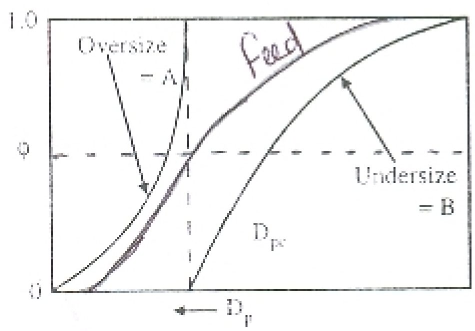
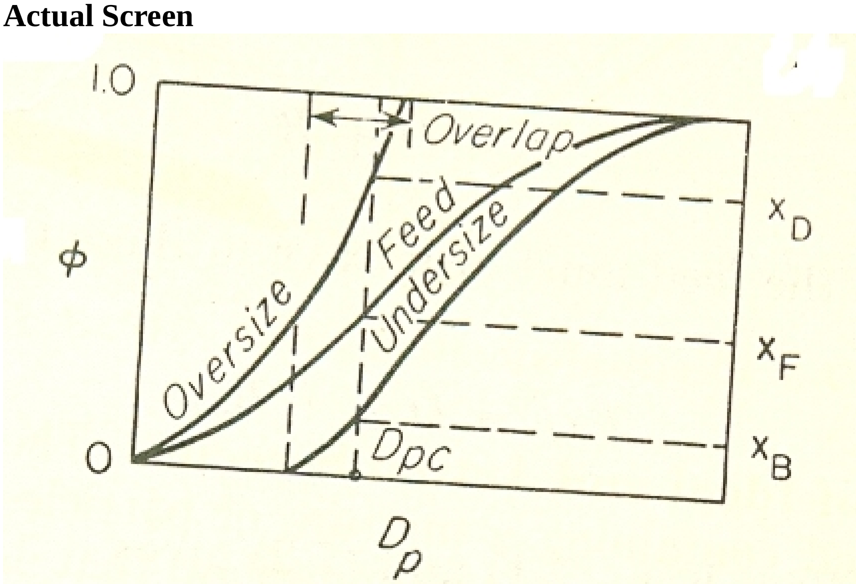
WINTER-14 EXAMINATION

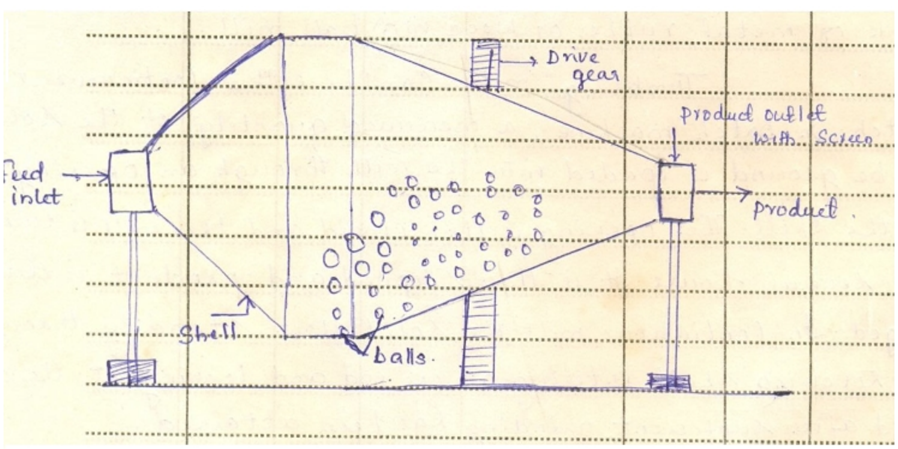
Model Answer

Important Instructions to examiners:

