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(Autonomous)
(ISO/IEC - 27001 - 2005 Certified)

WINTER-19 EXAMINATION
Model Answer

___

Subject title: Mechanical Operation

Subject code: 22313

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.

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Q No.		Answer	Marking scheme
1		**Attempt any FIVE of the following**	**10**
1	a	**Definition of Sphericity:** Sphericity(φ_s) is the ratio of surface-volume ratio for a sphere of diameter Dp to the surface–volume ratio for the particle whose nominal size is Dp. **OR** It is the ratio of surface area of sphere of same volume as particle to surface area of particle	2
1	b	**Principles by which size reduction takes place** 1. Compression 2. Impact 3. Attrition 4.Cutting	½ mark each
1	c	**Definition:** **(i) Mesh number:** It is the number of openings per linear inch counting from the center of any wire to a point exactly one inch distant. **(ii) oversize particle:** Particles whose size is greater than the size of the opening of the screen (screen aperture) is known as oversize particle	1 1
1	d	**Equipment used for** **(i) sedimentation:(any one)** Thickener, clarifier	1

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		(ii) Filteration:(any one)	
		Rotary drum filter, sand filter, plate and frame filter press, basket centrifuge etc	1
1	e	**Working principle of cyclone separator:**	2
		A cyclone separator is essentially a settling chamber in which centrifugal force is use for separating fine solid particles from gases.	
1	f	**Conveyor used for**	
		(i) Horizontal movement:(any one)	
		Belt conveyor, chain conveyor, screw conveyor, pneumatic conveyor	1
		(ii) Vertical movement	
		Bucket elevator	1
1	g	**Diagram of turbine type agitator:** (a) Open straight blade (b) Bladed disk/ flat disk blade (c) Vertical curved blade (d) Shrouded curved blade with diffuser ring	2 marks for any one diagram
2		**Attempt any THREE of the following**	**12**
2	a	**Open circuit grinding:**	
		If the feed material is passed only once through the size reduction machine and no attempt is made to return the oversize material to it for further reduction , the process is known as open circuit grinding	2

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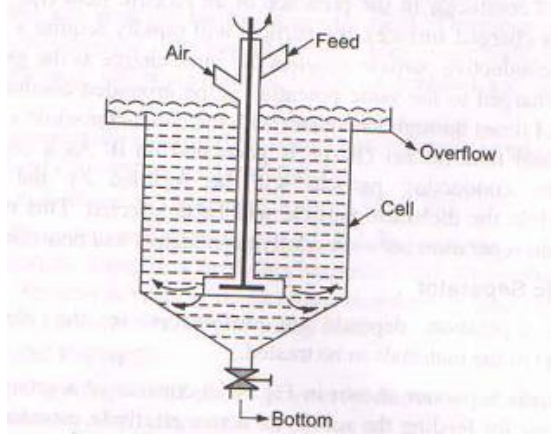|			
		Closed Circuit grinding: If the partially ground material from the size reduction equipment is sent to the size separation unit, from where undersize material is withdrawn as product and oversize material is returned to the machine for regrinding, the process is known as closed circuit grinding. 	2
2	b	**Froth flotation:** **Working:** Water is taken into the cell; material is fed to the cell. Then promoters and frothers are added. Agitation is given and air is bubbled in the form of fine bubbles. Air-avid particles (hydrophobic) 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

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			2
2	c	**(i) Factors affecting the rate of sedimentation:** 1. Particle size 2. Density the particle 3. Temperature of the slurry 4. Concentration of the slurry 5. Viscosity of the fluid medium 6. Chemical pretreatment of the feed suspension 7. Depth of the tank below feed inlet	½ mark each for any four points
		(ii) Free settling: Free settling is the settling of the particle unaffected by other particle and the boundary of the container. Practically free settling conditions exist if the concentration of the particles in suspension is less than 1% wt.by solid.	1
		Hindered settling: Hindered settling is the settling of particles affected by other particles and by the boundary of the container. When the concentration of the solid particles is large (> 1% by wt.),the particles are so close to each other that the surrounding particles will interfere with the motion of other particles.	1

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2	d	**Electrostatic precipitator**	
		Working :	
		A high voltage is applied to the discharge wires to form an electric field between the wires and the collecting plates and also ionizes the gas around the discharge wires to supply ions. When the gas that contains an aerosol (dust,mist) flows between the collecting plates and the discharge wires, the aerosol particles in the gas are charged by the ions. The Coulomb force caused by the electric field causes the charged particles to be collected on the collecting plates, and the gas is purified.	2
		Diagram:	
			2
		OR	

