of 30 to45$^{0.}$ The slope & path of the material is parallel to the length of the bars. The length of bar is upto 3 m & spacing between the bars is 50 to 200mm. The material of construction of the bars is Manganese steel to reduce wear. Usually the bar is shaped in such a way that it's top is wider than the bottom,& hence the bars can be made fairly deep for strength without being choked by material passing partway through them.  Grizzly Screen	3 1	4

4-b	**Principle of Electrostatic Separator**:"If one or more of the materials of a granular mixture can acquire a surface charge on or just before entering an electrostatic field,the particles of that material will be attracted towards the active electrode or repelled from it depending on the charge on the particles." It is the method of separation of solid particles based on differential attraction or repulsion of charged particles under the influence of an electric field. The difference in electrical properties of different materials is responsible for such a separation. Charging of particles is done by 1) Contact electrification 2) Electrification by conductive induction 3) Electrification by bombardment	3 1	4
4-c	**The factors affecting filtration** are as follows: 1) **Pressure drop** across the feed inlet & far side of the filter medium:If pressure drop is more, filtration rate is more. 2) **Area of filtering surface**: Rate of filtration is directly propotional to area of filter surface) 3)**Viscosity of filtrate**::Rate of filtration is inversely propotional to viscosity of filtrate. 4) **Porosity of cake** :Increase in porosity of cake will increase the rate of filtration.addition of filter aids increases the porosity of cake.	1 mark each	4
4-d	**Pressure Sand Filters**: Pressure sand filter consists of a pressure vessel-this may be either vertical or horizontal-fitted with a set of frontal pipe work and valves, graded silica quartz	4	4

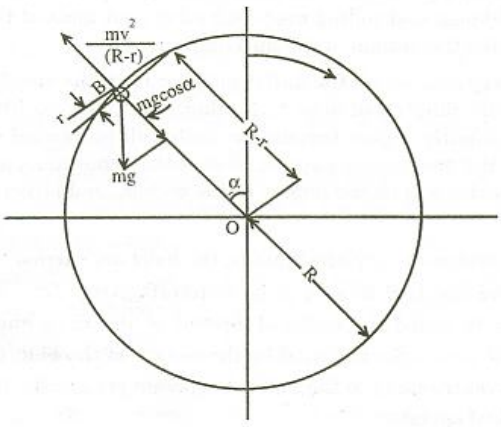
sand supported by layers of graded under bed consisting of pebbles and gravels, a top distributor to distribute the incoming water uniformly throughout the cross section of the filter, and an under drain system to collect filtered water.

In the operation, water to be filtered is pumped through the bed under pressure.

Raw water (water containing suspended impurities) flows down wards through the filter bed and as the suspended matter- which has usually been treated by addition of a coagulant like alum- is retained on the sand surface and between the sand grains immediately below the surface.

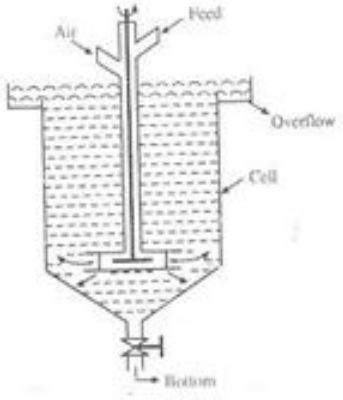
4-e **Difference Between Sedimentation & Filtration**: 1 mark each — 4

Point	Sedimentation	Filtration
Principle	It is the removal of solid particles from a suspension by settling under gravity.	It is the separation of solid particles from a suspension by using a porous medium which retains the solid particles & allows the liquid to pass through it.
Force	The gravitational force is responsible for separation.	The pressure difference across the filter medium is responsible for filtration.
Equipment used	Dorr thickener, Sedimentation basins	Filter press, Rotary drum filter
Product	: Clear liquid is the product	In cake filtration, wet cake

