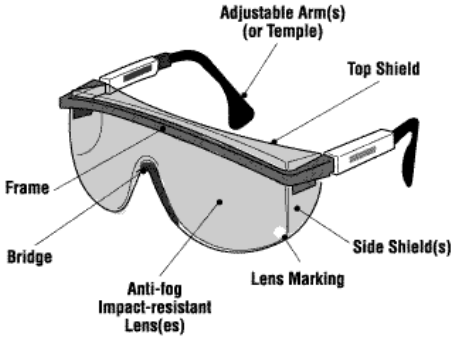
Important Instructions to examiners:

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	Sub q.no	Answer	marks
1-A		**Answer any 3**	**12**
1A	a	**Plant safely provision in an industry (any 4)** 1. Safe work place layout: The layout should be such that every workman has enough space to move and operate. 2. Design of control facilities: Dikes of liquid storage tanks are normally sized to contain the volume of the largest tank plus 10% of the volume of the remaining tanks within a common enclosure. 3. Proper working conditions: Air temperature, purity, velocity, humidity are controlled for comfort. 4. Safe material handling: Careless handling of heavy materials and components is a major source of back and foot injuries. 5. Use of personnel protective devices: Personal protective devices such as breathing apparatus, helmet, hard hat, ear plug, ear muff, safety shoues, apron, goggles etc should be used. 6. Safety activities in the organization: Provide wire meshguards to all rotating parts, High voltage equipment and machines which cannot be guarded should be fenced.	1 mark each
1A	b	**Common sources of electrical hazards** : The danger of injury through electrical shock is present whenever electrical power is used. The primary effect of electric shock are due to current actually flowing through the body. Electrical burns occur when the body completes a	4

		circuit connecting the power source with the ground. **Potential sources :** 1. Voltages between phases and between phases and neutral. 2. Voltages between phases, neutral and earth where there is any conductive surfaces. 3. Voltages across open switch contacts. 4. Voltages across undischarged capacitors. 5. Voltages on disconnected conductors. 6. Voltages caused by static electricity. 7. Incorrect wiring connection. 8. Faulty equipment.	
1A	c	**Diagram of personal protective device(any 2)**  Helmet hand gloves	2 mark each

		  Ear plug Apron(suit)   Goggle Safety shoes	
1A	d	**Factors to be considered for selection of proper respiratory devices(any 4)** i) The nature of the hazardous operation or process. ii) Type of the contaminant and its properties. iii) Duration for which the protection will be needed.	1 mark each

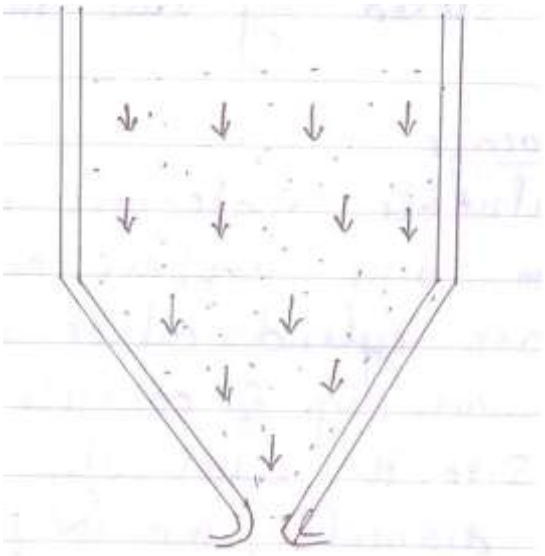
		iv) Location of the hazardous area. v) State of health of the personnel involved . vi) Functional and physical characteristics and limitation of the protective devices available.	
1-B		**Any one**	**6**
1B	a	**Classes of explosive are** : 1. Category X: Those explosives which have a fire or a slight explosion risk. 2. Category Y: Those explosives which have a mass fire risk or moderate explosion risk, but not the risk of mass explosion. 3. Category Z: Those explosives which have a mass explosion risk and major missile effect. 4. Category ZZ: Those explosives which have a mass explosion risk and minor missile effect. **OR** **Classification of explosives :** Explosives are divided in to eight classes. 1. Class 1 – Gun powder (KNO_3, C&S) 2. Class 2 – Nitrate mixture 3. Class 3 – Nitro compound class 4. Class 4- Chlorate mixture class 5. Class 5 – Fulminate class (with C, N_2 & O_2) 6. Class 6 – Ammunition class 7. Class 7 – Firework class	6