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3		**Attempt any THREE of the following**	12
3	a	**Hammer mill:**	
		Diagram:	

Working:

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

2

2

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		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.	
3	b	Data: Radius of Ball mill = R = D/2 = 1200 /2 = 600 mm =0.6 m Radius of Ball = d/2 = 75 /2 = 37.5 mm =0.0375m The critical speed of Ball mill is $$N_c = 1/2\pi \sqrt{\frac{g}{R-r}}$$ $$N_c = 1/2\pi \sqrt{\frac{9.81}{0.6 - 0.0375}} = 0.665 \text{ rps}$$ Operating speed of Ball mill = $N_c *0.7$ $= 0.55 \ X \ 0.665 = \textbf{0.4655 rps = 27.93rpm}$	2 2
3	c	**Magnetic drum separator:** **Diagram:** 	2
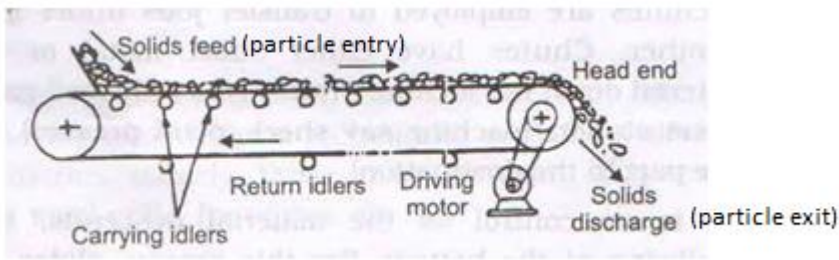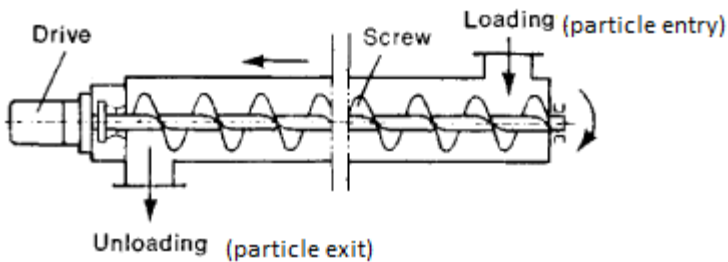
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		Working: The feed (mixture of magnetic & non-magnetic materials) is admitted at the top & is allowed to fall on the rotating drum. The non-magnetic material is discharged in a normal manner. The magnetic material adheres to the drum & falls off underside when the drum loses the contact of the magnet assembly.	2
3	d	**Diagram with parts and particle entry and exit:** **(i) Belt conveyor:** **(ii) Screw Conveyor:** 	2 2
4		**Attempt any THREE of the following**	**12**
4	a	$$\frac{P}{\dot{m}} = 0.3162W_i \left[\frac{1}{\sqrt{D_{pb}}} - \frac{1}{\sqrt{D_{pa}}} \right]$$ $\dot{m} = 150$ ton/hr. $\quad W_i = 12.74$ $D_{pb} =$ Product size $= 3.125$ mm	

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		D_{pa} = Feed size = 50 mm Putting all the values, $$\frac{P}{150} = 0.3162 * 12.74 \left[\frac{1}{\sqrt{3.125}} - \frac{1}{\sqrt{50}}\right]$$ $$\frac{P}{150} = 0.3162 * 12.74 \left[\frac{1}{0.561} - \frac{1}{0.1414}\right]$$ $$\frac{P}{150} = 1.71$$ Power required P = **256.4kW**	2 2
4	b	**Importance of screening/ screen analysis in chemical industry:** Screening is carried out in industry to 1. Remove fines from the feed material before sending it for size reduction. 2. Prevent the oversize material from entering into any other unit operation. 3. Produce a commercial grade material to meet particle size specification. 4. Remove fines from a finished product prior to shipping 5. Determination of particle size is more important in Chemical Engineering, as the particle size determines the effectiveness of final product. The characters of particle such as bulk density, physical stability, permeability and many more are decided by its size.	1 mark each for any four
4	c	**Basket centrifuge** **Principle:** : A centrifuge is any rotating machine in which centrifugal force is utilized for separation of solids from liquids. **Working:** Slurry fed to the rotating basket is forced against basket sides by centrifugal force. The liquid passes through the filter medium into the casing and out through a discharge pipe, while the solids form a filter cake against the filter	1