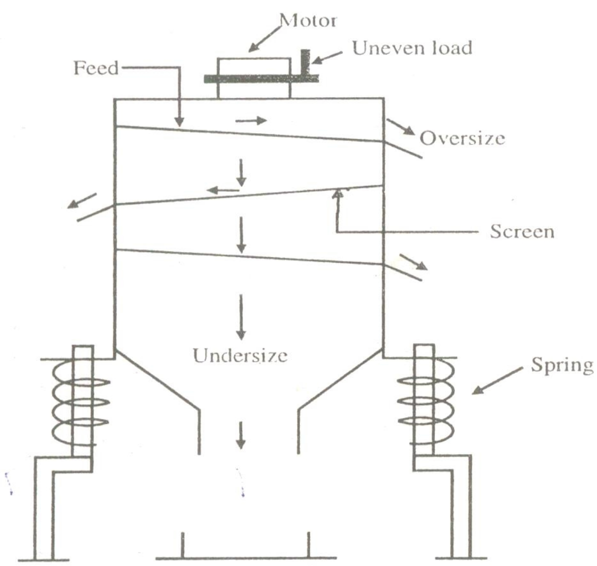
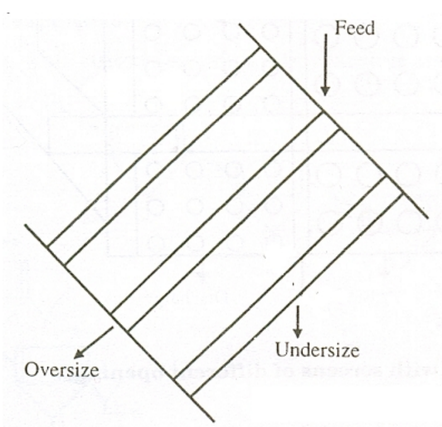
1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling 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-a	**Importance of size reduction equipment:** Size reduction is done 1. To increase the surface area in order to increase the rate of physical or chemical process 2. To improve mixing of constituents in solid-solid mixing 3. To improve solubility 4. Easy packing and handling	½ mark each	2
1A-b	**Bond's law** It states that work required to form particle of size D_p from very large feed is proportional to the square root of the surface to volume ratio of the product S_p / V_p $\frac{P}{\dot{m}} = \frac{K_b}{\sqrt{D_p}}$ where P is the power required $\dot{m}$ is mass flow rate K_b is Bond's constant	2	2
1A-c	**Mesh:** It is the number of openings per linear inch counting from the centre of any wire to a point exactly one inch distant.	2	2
1A-d	**Graphical representation of ideal and actual screen.** **Ideal screen**		2

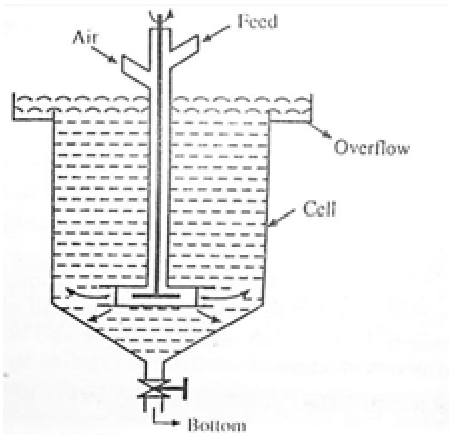
		1	
	Actual Screen  D_{pc} is the cut diameter.	1	
1A-e	**Homogeneous mixture** A mixture which is uniform throughout in physical state and chemical composition is called homogeneous mixture.	2	2
1A-f	**Name of chemical industries where unit operations are carried out:** Petrochemical, petroleum, fertilizer, alcohol, food, pharmaceuticals, paint, dye, oil, cement etc	1 mark each for any two	2

1A-g	**Methods of separating solids from solid-liquid mixture:** 1. sedimentation 2. filtration 3.Centrifuging(centrifugation)	1 mark each for any two	2
1A-h	**Methods of avoiding Vortex Formation:** There are four methods of avoiding vortex formation 1) Off-center mounting of the impeller. 2) Use of Baffles 3) Use of diffuser ring with turbines 4) Angular entry of agitators.	½ mark each	2
1B-a	**Ball mill:** **Principle:** Ball mill works on the principle of impact and attrition. **Diagram:**  **Construction:** The ball mill consists of a steel lined cylindrical shell containing steel balls with its axis horizontal. Feed enters from left through a 60^0 cone in to the primary grinding zone where the diameter of the shell is maximum. And the product leaves through a 30^0 cone to the outlet. The balls act as the grinding medium. Inside of the shell is lined with abrasion resistant	1 2 1	4

	material.		
1B-b	**Classification of size reduction equipment** 1. Crushers – Used for breaking large pieces of solid materials into small lumps (product size upto 6mm) 2. Grinders – Reduces crushed feed to powder (Product size up to 200 mesh). 3. Ultrafine grinders – Accepts feed particles having size less than 6mm and gives product of size 1to 50 µm 4. Cutters – Gives product of definite size and shape.	1 mark each	4
1B-c	$x_F = 0.47$ $x_D = 0.85$ $x_B = 0.195$ Mass ratio of overflow to feed = $\frac{D}{F} = \frac{xF - xB}{xD - xB} = \frac{0.47-0.195}{0.85-0.195}$ = **0.4198** Mass ratio of underflow to feed = $\frac{B}{F} = \frac{xD - xF}{xD - xB} = \frac{0.85-0.47}{0.85-0.195}$ = **0.5801**	 2 2	4
2-a	$D_{pa} = 50mm$ $D_{pb} = 5mm$ P = 80Kw W_i = 6.73KwH/Ton $\frac{P}{\dot{m}} = 0.3162\ W_i\left(\frac{1}{\sqrt{D_{pb}}} - \frac{1}{\sqrt{D_{pa}}}\right)$ $\frac{80}{\dot{m}} = 0.6507$ $\dot{m}$ = **122.94 tons/hr**	 2 1 1	4
2-b	**Vibrating screen:** **Industrial importance:** 1. They are used where large capacity and high efficiency are desired.	 2	4