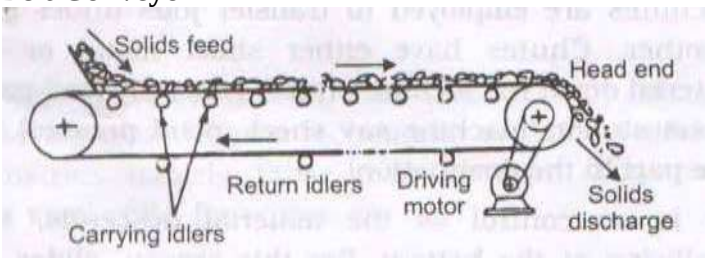
		8. Class 8 – Liquid oxygen explosive class	
1B	b	**Self - Contained Breathing Apparatus:** Self contained breathing apparatus is used intermittently, often for rescue purpose. A high efficiency face mask is supplied with clean fresh air from air cylinders worn on the operator's back. Self- Contained Breathing Apparatus will need adequate maintenance and cleaning. It should also have warning systems to indicate when the cylinder is running empty. Extensive training is needed for operators using self - contained breathing apparatus and it is rarely used in normal work. These are designed to supply complete respiratory protection is any concentration of toxic gases or even in environment deficient of oxygen. These are mainly of three types. a. With compressed air or oxygen cylinder: Here breathable compressed air or oxygen is supplied to the full face piece through a pressure regulating valve from a cylinder carried by the user. The wearer's exhaled breath escapes to the surrounding air through an exhalation valve. b. Oxygen rebreathing or recirculating type: Here compressed oxygen from cylinder passes through a pressure reducing and regulating valve into a breathing bag. The wearer inhales oxygen through a one way inhaler valve. The exhaled CO_2 along with oxygen and moisture passes through a canister containing a chemical, which absorbs CO_2 and moisture and then passes through a cooler. Finally the purified exhaled air flows into the breathing bag, where it mixes with the incoming oxygen from	2 marks for diagram and 4 marks for description of any one type.

		the cylinder. c. Oxygen regenerating type: This type uses the same principle of re breathing apparatus, but function in a different manner. Here CO_2 is absorbed by the chemical in the canister and the moisture reacts with another chemical and this reaction liberates oxygen. 	
2		**Answer any 4**	**16**
2	a	**Process for safe storage of sulphuric acid:** Storage tanks for sulphuric acid in strength of 93% to 99% are fabricated from carbon steel. At normal temperature, there is some attack on the steel resulting in the evolution of hydrogen gas and the formation of an iron sulphate precipitate, most of which settles to the bottom of the tank. Wall thickness	4

		should be carefully calculated to provide for corrosion allowances and for the high specific gravity of the acid. Many storage tanks use anodic protection system to minimize corrosion. Routine storage tank cleaning and inspection should be done. Other materials such as stainless steel are sometimes used for smaller tanks. It is recommended that storage tanks be enclosed by a secondary containment wall having a capacity not less than 120% of the largest tank volume. The containment area should be kept dry and clean. In the event of a leak, the acid should be neutralized and pumped out before it reaches a sewer or water source.	
2	b	**Different breathing and respiratory protection equipment:** 1. Air Purifying Type a. Mechanical filter respirators: b. Canister gas masks: c. Chemical Cartridge Respirators: 2. Air Supplied Type: This includes- a. Air line respirators: b. Fresh air or Suction Hose Masks: 3. Self Contained Breathing Apparatus: These are mainly of three types. a. With compressed air or oxygen cylinder b. Oxygen rebreathing or recirculating type c. Oxygen regenerating type **Canister gas mask:** This consists of a full face mask connected to a canister	2