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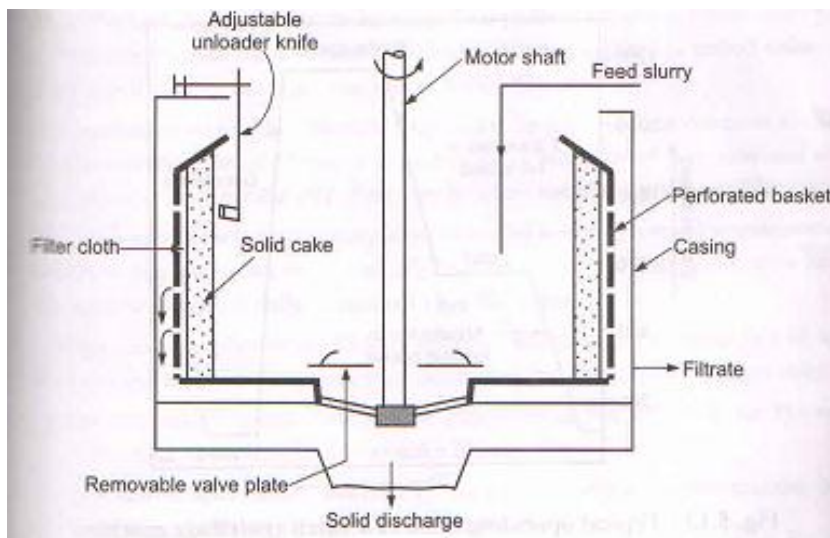
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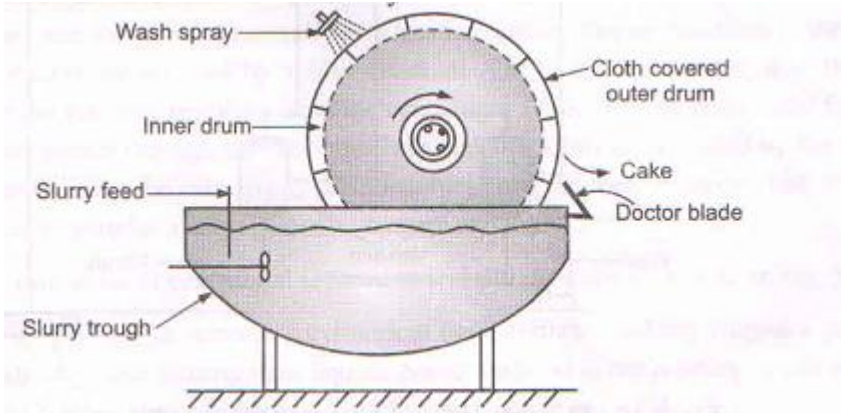|			
		medium. Cake is washed by spraying wash liquid to remove soluble material. Wash liquid leaves the centrifuge through the discharge pipe. After washing, cake is spun at higher speed. The cake is dislodged from the filter cloth with the help of an unloader knife. 	3
4	d	**Rotary drum filter:** **Working:** Filter drum is immersed in slurry, vacuum applied to filter medium causes cake to deposit on outer surface of drum. Cake is washed by spraying wash liquid; wash liquid is collected in a separate tank. Then cake enters into drying zone as drum rotates where cake is partially dried by sucking air through cake of solids. Then vacuum is cut off & cake removed with a doctor's knife. Air is blown for removal of cake.	2