	2. They have high accuracy of sizing and low maintenance cost per ton of material handled. **Diagram**  	2	
2-c	**Grizzly screen** **Diagram**  **Construction** A grizzly is a grid of parallel metal bars set in an inclined stationary frame	1 2	4

	,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 up to 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 its top is wider than the bottom, & hence the bars can be made fairly deep for strength without being choked by material passing through them. **Application:** It is used in the separation of fines from the feed to a primary crusher.	1	
2-d	**Laws of classification are** 1. Coarse particles have faster settling velocity than small particles of same density. 2.Heavier(high density) particles have faster settling velocity than light particles of same size 3. Settling velocity of particles decreases as density and viscosity of fluid medium increases. **Equipments used for classification:** 1.Gravity settling tank 2. Spiral classifiers 3.Cone classifiers 4.Drag classifiers 5.Rake classifiers 6. Double cone classifiers.	2 2 marks for any four	
2-e	**Froth flotation**		4

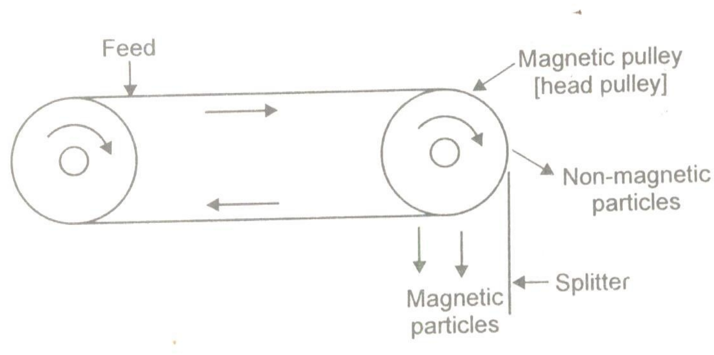
		2	
	Explanation: The mechanically agitated cell consists of a tank having square or circular cross-section. It is provided with an agitator which violently agitates the pulp. The air from a compressor is introduced into the system through a downpipe surrounding the impeller shaft. The bottom of the tank is conical and is provided with a discharge for tailing. An overflow is provided at the top for mineralized froth removal. Water is taken into the cell; material is fed to the cell. Then promoters and frothers are added. Agitations are given and air is bubbled in the form of fine bubbles. Air-avid (hydrophobic) 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. Hydrophilic particles will sink to the bottom and removed from the discharge for tailing.	2	
2-f	**Difference between constant rate filtration and constant pressure filtration**	1 mark each	4

Constant rate filtration	Constant pressure filtration

	1.Rate of filtration is maintained constant	1. Rate of filtration varies		
	2. pressure drop is varying	2. Pressure drop is constant		
	3.Starts with low inlet pressure and continuously increasing the pressure to overcome the resistance of the cake	3. High inlet pressure is applied which is maintained throughout.		
	4. The first particles filtered will not be compacted into a tight mass.	4. The first particles filtered will be compacted into a tight mass due to the high initial pressure applied.		

3-a	**Working of Hammer Mill:** The material to be crushed is fed from the top.The material is thrown out centrifugally & crushed by being beaten between the hammer bars or against the breaker plates fixed around the periphery of the cylindrical casing. The material is beaten by the hammers until it is small enough to fall through a screen. Intermediate hammer mills give a product 25 mm to 20 mesh in particle size.For fine production ,the peripheral speed of hammer tips may reach 112 m/s & they reduce 0.1 to 15 t/hr of the material to sizes finer than 200 mesh.	4	4
3-b	**Variables affecting the 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.	1 mark each	4

