**SUMMER-15 EXAMINATION**

**Model Answer**

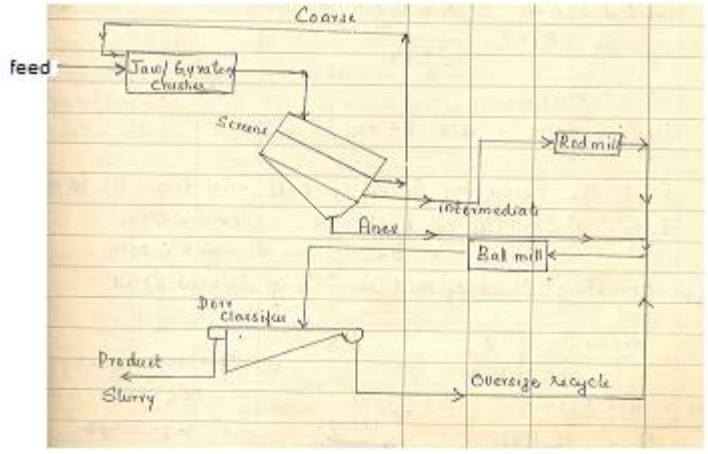
Subject code :(17313)



**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 | **Crushing efficiency:**<br>It is the ratio of surface energy created by crushing to the energy absorbed by the solid. | 2 | 2 |
| 1A-b | **Rittinger's law**<br>It states that the work required in crushing is proportional to the new surface created.<br>$\frac{P}{\dot{m}} = K_r(\frac{1}{\bar{D}_{sb}} - \frac{1}{\bar{D}_{sa}})$<br>where P is the power required<br>$\dot{m}$ is mass flow rate<br>$K_r$ is Rittinger's constant<br>$\bar{D}_{sa}$ = Volume surface mean diameter of feed<br>$\bar{D}_{sb}$ = Volume surface mean diameter of product. | 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.<br>**Screen aperture**: Minimum clear space between edges of openings in the screening surface is termed as screen aperture | 1<br>1 | 2 |
| 1A-d | **Overall material balance for a screen:**<br>Feed = Overflow + Underflow<br>F = D + B | 2 | 2 |
| 1A-e | **Types of impellers:**<br>Propellers, paddles and turbines | 2 | 2 |
| 1A-f | **Separation of solids based on**<br>i) **Specific gravity -** Jigging | 1 | 2 |

| | | | |
|---|---|---|---|
| | **ii) Surface properties of materials** – Froth floatation | 1 | |
| 1A-g | **Principle of Electrostatic Separation:** 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 |
| 1A-h | **Agitation:**<br>It is the induced motion of material in a tank or a vessel.<br>**Mixing:**<br>It is the process of taking at least two different materials and causing them to distribute randomly through one another. | 1<br><br>1 | 2 |
| 1B-a | **Closed Circuit grinding:**<br>If the partially ground material from the size reduction equipment is sent to the size separation unit, from where undersize material is withdrawn as product and oversize material is returned to the machine for regrinding, the process is known as closed circuit grinding.<br>  <br> | 2<br><br>2 | 4 |
| 1B-b | **Angle of nip**: Angle of nip is the angle formed by tangents to the roll faces at a point of contact with particle to be crushed. | 2 | 4 |

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|---|---|---|---|
| | Cos α = $\frac{r+d}{r+R}$<br>Where α is half the angle of nip<br>d is the half the distance between the rolls.<br>r is the radius of the rolls<br>R is the radius of the feed | 2 | |
| 1B-c | **Derivation for Effectiveness of a screen:**<br>Let feed consists of material A & B,where A is the oversize & B is the undersize material.<br>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.<br>**Screen effectiveness based on the oversize material A ($E_A$)** is the ratio of oversize material A that is actually in the overflow to the amount of A in the feed. Thus<br>$E_A = \frac{Dx_D}{Fx_F}$<br>**Screen effectiveness $E_B$ based on the undersize material** is the ratio of undersize material B that is actually in the under flow to the amount of B in the feed<br>$E_B = \frac{B(1-x_B)}{F(1-x_F)}$<br>**Overall effectiveness is**<br>E = $E_A$ $E_B$ =<br>But $\frac{B}{F} = \frac{xD - xF}{xD - xB}$ and $\frac{D}{F} = \frac{xF - xB}{xD - xB}$<br>$E = E_A E_B = \frac{(x_F - x_B)(x_D - x_F)x_D(1-x_B)}{(x_D - x_B)^2(1-x_F)x_F}$ | 1<br>1<br>1<br>1 | 4 |