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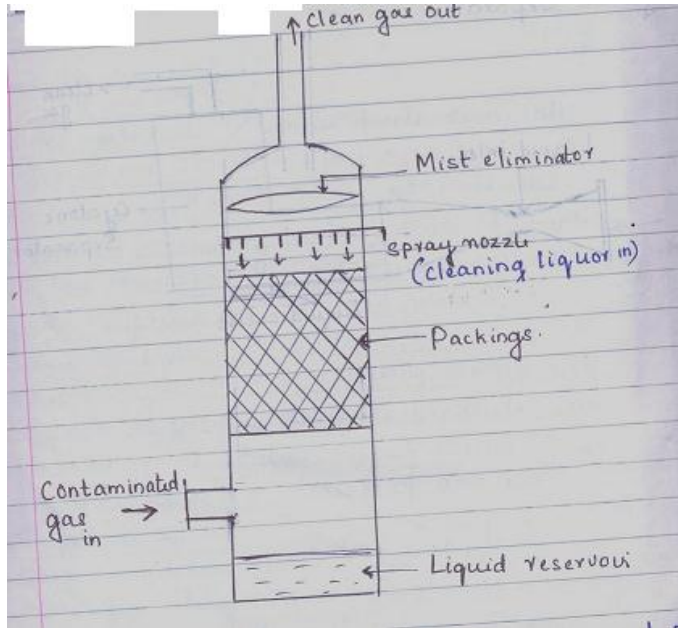|		**Diagram:**	
			2
4	e	**Industrial application**	
		(i) Fabric filter:(any two)	
		Fabric filters are used filters to control emission of air pollutants by power plants, steel mills, pharmaceutical producers, food manufacturers etc	1 mark each
		(ii)Electrostatic filter:(any two)	
		Electrostatic precipitators are used in ore dressing, for removing ash from mined coal, recycling of plastic waste , Coal-burning electric generating plants, primary and secondary smelters, incinerators etc	1 mark each
5		**Attempt any TWO of the following**	**12**
5	a	**Wet scrubber:** **Construction and working** The contaminated air is drawn through a packing zone filled with suitable packing which are irrigated with cleaning liquor. The impurities come in good contact with the absorbing liquor and hence a high cleaning efficiency is obtained. A mist eliminator following the packing zone removes any entrained liquid particles, leaving the exhaust air containing less than 2% of the original	4

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contaminant.

(OR)

Construction:

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		Wet scrubber systems generally consist of the following components: • Ductwork and fan system • A saturation chamber (optional) • Scrubbing vessel • Entrainment separator or mist eliminator • Pumping (and possible recycle system) • Spent scrubbing liquid treatment and/or reuse system • An exhaust stack **Working:** In a wet scrubber, the polluted gas stream is brought into contact with the scrubbing liquid, by spraying it with the liquid, by forcing it through a pool of liquid, so as to remove the pollutants.	
5	b	**Swirling and Vortexing:** If low viscosity liquid is stirred in an unbaffled tank by a centrally mounted agitator, there is a tendency for nearly pure rotary flow pattern to be developed and lighter liquid, ie air is usually drawn in to form a vortex and the degree of agitation is very much reduced. This phenomenon which takes place in an unbaffled tank regardless of the type of impeller is known as vortexing. **Methods to avoid Vortexing :** 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.	3 3

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Angular entry of agitator

Off center entry of agitator

Baffles

Baffled tank

5	c	**Industrial Application of:**	
		(i)Pneumatic Conveyor:(any two)	1 mark
		1. feeding mixers with powders of all types	each
		2.supplying reactors	
		3. supplying vibrating sifters	
		(ii)Chain Conveyor:(any two)	
		1.supplying granulators	1 mark
		2. automatically feeding packaging machines	each
		3.automatically feeding encapsulating machines, compressing machines, etc	

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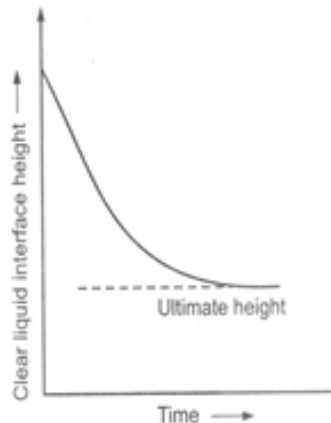|			
		(iii) **Screw Conveyor:(any two)** It is used for conveying 1. Municipal Dewatered Sludge or Bio solids 2. Oilfield Drill Cuttings 3. Food Waste 4. Dewatered Grit or Screenings 5. Filter Press Cake	1 mark each
6		**Attempt any TWO of the following**	**12**
6	a	**Batch sedimentation:** A- clear liquid B- Original slurry C- transition zone D- settled solids Prepare slurry of uniform concentration. The particles begin to settle and attain terminal settling velocity under hindered settling conditions. The heavier faster settling particles settled at the bottom are indicated by zone D. Above zone D forms another layer called zone C, which is a transition layer, the solid content of which varies from that in the original pulp to that in zone D. Above zone C is zone B which has the same concentration as the original pulp. Above zone B is zone A, which is a zone of clear liquid. As sedimentation continues, the depth of zone A and D increases, that of zone C remains constant and zone B decreases. After further settling, zone B and C	2 4