		through a corrugated hose. The canister contains certain neutralizing chemicals, which can absorb a particular contaminant. Universal canisters capable of absorbing 3 or 4 different contaminants are also available. The life of these universal canisters is much less than the canisters designed for one particular contaminant.	2
2	c	**Safety audit** is a proactive process by which and organization is able to continually evaluate and monitor the progress of its safety and health programs. Audits are designed to rate an organization's total safety and health program, identify it's strength and weakness , show where improvement are needed , and obtain commitment and target dates for correcting problems. **Objectives are:** 1. Confirm that safety, health, fire and environmental program activities and controls are in place and functioning. 2. Verify that the facility is in compliance with internal benchmarks and government regulations. 3. Assess past and current practices to identify and correct safety impediments which may result in personal injuries, property damage or business interruption.	4
2	d	**Mass flow bins** **Construction & Working:** These are characterized by shallow angle of converging section. In mass flow bin, every particle of the bulk material in the hopper begins to move when the outlet is opened. Hence mass flow bins has steep wall slopes of the converging sections. It has relatively large outlet to the feeder or flow control valve. The cohesive solids stored in mass flow bins form	4

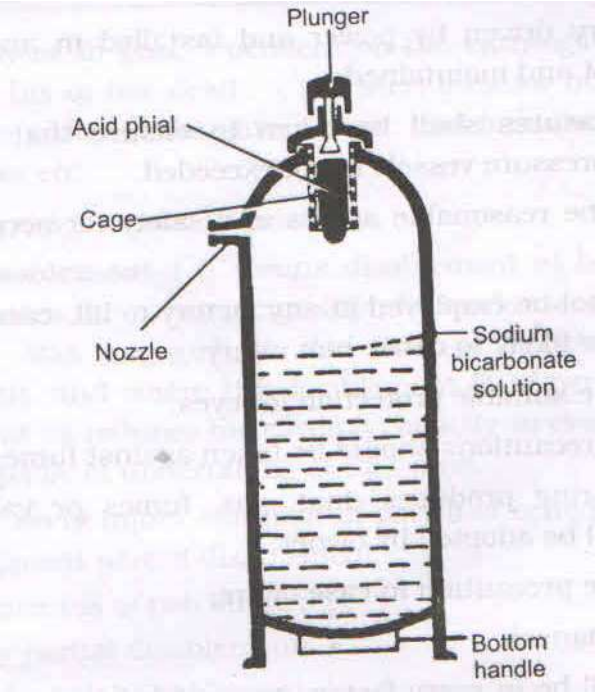
		cohesive arch at the opening which acts as the obstruction to the gravity flow of material. It is overcome by providing some discharge aid. 	
2	e	**Principle of fire extinguishing:** **Fire may be extinguished** by withdrawal of flammable contents, interrupting flammable flow, isolating fuel from air, heat removal to below reaction temperature. **Withdrawal of flammable contents** can be accomplished by 1).Blowing down the vessel and piping contents (2)Pump out or 3)draining Flammable flow may be interrupted by the shutdown of pumps, closing of valves. **Isolation of flammable flow** from the air is accomplished by blanketing with steam or water spray, foam, CO_2 etc.	4
3		**Answer any 4**	**16**
3	a	**Noise Hazard** : Un wanted sound is called noise. Sound levels that cause	4

		hearing loss begin at 85 db. Hearing loss occurs more quickly with louder noise. High sound levels cause serious health risks. Hearing damage results from an exposure to loud noises over an extended period of time. **Effect of noise on human being** : High sound levels pose serious health risk to the people who work long hours around the equipment which generate high noise levels. Hearing damage results from an exposure to loud noises over an extended period of time. Deafness and loss hearing usually occur with the high frequency sound and not be lower frequency sound. Hearing is lost as auditory nerve endings are exposed to the same frequency of sound for extended time periods. The nerves lose their ability to recover from that hostile frequency. The ability to hear that sound frequency is then decreasing forever. Hearing loss accumulates over time and cannot be revers. Hearing aid assistance may be necessary.	
3	b	**Belt Conveyor** 	4
3	c	**Objectives of Plant Maintenance :** 1. To achieve minimum breakdown and to keep the plant in good working condition at the lowest possible cost. 2. To keep the plant in good working condition at the lowest possible cost. 3. Machines and other facilities should be kept in such a condition which	1 mark each