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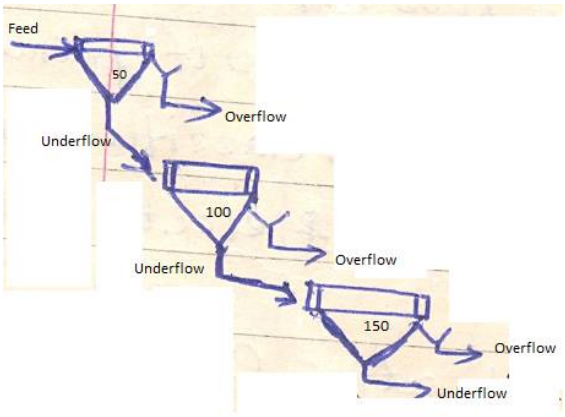
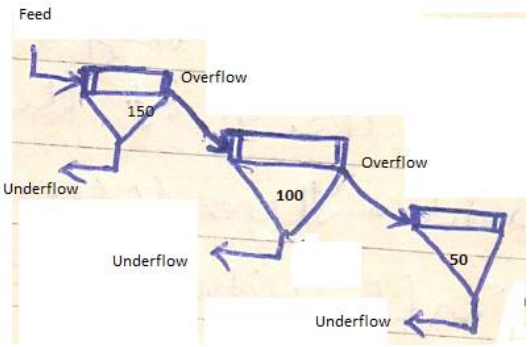
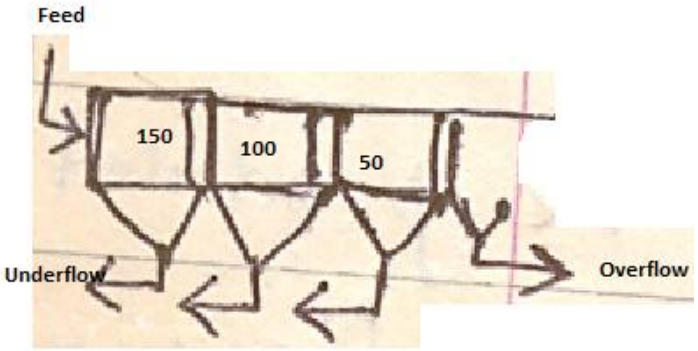
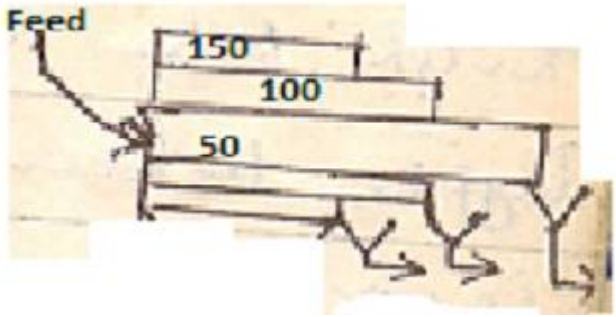
| 2-a | **Work Index:**<br>It is defined as the gross energy requirement in KWH / ton of feed needed to reduce a very large feed to such a size that 80% of the product passes a 100micrometer screen.<br>**Formula:**<br>$\frac{P}{\dot{m}} = 0.3162\ W_i \left( \frac{1}{\sqrt{D_{Pb}}} - \frac{1}{\sqrt{D_{Pa}}} \right)$<br>Where P is the power required in Kw<br>$\dot{m}$ is the mass flow rate in tons / hr.<br>$D_{Pa}$ and $D_{Pb}$ size of the feed and product respectively in mm | 2<br><br>2 | 4 |
| 2-b | **Various trommel arrangements**<br>  <br><br>(a) Coarsest trommel first | 1 mark each | 4 |




(b) Finest trommel first




(c) Single trommel with different perforations




d) Different size screen on concentric trommels.