	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. **Number of Screening Surfaces**: Use of single-deck screens in series results into most efficient operation as in case of multiple –deck screens, lower decks are not fed ,so their entire area is not used & each separation requires a different combination of angle ,speed & amplitude of vibration for the best performance. 4. **Amplitude &frequency of Vibration**: Proper amplitude of vibration is selected to prevent binding of screen &for long bearing life.		
3-c	**<u>Tramp iron</u>**: Iron courser than 1/8 inch (3.125mm) is called as tramp iron. Magnetic Head Pulley: **<u>Construction & Working of Magnetic Pulleys</u>** :Magnetic pulleys with diameter 1500 mm & width upto 1500 mm are used. Belt speed: 53m/ min for 300 mm diameter & 150m/min for 1500 mm diameter. The pulley is incorporated in a belt conveyor at discharge end.As the material in the form of a thin sheet is conveyed over the pulley ,magnetically inert material drops off the belt in normal way while magnetic material adheres to the belt & falls off from underside where the belt loses the contact with the pulley.The material to be separated must be supplied in the form of a thin sheet in order to subject all the particles to a magnetic field of the same intensity.	1 1 1	4

<table>
<tr><td></td><td>
</td><td>1</td><td></td></tr>
<tr><td>3-d</td><td><u>Comparison between Constant pressure filtration and constant rate filtration:</u>
<table>
<tr><th>Constant rate filtration</th><th>Constant pressure filtration</th></tr>
<tr><td>1.Rate of filtration is maintained constant</td><td>1. Rate of filtration varies</td></tr>
<tr><td>2. pressure drop is varying</td><td>2. Pressure drop is constant</td></tr>
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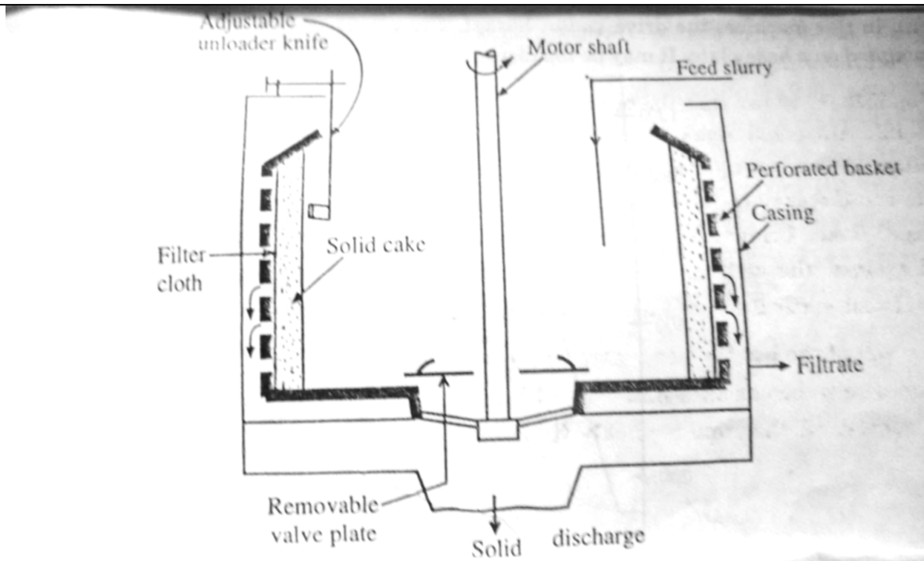
</table></td><td>1 mark each</td><td>4</td></tr>
<tr><td>3-e</td><td><u>Basket Centrifuge</u>:</td><td></td><td>4</td></tr>
</table>

	 **Application of centrifuge**: It can be employed in various sectors like oil refineries,food ,chemical ,textile ,sugar etc.(any 1 application)	3 1	
3-f	**<u>Vacuum drum Filter</u>**: **Construction**: It consists of cylindrical sheet metal drum(dia.50 – 400 cm & length: 50 – 800 cm)mounted horizontally. Outer surface of drum is formed of perforated plate .Filter medium (canvas cloth) covers drum which turns at 0.1 to 2 rpm in agitated slurry trough. Inside outer drum ,asmaller drum wth a solid surface. Annular space between two drums is divided into compartmens by radial partitons& separate connection is made & have a rotary valve.As drum rotates vacuum & air are alternately applied to each compartment.	3	4