	of operation	with thickened sludge at the bottom	of solids is the product .In clarifying filters sparkling clear liquid is the product.		
4-f	**Free Settling(any 2 pts.):** 1)It is the settling wherein the fall of the particle in a gravitational field through a stationary field is not affected by walls of the container & other particles.(the particles are at sufficient distance from wall & other particles). 2)In this settling,the individual particle does not collide with other particles or with the wall of container. 3)Practically free settling conditions exist if the concentration of the particles in suspension is less than 1% wt.by solid			2 marks each	4
5-a	The speed at which the outermost balls break contact with the wall depends on the balance between centrifugal force and gravitational force.  Consider the ball at point B on the periphery of the ball mill. - Let **'R'** be the radius of the mill and **' r'** be the radius of the Ball. -**R-r** represents the distance between the center of the ball and the axis of the			1	8

	mill. - α be the angle between OB and vertical through the point O. The force acting on the ball are : 1. The force of gravity = mg where 'm' is the mass of the ball 2. The centrifugal force = $mv^2 / (R-r)$. where 'v' is the peripheral speed -The component of gravity opposing the centrifugal force is 'mgcosα' -As the angle α decreases,the centrifugal force increases. -Unless the speed crosses the critical value, a stage is reached where the above opposing forces are equal and ball is ready to fall away from the wall. -The angle which the said phenomenon occurs is found out by equating the two opposing forces, Thus, $mg\cos\alpha = mv^2 / (R-r)$ ---- (1) $\cos\alpha = v^2 / (R-r)\, g$ -------(2) The relationship between the peripheral speed and the speedof rotation is given by $v = 2\pi N (R - r)$ ----------(3) substituting the vale of ' v' in equation (2) $\cos\alpha = 4\pi^2 N^2 (R - r) / g$ -------(4) At the critical speed : $\alpha = 0$ and thus $\cos\alpha = 1$ and N becomes the critical speed Nc $\cos\alpha = 1 = 4\pi^2 N^2 (R - r) / g$ $Nc^2 = g / 4\pi^2 (R - r)$	2 2	

	$$Nc = \frac{1}{2\pi}\sqrt{\frac{g}{R-r}}$$ **Data:** Diameter of ball mill = 450 mm = 0.45 m Diameter of ball = 25 mm = 0.025 m Cririca l speed of ball mill (Nc) $$Nc = \frac{1}{2\pi}\sqrt{\frac{g}{R-r}}$$ $g = 9.81\ m/s^2$ R= 450/2 = 225 mm = 0.225 m r = 25/2 = 12.5 mm = 0.0125 m $$Nc = \frac{1}{2\pi}\sqrt{\frac{9.81}{0.225 - 0.0125}}$$ Nc = 1.08 r.p.s.= 1.08 x 60 = 64.88 ≈ 65 r.p.m. **Critical speed = 65 r.p.m.**	1 2	
5-b	**Froth Floatation:** Floatation refers to an operation in which one solid is separated from another by floating one of them at or on the liquid surfaces. Separation of a mixture of solids using Froth flotation methods depends on the difference in surface properties of the materials involved. **Froth Floatation Cell:** • **Diagram:**	2 2	8



2

- **Construction:**

1.The mechanically agitated cell consists of a tank having square or circular cross-section.

2.It is provided with an agitator which violently agitates the pulp.

3.The air from a compressor is introduced into the system through a downpipe surrounding the impeller shaft.

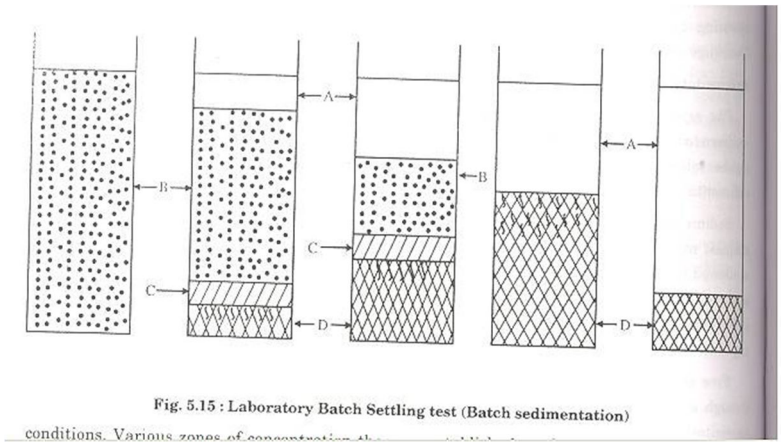
4.The bottom of the tank is conical and is provided with a discharge for tailing.