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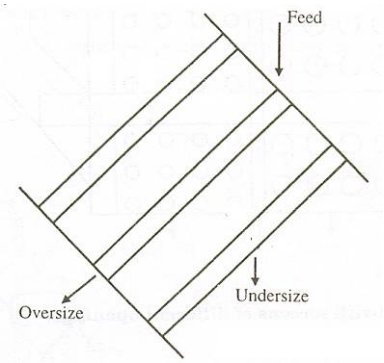
|---|---|---|---|
| 2-c | **Grizzly screen:**<br>**Construction:**<br>  <br><br>A grizzly is a grid of parallel metal bars set in an inclined stationary frame ,with a slope of 30 to$45^0$. The slope & path of the material is parallel to the length of the bars. The length of bar is up to 3 m & spacing 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. | 4 | 4 |
| 2-d | **Classification:**<br>It is the separation of solid particles (from a slurry) into several fractions based on terminal settling velocities.<br>**Laws of classification are**<br>1. Coarse particles have faster settling velocity than small particles of same density.<br>2.Heavier(high density) particles have faster settling velocity than light particles of same size<br>3. Settling velocity of particles decreases as density and viscosity of fluid | 1<br><br><br><br><br>3 | 4 |

| | | | |
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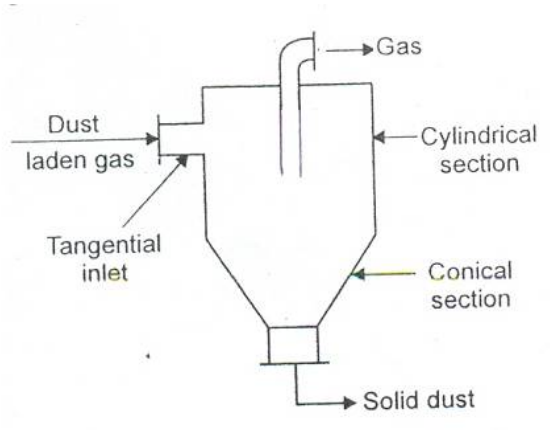
| | medium increases. | | |
| 2-e | **Cyclone separator:**<br>  <br><br>***First part of the question is not clear. so full mark should be given for the diagram*** | 4 | 4 |
| 2-f | **Constant rate Filtration:** The method in which the pressure drop is varied usually from minimum at the start of filtration to a maximum at the end of filtration so that the rate of filtration is constant throughout the run is called Constant rate filtration.<br>**Constant Pressure Filtration:** The method 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 run is called Constant pressure filtration. | 2<br>2 | 4 |
| 3-a | **Hammer Mill**:<br>**Principle** :Size reduction by achieved by impact & attrition<br>**Diagram:** | 1 | 4 |

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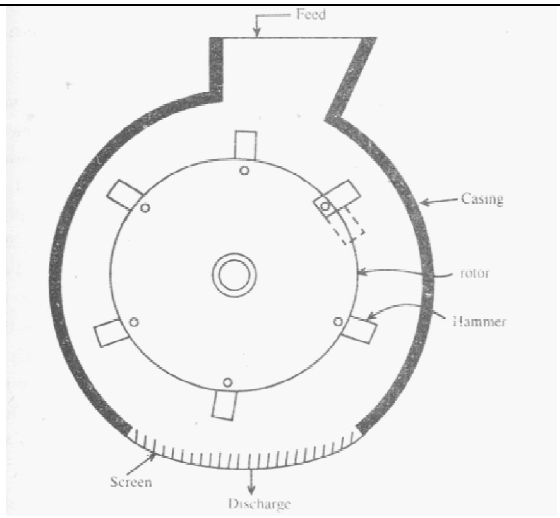
|---|---|---|---|
| |  | 3 | |
| 3-b | **Factors affecting the performance of screen**.<br>1) **Method of feeding**:<br>Particles should approach the screening surface in a direction parallel to the longitudinal axis (perpendicular) of the screen. Particles should be fed at as low velocity as possible.<br>2) **Screen slope**:<br>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.<br>3. **Number of Screening Surfaces**:<br>Use of single-deck screens in series results into most efficient operation. In the 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.<br>4. **Amplitude &frequency of Vibration**: | 1 mark each for any 4 points | 4 |