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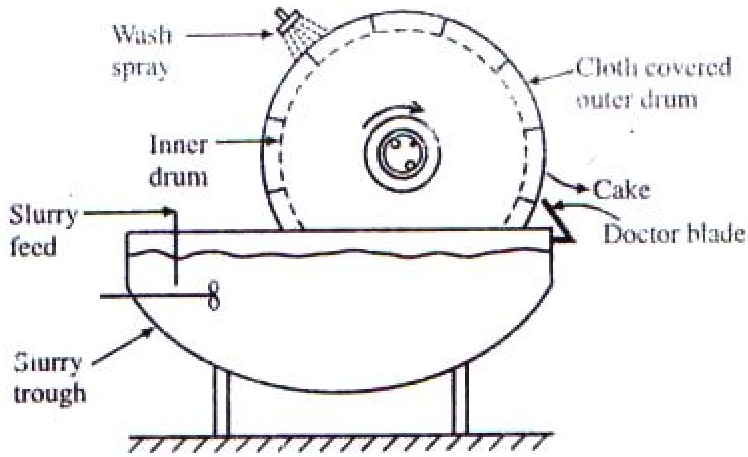
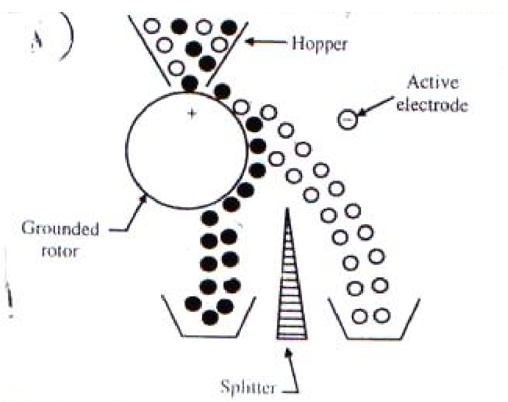
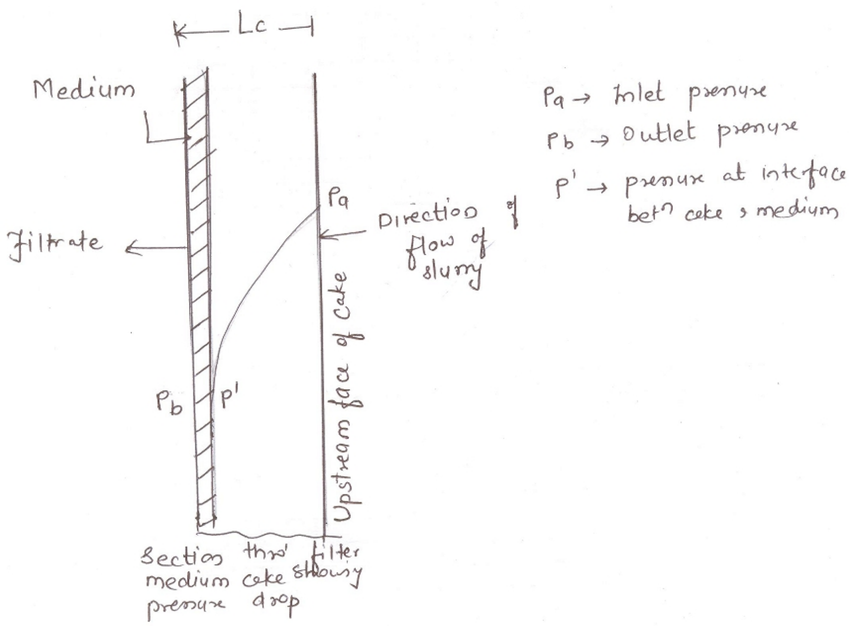
<tr><td></td><td>

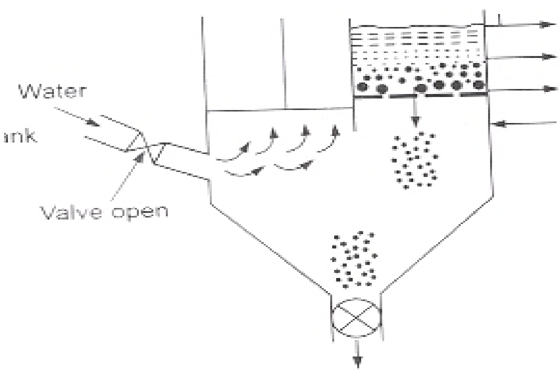
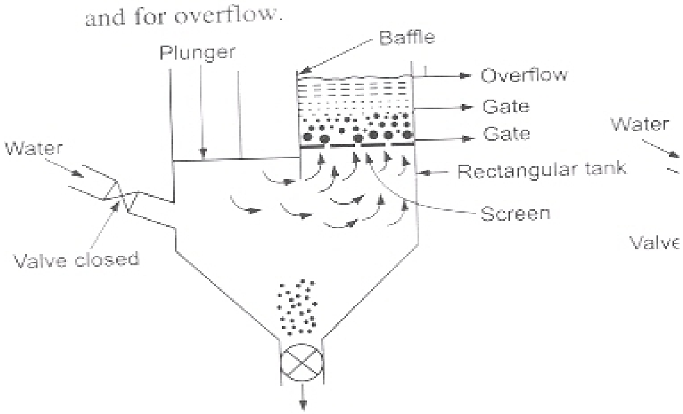
Working principle: In vacuum filter atmospheric pressure is applied in the upstream side and sub atmospheric pressure or vacuum is applied on the downstream side.</td><td>1</td><td></td></tr>
<tr><td>4-a</td><td><u>Derivation forEffectiveness of a screen:</u>
Let feed consists of material A & B,where A is the oversize & B is the undersize material.
Material balances over a screen: 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.
Overall material balance:
Feed = Overflow + Underflow
$F = D + B$ eq. 1
Material balance of A over a screen
$Fx_F = Dx_D + Bx_B$ eq.2</td><td>1</td><td>4</td></tr>
</table>