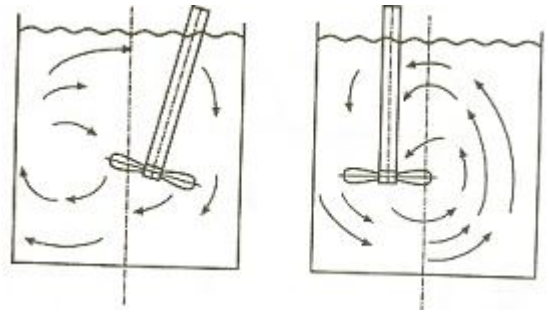
2

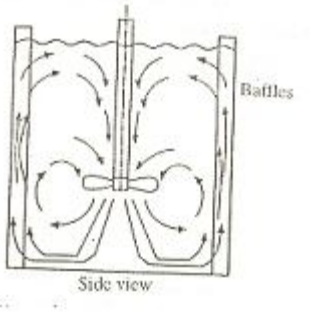
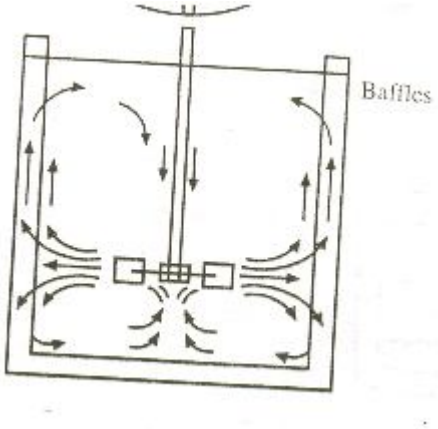
An overflow is provided at the top for mineralized froth removal.

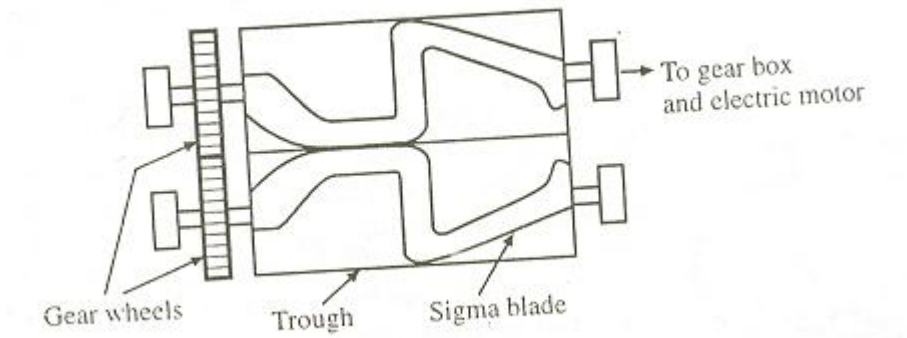
- **Working:**

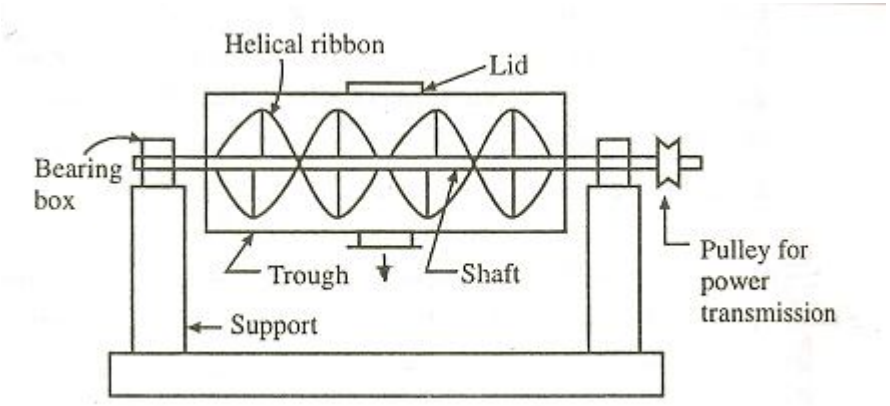
1. Water is taken into the cell; material is feed to the cell.
2. The promoters and frothers are added.
3. Agitations are given and air is bubbled in the form of fine bubbles.
4. Air-avid particles due to reduction in their effective density, will rise to the surface and be held in the froth before they are discharged from the overflow
5. Hydrophilic particles will sink to the bottom and removed from the discharge for tailing