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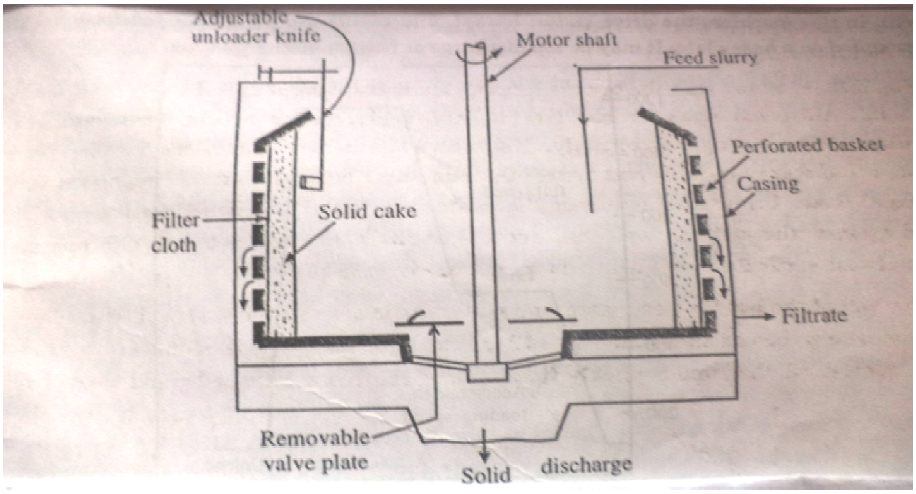
| | Proper amplitude of vibration is selected to prevent binding of screen &for long bearing life.<br>5) **Moisture in feed** : the moisture in feed adversely affects screening operation &should be removed. | | |
| 3-c | **Classification of solids based on magnetic properties**<br>1) **Diamagnetic solids** :which when placed in a magnetic field are repelled by it.<br>2) **Paramagnetic solids**: which when placed in a magnetic field are attracted by the magnetic field.<br>3)**Ferromagnetic solids**: having a high susceptibility to magnetization, the strength of which depends on that of the applied magnetizing field, and which may persist after removal of the applied field<br>**Tramp iron**: Iron courser than 1/8 inch (3.125mm) is called as tramp iron. | 1<br>1<br>1<br>1 | 4 |
| 3-d | In case of constant pressure filtration, application of high pressure results in a low rate of filtration as the first particles filtered will be compacted into a tight mass that largely fills the pores of filter cloth.<br>In case of constant rate filtration, as the maximum pressure is reached towards the end of the run, the whole cycle is operated at less than the maximum capacity. Therefore filters are neither operated under constant pressure nor under constant rate .Practically filtration is carried out at constant rate until the inlet pressure reaches a specified maximum & then it is continued at constant pressure until the end of run. | 2<br>2 | 4 |
| 3-e | **Pressure filters** are preferred. | 1 | 4 |

<table>
<tr><td></td><td>In case of vacuum filters,it can not used for filtration of hot liquids due to their tendancy to boil.We can not use vacuum filtration to filter a solid from a liquid having low boiling point. Any solvent which boils at about 125 degrees or lower will boil off under the reduced pressure in the vacuum filter.</td><td>3</td><td></td></tr>
<tr><td>3-f</td><td>Diagram of top suspended batch centrifuge:<br> 
</td><td>2 marks for diagram and 2 marks for labeling</td><td>4</td></tr>
<tr><td>4A-a</td><td>
<table>
<tr><th>Sr.No.</th><th>Basis</th><th>Grizzlies</th><th>Vibrating screen</th></tr>
<tr><td>1</td><td>Motion imparted to screening surface</td><td>No motion is imparted to screening surface</td><td>Set of screens vibrated electrically or mechanically.</td></tr>
<tr><td>2</td><td>No. of screening surface in one assembly</td><td>Only one</td><td>Assembly with maximum 3decks</td></tr>
<tr><td>3</td><td>Material of construction</td><td>Manganese steel</td><td>Mild steel or stainless steel</td></tr>
</table>
</td><td>1 mark each</td><td>4</td></tr>
</table>