	As F-B = D *eq.3* *Putting value of D from eq.3 into eq.2,we get* $Fx_F = (F-B)x_D + Bx_B$ $Fx_F = Fx_D - Bx_D + Bx_B$ $(x_D - x_F)F = (x_D - x_B)B$ $\frac{B}{F} = \frac{xD - xF}{xD - xB}$ Elimination of *B* from the above equations gives $\frac{D}{F} = \frac{xF - xB}{xD - xB}$ Screen effectiveness 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 $E_A = \frac{Dx_D}{Fx_F}$ where E_A is the screen effectiveness based on the oversize. Similarly, an effectiveness E_B based on the undersize materials is given by $E_B = \frac{B(1-x_B)}{F(1-x_F)}$ A combined overall effectiveness can be defined as the	1 1	

	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	
4-b	**Electrostatic Separator**: **Principle of ElectrostaticPrecipitator**:"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."Or 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. 	2 2	4
4-c	**Factors affecting rate of filtration**: 1)**Viscosity of filtrate** :Rate of filtration is inversely propotional to viscosity of filtrate. 2) **Area of filter** :Rate of filtration is directly proportional to area of filter surface.	1 mark each	4

	3) **Porosity of cake**: Porosity of cake increases the rate of filtration . 4)**Pressure drop across the filter medium**:If pressure drop across the feed inlet & far side of the filter medium is more, filtration rate is more.		
4-d	**Pressure distribution across the cake & filter medium:**  	4	4
4-e	**Terminal Settling Velocity**: In sedimentation, as the particle falls, its velocity increases and will continue to increase until the resisting force and the accelerating force (force of gravity) are equal. When this point is reached, the particle will settle t a definite constant velocity during remainder of the fall. This velocity is termed as terminal settling velocity.	4	4
4-f	**Free Settling**: 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). In this settling,the individual particle does not collide with other particles or	1	4

	with the wall of container. Practically free settling conditions exist if the concentration of the particles in suspension is less than 1% wt.by solid. Example: Water with dust particles(less than 1% wt of dust) **Hindered Settling** : If the fall of individual particle through stationary fluid is impeded other particles & wall of container, the process is called as hindered settling. Condition for hindered settling : When the concentration of the solid particles is large(> 1% by wt),the particles are so closed to each other that the surrounding particles will interfere with the motion of other particles. Example: Industrial Waste water with sediments/sludge	1 1 1	
5-a	**Data:** Diameter of ball mill = 600 mm = 0.60 m Diameter of ball = 40 mm = 0.040 m Crirical speed of ball mill (Nc) $Nc = \frac{1}{2\pi} \sqrt{\frac{g}{R - r}}$ g = 9.81 m/s² R= 600/2 = 300 mm = 0.300 m r = 40/2 = 20 mm = 0.020 m $Nc = \frac{1}{2\pi} \sqrt{\frac{9.81}{0.300 - 0.020}}$ Nc = 0.942 r.p.s.= 0.942 x 60 = 56.52 ≈ 57 r.p.m. **Critical speed = 57 r.p.m.**	2 2 2 2	8

5-b	**JIGGING:** Jigging is a process of gravity concentration where solids are separated based upon the differences in the behaviors of particles through a moving fluid which in turn, depends upon densities /specific gravity. **Diagram:**  (b) Upward stroke ıulic jig and for overflow.  (a) Downward stroke Fig. 4.8 : Hydraulic ji **Industrial Application:**	2 2 2	8

1)It is used to treat iron ores.

2)It is used treat lead –zinc ores & some non-metalic ores like barite and diamonds

3)It is used for coal concentration.