5-c	**Laboratory test of Batch Sedimentation:**  Fig. 5.15 : Laboratory Batch Settling test (Batch sedimentation) conditions. Various zones of concentration th 1.The mechanism of settling may be described by batch settling test in glass cylinder in laboratory. 2. As shown in figure, cylinder containing a newly prepared slurry of a uniform concentration of uniform solid particles through. 3. As soon as the process strats, all the particles begin to settle and are believed to approach rapidly terminal settling velocities under hindered settling condition 4. Various zones of concentration then are established. The heavier faster settling particles settled at the bottom of glass cylinder are indicated by Zone D. 5.Above zone D forms another layer, called zone C ,a region of variable size distribution and non uniform concentration.	3 5	8

	6.The boundary between C and D is usually obscure and is marked by vertical channels through which fluid is rising from the lower zone D as it compresses. 7. Above zone C is zone B, which is a zone of uniform concentration of approximately the same concentration as that of original pulp. 8. Above the zone B is zone A, which is a zone of clear liquid. if original slurry is closed sized with respect to smallest particles, the boundary between A and B is Sharp.		
6-a	**Factors of filtration affecting rate of filtration:** The rate at which the filtrate is obtained in a filtration Operation i.e. the rate of filtration depends upon the following factors 1. Pressure drop across the feed inlet and far side of the filter medium. 2. Area of the filtrating surface. 3. Viscosity of the filtrate. 4. Resistance of the filter medium and intial layers of cake. 5. Resistance of the filter cake.	1 mark each for any 4 points	4
6-b	**i) Propeller** 	2 marks for any two	4

	 **ii) Turbine impeller** 	2	
6-c	**Pratical aims of Mixing:** 1.To promote a chemical reaction .It is the most important use of mixing in the chemical industry ,since intimate contact between reacting phases is necessary for reaction. 2.To produce simple physical mixtures – of two or more uniformly divided solids, two or more miscible liquids etc. 3. To carry out physical change- formation of crystals from a supersaturated solution. 4. To accomplish dispersion in which a quasi-homogeneous material is	2 marks each for any two	4

	produced from two or more immiscible fluids and from one or more fluid with finely divided solids.		
6-d	**Sigma Mixer:** **Construction:**  1)It consist of a short rectangular trough with saddle shaped bottom. 2) Two counter rotating blades are incorporated in the trough . 3) Blades are so placed and so shaped that the material turned up by one blade is immediately turned under adjacent one. 4)The blades are driven by through agear mechanism provided at either ends.	2	4

	5)The trough may be open or closed and may be jacted for heating or cooling. 6) The machine is operated batchwise fashion. 7) The machine can be emptied through a bottom valve. **Working:** 1)The material to be kneaded is dropped into the trough. 2) It is mixed of about 5 to 20 minutes or longer . 3) The trough is then unloaded by tilting it. 4) It is used for mixin very stiff masses. 5) The mixer employing sigma blades is capable of staring and operating with either liquids or solids or combination of both.	2	
6-e	**Sketch of Ribbon Blender:** 	2 marks for diagram and 2 marks for labelling	4
6-f	**Data :** Da = Impeller diameter = 60 cm μ = Viscosity = 10 Cp = 0.10 poise ρ = 1.45 g/cm³ N = Revolution per second Speed in rpm 90	 1	4

	$= \frac{\text{------------------}}{60} = \frac{\text{-----}}{60} = 1.5$ r.p.s. Reynolds number = $N_{Re} = \frac{N\ Da^2\ \rho}{\mu}$ $= \frac{100\ X\ 60^2\ X\ 1.45}{60\ X\ 0.10} = 87000$ So, flow is turbulent i.e. Np = Power number = C´ = Constant And the power is given by $P = C' \rho\ Da^5\ N^3$, Np = C´ = 1.05 $P = 1.05 \times 1.45 \times 60^5 \times 1.5^3$ $P = 400\ (Kg\ .m^2) / s^3$ P = 400 / gc P = 400 / 1 P = 400 J/ sec P = 400 Watt ------- ans	1 1 1	