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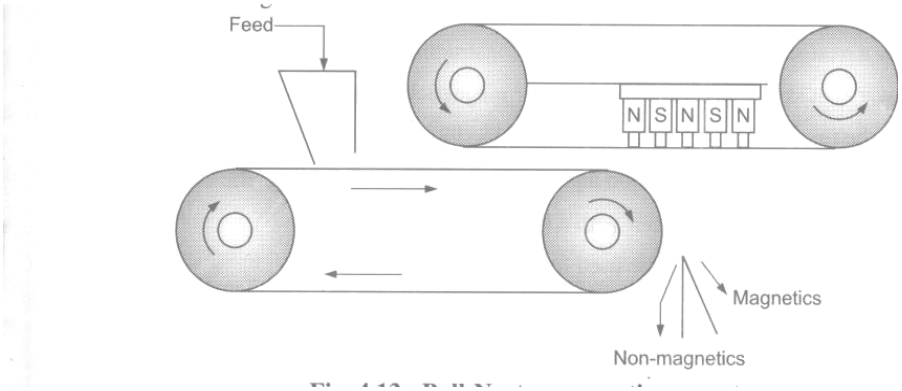
| | 4 | Application | Can handle large size of feed. Used in separation of the undersize or fines from the feed to a primary crusher | Used when large capacity and high efficiency are required.widely used for grading and screening materials like minerals, quarry, building materials, chemical industry | | |
| 4A-b | **Working of Ball –Norton Machine**:<br>It is used for separating magnetic ores from the associated mineral matter. The material to be separated is fed to the lower belt in the form of a thin sheet & is conveyed under the second belt where it is subjected to a magnetic field. The non-magnetic material is discharged in the normal manner, whereas the magnetic material adheres to the lower side of the upper belt & thus carried some distance away from the discharge point of nonmagnetic materials. It ultimately drops-off the belt in to the separate compartment when the belt loses the contact of magnet assembly.<br>  <br> | | | 2<br><br>2 | 4 |

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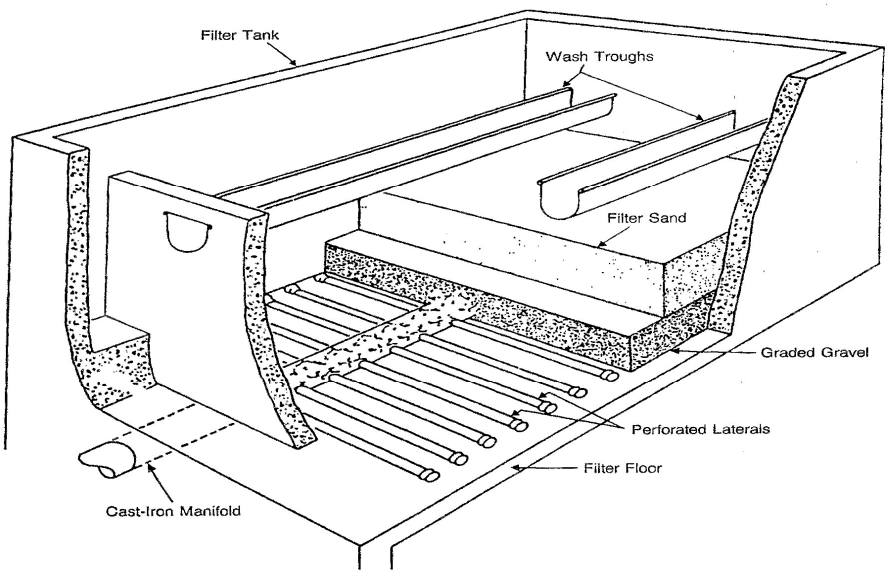
| 4A-c | **Pressure Sand Filters**:<br><br>Pressure sand filter consists of a pressure vessel-this may be either vertical or horizontal-fitted with a set of frontal pipe work and valves, graded silica quartz sand supported by layers of graded under bed consisting of pebbles and gravels, a top distributor to distribute the incoming water uniformly throughout the cross section of the filter, and an under drain system to collect filtered water.<br>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.<br>The Pressure sand filter is now taken out of service and cleaning of the filter is effected by flow rate.<br><br>  <br><br><br>**OR** | 2 | 4 |