		permits them to be used at their optimum capacity without any interruption. 4. Maintenance division of the factory ensures the availability of the machines, buildings and services required by other section of the factory for the performance of their function.	
3	d	**Scheduled maintenance:** Scheduled maintenance is a stich-in-time procedure which is aimed at avoiding breakdowns. Breakdowns can be dangerous to life and hence should be minimized. This method of maintenance incorporates inspection, lubrication, repair and overhaul of certain equipment which if neglected may result in breakdown. Scheduled maintenance practice is generally adopted for overhauling of machines, cleaning of water and other tanks, white washing of buildings etc.	4
3	e	**Startup of a plant:** A chemical plant is started at two different times, 1. When it is constructed, erected and to be commissioned first time for production. The procedure here to be followed is to take water in the plant to check the fluid flowing through equipment and pipelines without any leakage, at the desired flow rate, pressure and temperature. If any leakage is observed, it can be rectified. This is the safest and cheapest way of checking the functioning of the plant equipment in total. 2. When plant is stopped for annual major shutdown, then the procedure to be followed for start- up of a plant is	4

		i) To take water in the plant to check the fluid flowing through equipment and pipelines without any leakage, at the desired flow rate, pressure and temperature. If any leakage is observed, it can be rectified. Thus is the safest and cheapest way of checking the functioning of the plant equipment in total. **ii)** Once it is assured that fluid flow takes place without any problem, the total plant water is drained off and water is removed and then slowly loaded in stepwise and retched to desire capacity in stepwise. It is always advisable to operate the plant with 50% capacity for few days and after full satisfaction of plant working, it is taken up to full capacity.	
4-A		**Answer any 3**	**12**
4A	a	**Safety precautions in the storage of flammable and combustible liquids:** The storage of flammable and combustible liquids in a laboratory must be kept to the minimum needed for research and operations. Flammable liquids have a flash point below 100^0F. The storage of flammable liquids in the laboratory must not exceed a 2 days supply or 10 gallons whichever is less. Whenever possible, flammable liquids should be stored in a flammable liquids storage cabinet. Flammable liquid storage cabinets are not intended for the storage of highly toxic materials, acids, bases, compressed gases. Flammables should not be stored in areas exposed to direct sunlight. Use approved storage containers and safety cans for flammable liquids. Use plastic spill trays under containers for strong corrosive agents. Do not store liquids above eye level.	4

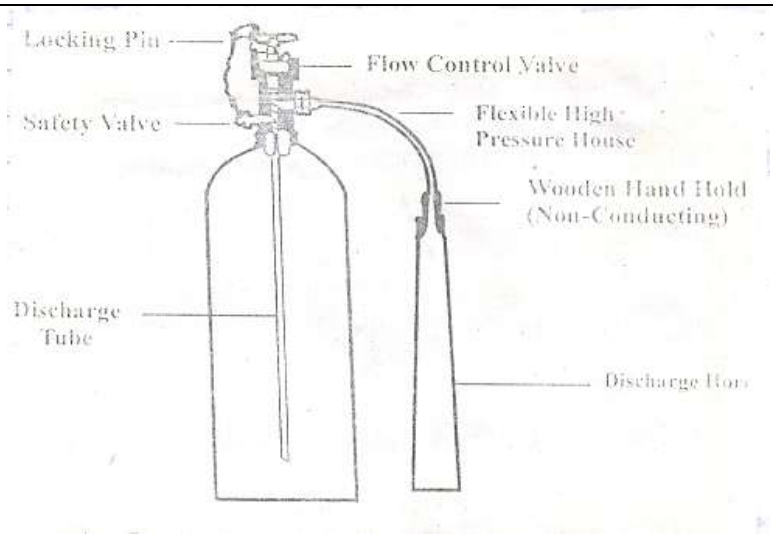
		Original containers of inflammable liquids shall be placed in an outside container or acid carrying bucket.	
4A	b	**Underground storage**: *Liquids are stored underground in porous media between impervious rocks. Cavities are formed in salt domes by dissolving the salt and pumping it out. This method has application for storing petroleum product, both liquid and gasses. Hazardous or radioactive materials are stored in underground tunnels or storage tanks **Open atmospheric tanks:** *Open atmospheric tanks are used for storing liquids that will not be harmed by water, weather or atmospheric pollution. **The closed tanks:** *The closed tanks have fixed or floating roof. Fixed roofs are either domed or coned with intermediate supports. *Fixed roof atmospheric tanks require vents to prevent pressure changes which would result from temperature changes and withdrawal or addition of liquid. *Vent loss is prevented by using variable volume tanks which have floating roofs. Floating roof must have a seal between roof and tank shell. *For storing liquids under pressure, the tank has curved surface in the form of sphere ellipsoid shapes. *Plastics or glass coating are applied to the corrosive liquids which are to be stored in glass lined tanks.	4
4A	c	**Advantage of preventive maintenance:(any 8)** 1. Reduced break down and connected down time.	½ mark