2

5-c

Graph of Concentration at various height Vs Time

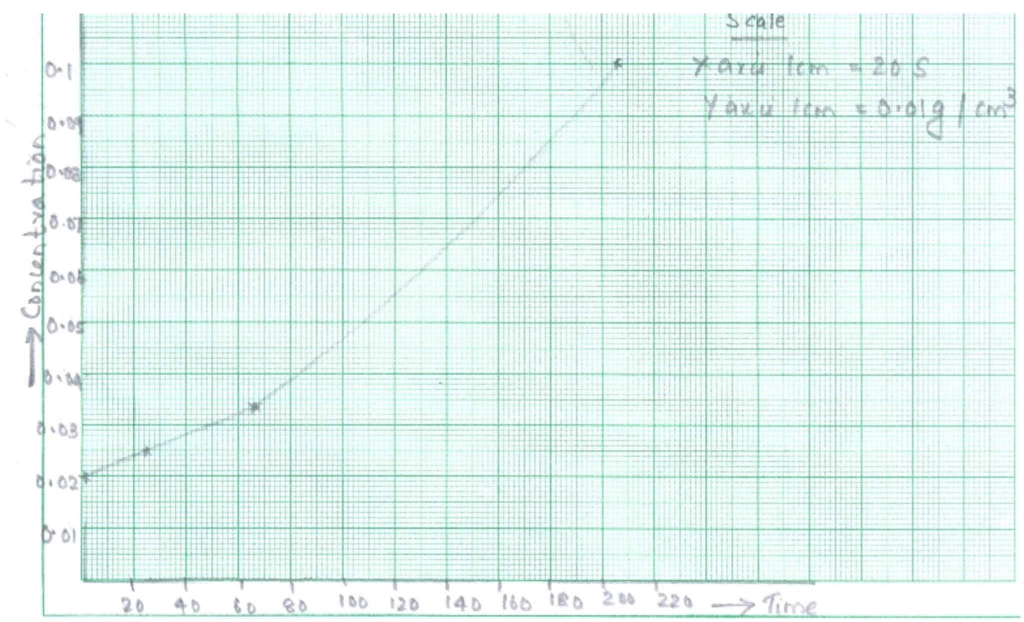
8

$C_0Z_0 = C_iZ_i$

$C_0 = 20g/l = 0.02g/cm^3$ $Z_0 = 50cm$

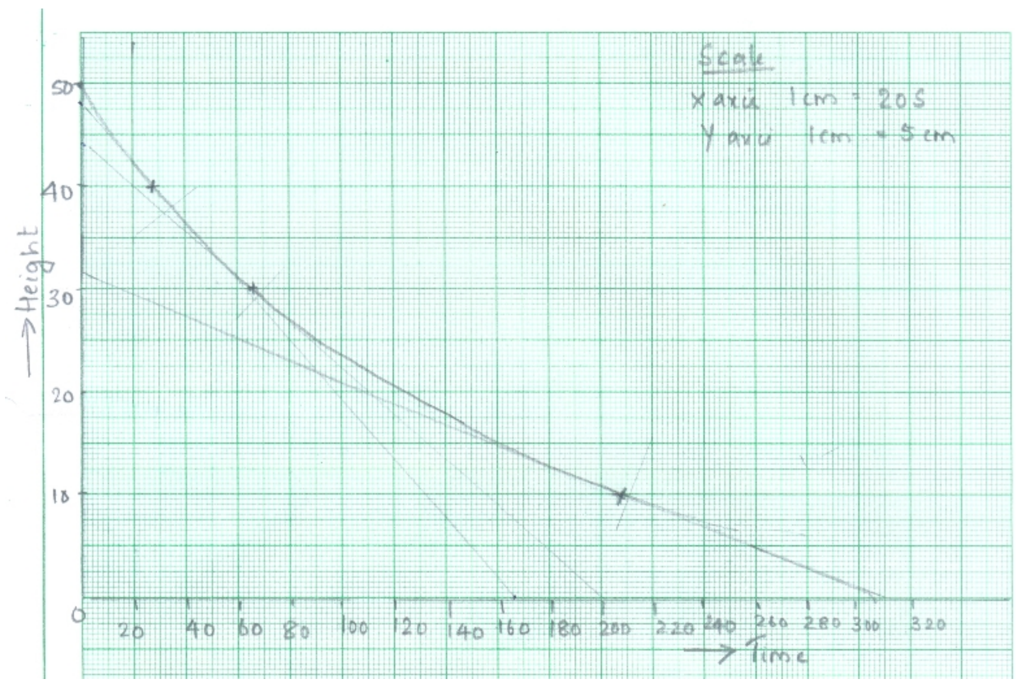
2

Height	50	40	30	10
Time	0	25	65	205
Concentration	0.02	0.025	0.033	0.1



3

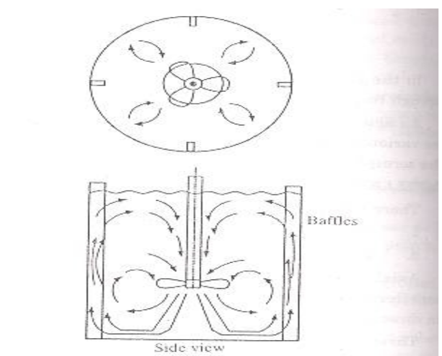
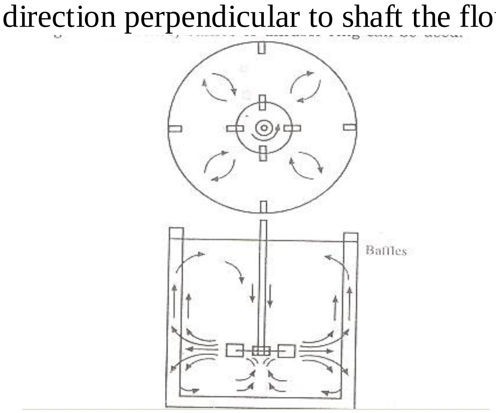
For finding settling velocity: Draw tangents at selected points on the graph of height Vs time. The slope of the tangent gives the settling velocity at that height.

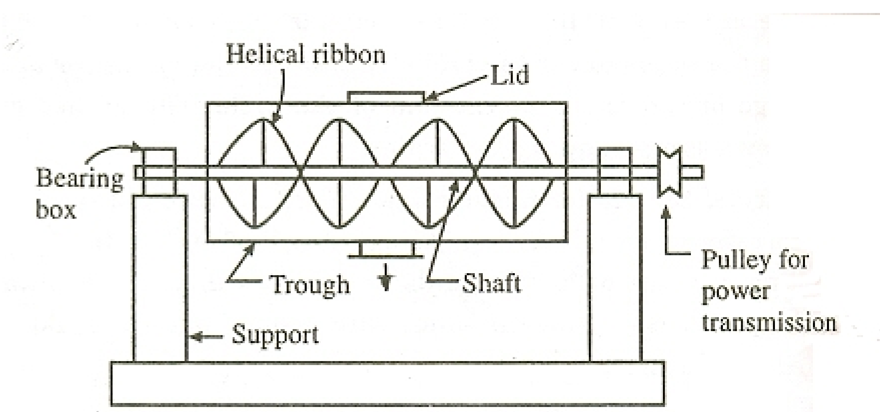


Height	48	44	31.5
Time	166	200	310
Settling velocity	0.289	0.22	0.1016

3 marks should be given for any one value of settling velocity

Q. No.	Answer	Marks	Total Marks
6-a	**Filter aid:** A filter aid is granular or fibrous material which packs to form a bed of very high voidage. Because of this ,they are capable of increasing the porosity of the filter cake.	2	4
	Methods of using Filter Aid: 1) Adding a filter aid to the slurry before filtration 2) Precoating i.e. by depositing a layer of filter aid on the filter medium before filtration	2	

6-b	**Different Types of flow patterns generated in Agitated vessel:** **1) Axial Flow pattern:** When impellers generate flow currents parallel to axis of shaft the flow pattern is called as Axial Flow pattern . In axial flow pattern longitudinal velocity component acts in the direction parallel with the shaft  **Example :** Mixing of paper pulp is carried out by this pattern. **2) Radial Flow pattern:** When impeller generates flow current in tangential or radial i.e. in direction perpendicular to shaft the flow pattern is called Radial Flow pattern.  **Example:** For mixing of some pseudo plastic fluid system this type flow pattern is used.	2 2	4
6-c	**Necessity of Mixing in Process Industries :**	1 mark	4

	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 produced from two or more immiscible fluids and from one or more fluid with finely divided solids.	each	
6-d	**Ribbon Blender:** **Diagram:**  **Working:** In this mixer, two counteracting ribbons are mounted on the same shaft. one of the ribbons moves the solids slowly in one direction, while the other one moves the solids quickly in the other direction . mixing take place due to the	2	4

	turbulence generated by counteracting ribbons and not only by motion of the solids through the trough.	2	
6-e	**Working Principle of Sigma Mixer:** In this mixer, the mixing action is a combination of bulk movement, smearing, stretching, folding, dividing and recombining as the material is pulled and squeezed against the blades, saddles and the walls of trough. The material to be kneaded is dropped into the trough and mixed for a period of about 5 to 20 minutes	4	4
6-f	**Industrial application of Muller Mixer :** 1) It used to crush the material, breaking down lumps and agglomerates. 2) It is used for handling batches of heavy solids. 3) It is used for uniform coating the particles of granular solids with a small amount of liquid. 4) It is used for handling batches of pastes.	1 mark each	4