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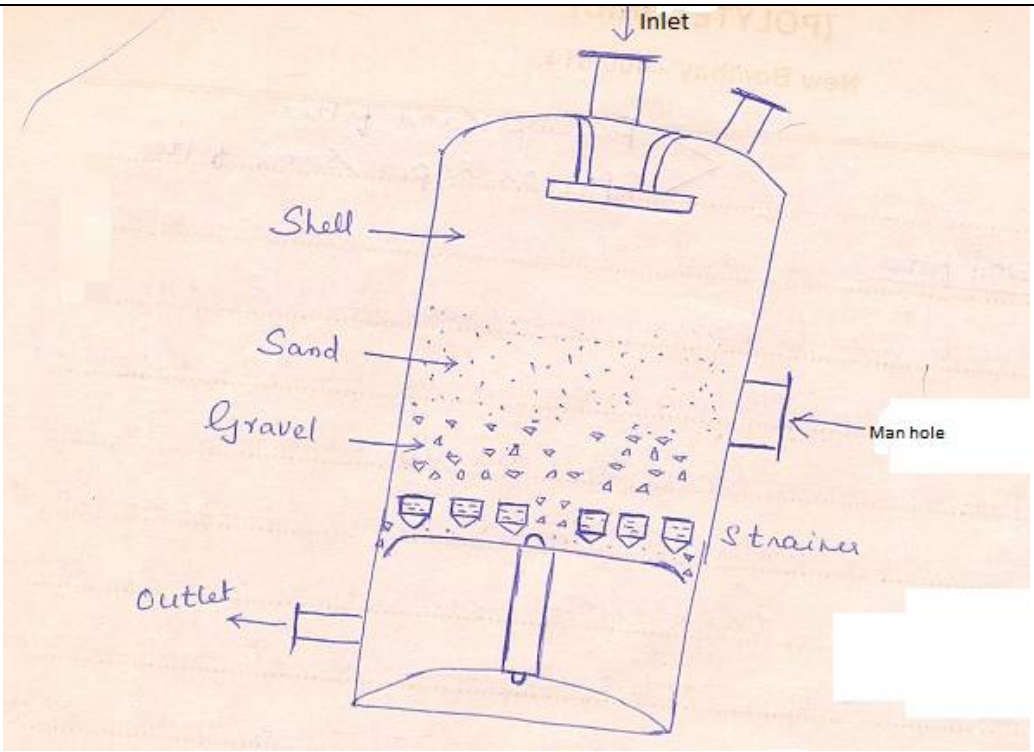
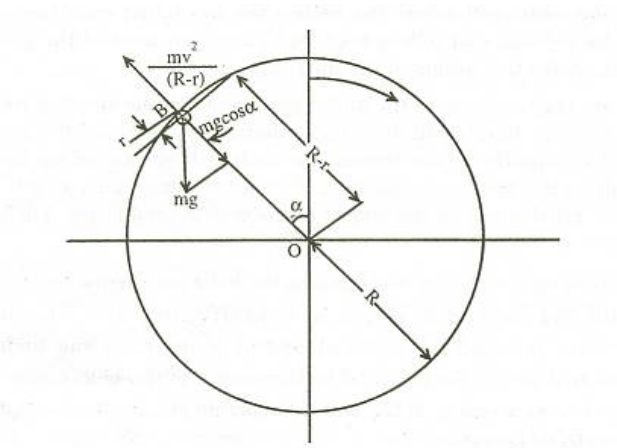
| |  | 2 | |
| 4A-d | **Classification of filters**<br>**i)based on function**:<br>1. Clarifying filters /Deep bed filters :used to remove small amounts of solids to produce sparkling clear liquids.<br>2. Cake filters : used to separate large amounts of solids in the form of cake of crystals.<br>**ii)based on Driving force**:<br>1)Gravity filters<br>2) Vacuum filters<br>3)Pressure filters<br>4) Centrifugal filters | 2<br>2 | 4 |

<table>
<tr><td>4A-e</td><td>Free Settling:<br>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).<br>Hindered Settling :<br>The fall of individual particle through stationary fluid is impeded other particles & wall of container ,the process is called as hindered settling.<br>Effect of Free Settling on particle separation: The terminal falling velocity of a particle freely falling in a liquid is the velocity of the particle when the drag force equals the downward force of gravity acting on the particle. In this case,as the particles as well as wall of container are at sufficient distance, the falling of the individual particle will not be affected by other particle and the wall of the container. Hence settling takes place more fastly than in the case of hindered settling conditions. Separation is achieved more rapidly in free settling conditions.</td><td>1<br>1<br>2</td><td>4</td></tr>
<tr><td>4A-f</td><td><u>Differentiation in between Sedimentation & Centrifugation:</u><br><table><tr><th>Sr.No.</th><th>Basis</th><th>Sedimentation</th><th>Centrifugation</th></tr><tr><td>1</td><td>Principle</td><td>The separation of solids from a suspension in a liquid by gravity settling</td><td>The separation of immiscible liquids or solids from liquids by application of centrifugal force</td></tr></table></td><td>1 mark each</td><td>4</td></tr>
</table>