		2. Lesser odd time repairs and reduced over time to be maintenance work force. 3. Greater safety for workers. 4. Fewer large scale and repetitive repairs. 5. Low maintenance and repair cost. 6. Less stand by or reserve equipment and spare parts. 7. Identification of equipment requiring high maintenance cost. 8. Lower unit cost of manufacture. 9. Increased equipment life. 10. Better product quality.	each
4A	d	**Dry chemical powder fire extinguisher:**  	

		Construction: These are gas cartridge type and are activated by a plunger and controlled by a simple squeeze grip action thus enabling the discharge of the dry chemical powder, generally sodium or potassium bicarbonate base or ammonium phosphate base. To operate, remove the safety clip and press puncturing lever down. This will release CO_2gas from the cartridge and pressurize the chamber containing dry chemical. The discharge is controlled by the nozzle located at the end of the hose.	2
		Working :On fires involving either liquids in containers or spilled liquids, direct the jet towards the near edge of the fire and with rapid sweeping motion, drive the fire towards the far edge until all the flames are extinguished. On fires in falling liquids, direct the jet at the base of the flame and sweep upwards. On fires in electrical equipments, direct the jet straight at the fire. Where the equipment is closed, direct the jet into any opening with the object of penetrating the interior.	2
4-B		**Answer any one**	**6**
4B	a	**Principles of Materials handling includes:** **i) Planning Principles:** In this material handling should be planned and well integrated with production activity to obtain maximum overall operating efficiency. **ii) Operating Principles**: It includes a)Unit load handling principle: • Material should handle in bulk over distances. • Fragile or breakable materials should be arranged in trays or in layers separated by wood or card board, the whole being held by strapping.	6

		b) Gravity Principle : It suggests that • Material wherever possible should be moved using most economical gravity (motive) force. c) Flow of materials Principle: According to this material handling efficiency is the greatest when it approaches steady flow of materials, in as straight as possible with minimum of interruptions and minimum of back tracking. **iii)Equipment principles:** It includes mechanization principle, terminal time principle, dead weight principle, standardization principle, maintenance principle, speed principle & versatility principle **iv)Costing Principles:** a) Equipment selection principle: b) Replacement principle: Material handling cost is the lowest if the equipment is used only for its economic retentive period and is replaced by an alternative based on engineering economic principles. c) Handling cost appraisal principle: Periodic analysis of materials handling costs highlights areas of improvements. **v) General Principles :** a) Safety principle : Materials handling efficiency increases as working conditions are made safer and safer. b) Training principle This principle suggest that each employee should be given basic training in material handling techniques. d) Identification principle: Material must be kept identified by labeling on pallets and boxes. e) Location principle: All handling equipment should be placed at the right	