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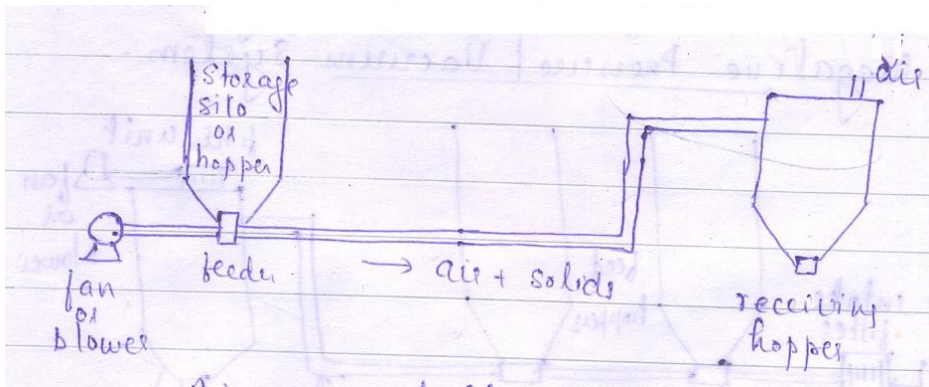Subject title: Mechanical Operation

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		disappear and all the solids are in zone D. Then a new effect called compression begins. In compression, a portion of the liquid which has accompanied the solids into the zone D is expelled and the thickness of this zone decreases. After some time, the sludge reaches ultimate height. The entire process is called sedimentation.	
6	b	**Positive type Pneumatic conveyor:** **Explanation:** It works on the principle of using a stream of air or gas for the transportation of dry granular solids through a pipe line. Air or suitable gas is blown along a pipeline, which carries the bulk solid to be	2 4

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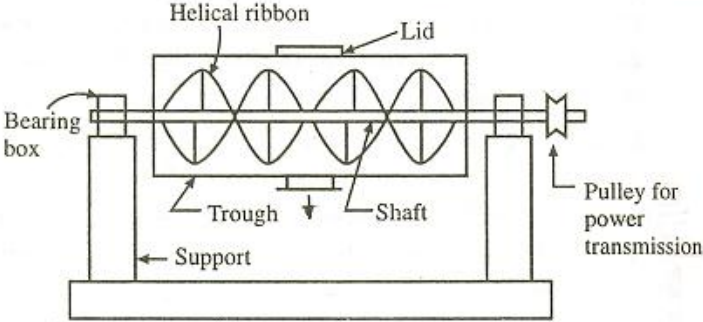|			
		conveyed. Fan or blower is used to deliver air into the pipeline. Feeders are used to introduce the material into the pipeline against the conveying gas pressure. Gas/ solid disengaging device are used at the discharge end of the pipeline, which separates the conveyed bulk solid from the conveying air stream. The cyclone separator or bag filter units are used for this purpose. The clean gas/ air coming out from these devices is fed back for conveying purpose. These systems are useful for picking up solid from one point band delivering them to various discharge points. They are used for free flowing materials up to ¼ inch size. But it is unsuitable for multiple pick up points on account of excess air leakage.	
		(OR)	
		Pneumatic conveying is nothing but transportation of dry bulk particulates or granular material through pipe line by a stream of air or gas.	
		This conveying system consist of the source of air/gas feeder with hopper, receiving hopper fitted with a means of separating the conveyed product from the conveying air	
		In this system, air or suitable gas is blown along a pipeline with help of fan or blower, which carries the bulk solid to be conveyed, fed from feeder that is finally discharged into a receiving hopper. The fan or blower is used to deliver air into pipeline. Feeders are used to introduce the material into the pipe line against the conveying gas pressure	
6	c	**Mixer/blender used for mixing dry powder:** Ribbon blender **Ribbon blender:**	1

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Construction:

It consists of a horizontal semi cylindrical trough having a central shaft & a helical ribbon agitator. Two counteracting ribbons are mounted on same shaft. One of the ribbons moves the solids slowly in one direction, while the other moves the solids in other direction .Mixing takes place due to turbulence generated by counteracting ribbons.

3

2