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | 2 | Application | Used in water treatment | Used in sugar refining | | |
| | | 3 | Space required | more | less | | |
| | | 4 | Equipment used | Sedimentation basins &thickeners | centrifuge | | |
| 5-a | **Derivation for Critical speed of ball mill:**<br>  <br><br>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 mill. Let **α** be the angle between OB and vertical through the point O.<br>The force acting on the ball are :<br>1. The force of gravity = mg where 'm' is the mass of the ball<br>2. The centrifugal force = $mv^2 / (R-r)$. where 'v' is the peripheral speed<br>The component of gravity opposing the centrifugal force is 'mgcosα' | | | | | 1<br>3 | 8 |

| | | | |
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| | As long as the centrifugal force exceeds the gravity force component, the particles will not lose contact with the wall. If the above opposing forces are equal, the ball is ready to fall away from the wall.<br>Thus,<br>$mg\cos\alpha = mv^2 / (R-r)$ ---- (1)<br>$\cos\alpha = v^2 / (R-r)\, g$ -------(2)<br>The relationship between the peripheral speed and the speed of rotation is given by $v = 2\pi N (R - r)$ ----------(3)<br>substituting the value of ' v' in equation (2)<br>$\cos\alpha = 4\pi^2 N^2 (R - r) / g$ -------(4)<br>At the critical speed : $\alpha = 0$ and thus $\cos\alpha = 1$ and N becomes the critical speed Nc<br>$\cos\alpha = 1 = 4\pi^2 N^2 (R - r) / g$<br>$Nc^2 = g / 4\pi^2 (R - r)$<br>$\mathbf{N_c = \frac{1}{2\pi}\sqrt{\frac{g}{(R-r)}}}$ | 2<br><br>2 | |
| 5-b | **Principle of froth flotation :**<br>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.<br>**Role of Promoters or collectors:** Promoters are materials which are adsorbed on the surface of the particles forming a unimolecular layer .Solids can be made hydrophobic with the help of promoters.<br>**Role of Modifiers:** Modifiers are materials which form surface films on the particle and thus preventing the adsorption of promoters.. | 2<br><br>2<br><br>2 | 8 |

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| | **Role of Frothing agent:** Frothing agents are materials which induce the formation of a froth of sufficient stability in order to retain the particles of the constituent which is to be floated to be discharged as an overflow. | 2 | |
| 5-c | **Functions of thickener:**<br>1. To produce clear liquid.<br>2. To produce given degree of thickening of suspension.<br>**Role of coagulants in filtration:**<br>I is not possible to remove finely divided and colloidal particles from water by filtration. In order to remove this, coagulants are added to water before filtration. The coagulants when added to water get hydrolyzed and form precipitates. The finely divided suspended matter get stick to this precipitate and are removed. Alum is the most commonly used coagulant. But if alum is to be used, water should have some alkalinity. For this, soda ash or lime is added to water. Alum coagulates best in the pH range of 6 to 8.<br>**Eg:** Aluminium sulphate( alum), ferrous sulphate | 2<br><br>4<br><br>2 | 8 |
| 6-a | **Formula to calculate filter medium resistance:**<br>$R_m = \frac{\Delta P_m}{\mu U}$<br>Where $R_m$ is the filter medium resistance.<br>$\Delta P_m$ is the pressure drop across the filter medium.<br>$\mu$ is the viscosity of the filtrate<br>U is the velocity of the filtrate.<br>**Formula to calculate cake resistance:**<br>$\alpha = \frac{\Delta P_{C\,A}}{\mu U m_C}$<br>Where $\Delta P_c$ is the pressure drop over cake.<br>A is the area of filter medium measured perpendicular to the direction of flow. | 1<br><br>1<br><br>1<br><br>1 | 4 |