		place and at the right time to avoid hunting and delays in materials handling. f) Material treatment principle: All types of materials should be treated as important since material handling costs are not related to the cost of materials.	
4B	b	**Various records to be examined during safety auditing: (any 6)** 1. Operational safety and health policy. 2. Safety organization chart. 3. Training records on safety, fire and first aid. 4. Records of plant safety inspection. 5. Accident investigation reports 6. Accident and dangerous occurrences, statistic and analysis. 7. Records of test and examination of equipment and structure. 8. Safe operating procedures for various operations. 9. Record of work permit. 10. Record of monitoring of flammable and explosive substances at work place. 11. Medical records of employees. 12. Records of waste disposal. 13. Maintenance procedure records. 14. House keeping inspection records. 15. Record of previous audits.	1 mark each
5		**Answer any 2**	**16**
5	a	**CO_2 type fire extinguishers:**	



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Construction:

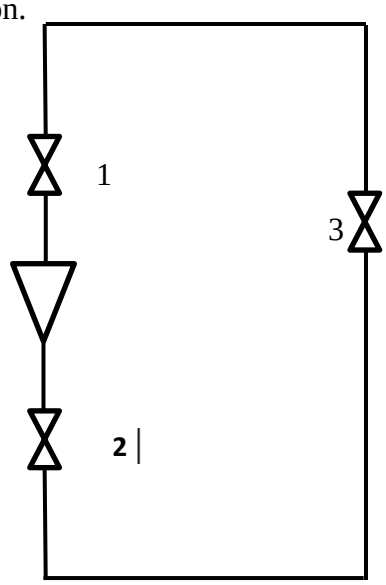
In CO_2 type fire extinguishers CO_2 gas is stored in the cylinder under pressure. The gas is discharged through a horn. These extinguishers are operated by removing the safety pin and operating a simple wheel value through which the rate of discharge can be regulated. CO_2 extinguishes fire primarily by reducing the oxygen content below that which will support combustion, normally between 35 and 75% in air. There is also some cooling effect.

2

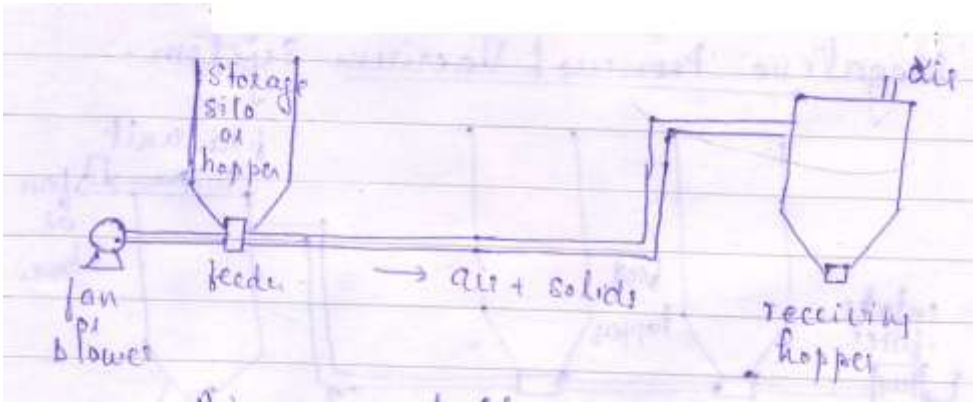
Working:

On fires involving either liquids in containers or spilled liquids, direct the jet towards the near edge of the fire and with rapid sweeping motion, drive the fire towards the far edge until all the flames are extinguished. On fires in falling liquids, direct the jet at the base of the flame and sweep upwards. On fires in electrical equipment, direct the jet straight at the fire. Where the equipment is