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|---|---|---|---|
| | μ is the viscosity of the filtrate<br>U is the velocity of the filtrate.<br>$m_c$ is the total mass of solids in the cake. | | |
| 6-b | **Methods to prevent Vortex Formation:**<br>There are four methods of prevention of swirling and vortex formation<br>a) Off-center mounting of the impeller.<br>b) Use of Baffles<br>c) Use of diffuser ring with turbines<br>d) Angular entry of agitators. | 2 marks each for any 2 points | 4 |
| 6-c | **Mixing index:**<br>It is a measure of the homogeneity of the mixture. ie the degree of uniformity of the mixture.<br>**Formula to calculate mixing index:**<br>**For granular solids**<br>$I_S = \sqrt{\frac{(N-1)\mu(1-\mu)}{n\sum_1^N (x_{i-}\overline{x})^2}}$<br>Where $I_S$ is the mixing index.<br>N is the number of sample.<br>μ is the weight fraction of desired solid in the feed.<br>$x_i$ is the weight fraction of desired solid in the sample/<br>$\bar{x}$ is the $\frac{\varepsilon X_i}{N}$<br>N is the number of particles in the sample.<br>***Formula to calculate mixing index for other types of mixtures should also be given consideration***. | 2<br>2 | 4 |
| 6-d | **Mixer used for coating granular solids with a small amount of liquid.**<br>Muller mixer. | 1 | 4 |

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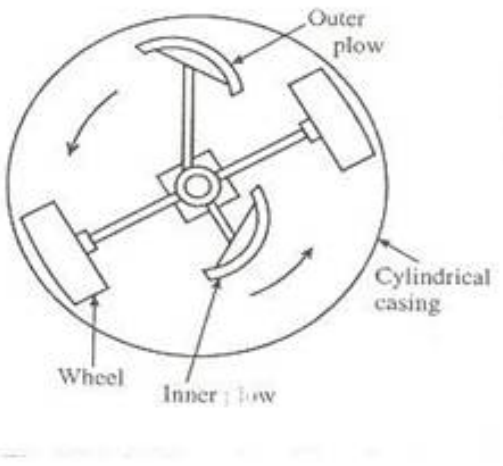
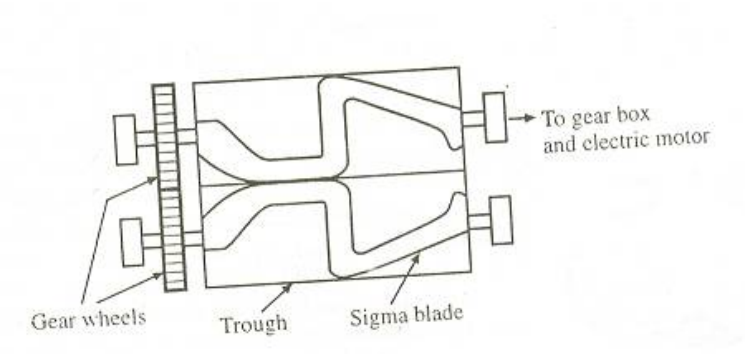
|---|---|---|---|
| | **Construction:**<br>  <br><br>It consists of a pan incorporating heavy wheels known as muller wheels. In some designs, the pan is stationary and the wheels rotate wheras in the other the pan is rotated the axis of the wheel is held stationary. Plows guide the solids under the muller wheels during mixing. A discharge opening is provided on the pan floor. | 3 | |
| 6-e | **Sigma Mixer:**<br>**Construction:**<br>  <br> | 2 | 4 |

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| | It consists of a short rectangular trough with saddle shaped bottom. Two counter rotating blades are incorporated in the trough. Blades are so placed and so shaped that the material turned up by one blade is immediately turned under adjacent one. The blades are driven by through a gear mechanism provided at either ends. The trough may be open or closed and may be jacketed for heating or cooling. The machine can be emptied through a bottom valve.<br>**Working:** The material to be kneaded is dropped into the trough. The blades turn towards each other at the top, drawing the mass downward. then shearing it between the walls and blades of the trough. It is mixed for about 5 to 20 minutes or longer . The trough is then unloaded by tilting it. | 2 | |
| 6-f | D = 40 cm = 0.4 m<br>N = 100 rpm = 1.667 rps<br>$\rho$ = 15 kg / $m^3$<br>Np = 9<br>$N_p = P / (N^3D^5\rho)$<br>$P = Np / (N^3D^5\rho) = 9 / (1.667^3 * 0.4^5 * 15) =$ **6.4 Watt** | 1<br><br>2<br>1 | 4 |