3

		closed, direct the jet into any opening with the object of penetrating the interior.	
5	b	**On line maintenance of Rotameter**: In a chemical plant, it is a normal practice to do on line maintenance work. This avoids total shutdown of the equipment or plant. This is possible, if proper pipe fittings are installed at the time of erection. e.g. Suppose there is a Rota meter in pipe line. If we desire to replace a broken glass pipe of Rota meter , we can close valve 1 & 2 and open 3 and divert the fluid through by pass line. After replacement of the glass pipe in the Rota meter close valve 3 and open 1 and 2. Thus it is possible to attend maintenance jobs in the line without stopping the production.  	4 4
5	c	**Differentiate between scheduled, preventive and predictive maintenance(any 3)** **Scheduled** | **Preventive** | **predictive maintenance**	8

		maintenance	**maintenance**		
		It is a stitch in time procedure which is aimed at avoiding breakdowns.	It is a pre breakdown work performed on a facility or equipment to eliminate breakdown or to keep such failures or breakdowns within the predetermined limits.	In this, conditions are measured periodically or on a continuous basis which enables maintenance men to take timely action.	
		This includes inspection, lubrication, repair and overhaul of equipment.	It locates weak spots in all equipment, provided them regular inspection and minor repairs.	It makes use of sophisticated instruments audio gauges, vibration analyzer etc to predict troubles.	
		Done by maintenance department	Done by production department/ maintenance department or a separate division of inspectors	Done by maintenance department	
		Adopted for overhauling of machines, cleaning of water and other tanks, white washing of building etc.	Used for all types of equipment	Used for maintenance of rotating equipment	

6		**Answer any 2**	**16**
6	a	**Positive Pressure Pneumatic conveyor:** **Diagram:**  **Construction and working**: Air or suitable gas is blown along a pipeline, which carries the bulk solid to be 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 is 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 upto ¼ inch size. But it is unsuitable for multiple pick up points on account of excess air leakage.	3 5
6	b	**Functions and duties of plant maintenance department:** (any 8) 1)Inspection 2)Engineering 3) Maintenance 4) Repair 5) Overhaul 6)Construction 7) Salvage 8) Clerical work	1mark each

		1)Inspection: i) Inspection of the plant facilities to examine their condition and to check for repairs needed. ii) Inspection to ensure the safe and efficient operation of plant equipment and machinery. **2)Engineering :** i) Engineering involves alternations and improvement in existing plant equipment to minimize breakdown. ii) Engineering and consulting services to production supervision. **3) Maintenance** : i) Maintenance of existing plant equipment. ii) Engineering and execution of planned maintenance, minor installations of equipment building and replacements. 4**) Repair:** i) To carry out corrective repair to alleviate unsatisfactory conditions found during preventive maintenance inspection. **5) Overhaul:** i) Overhaul is a planned, scheduled reconditioning of plant facilities such as machinery etc. ii) Overhaul involves replacement, reconditioning, reassembly, etc. **6)Construction :** i) In some organization, maintenance department is provided with equipment and personnel and it takes up construction job too. **7) Salvage :**	

		i) Maintenance department may also handle disposition of scrap or surplus materials. **8) Clerical work:** i) Maintenance department keeps records at i) of costs, ii) of time progress on jobs pertaining to important features of building and production equipment.	
6	c	**Corrective or breakdown maintenance:** This method of maintenance implies that repairs are made after the equipment is out of order and it cannot perform its normal function any longer. In such situation, production department calls on the maintenance department to rectify such defect. The maintenance people checks into the difficulty and makes necessary repairs. After rectifying the fault, maintenance people do not attend the equipment again until another failure or breakdown occurs. **Causes of Breakdown Maintenance:** 1) Failure to replace worn out parts. 2) Lack of Lubrication 3) Neglecting cooling system 4) Indifferent towards minor faults. 5) External forces e.g. too low or too high voltage wrong fuel etc. 6) Indifference towards equipment vibrations, unusual sounds caring out of rotating machinery etc. **Disadvantages of breakdown maintenance**:(any 4) 1) Breakdown generally occurs at in opportunate time. This leads to poor, hurried maintenance and excessive delays in production. 2) Reduction of output.	2 2 1 mark each

		3) Faster plant deterioration 4) Increased chances of accidents and less safety to both workers and machines. 5) More spoilt material. 6) Direct loss of profit. **7.** Breakdown maintenance cannot be employed for those plant items which are regulated by statutory provision eg. Cranes, lifts, and pressure vessels.	