Model Answer

Subject Title: Plant Safety & Maintenance

Subject code 17558

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	**Importance and Objectives of safety in chemical industry** : 1) To increase the rate of production 2) To reduce the cost of production. 3) To reduce the damage to equipment and machinery 4) To protect the life and limbs of the workers.	1 mark each
1A	b	**Effects of radiation hazard**: 1 .Ultraviolet radiation: Short term – sunburn conjunctivitis Long term- premature skin aeging, skin cancer and cataract 2. Infra red radiation: Burns to skin and eye tissues. 3. X rays: X rays are ionizing radiation. Ionizing radiation can affect human cells by stripping one or more electrons from an individual atom and forming an electrically charged particle called an ion. These ions can disrupt the machinery of cells, kill them or harm the genes that pass human traits from one generation to the next. Sometimes a damaged DNA molecule instructs a cell to mobilize all its resources and the resources of all its neighbours to produce as many copies of itself as possible. The offspring preserve the mandate , and a chain reaction takes place that crashes the system. This runaway reproductive zeal of a misguided cell is known as cancer and it is the worst hazard of radiation exposure.	1 1 2

1A	c	**Factors to be considered for selection of proper respiratory devices** 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. 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 mark each for any 4
1A	d	**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. **Blasting helmet** : Blasting helmets are used when operators are carrying out blast cleaning of structures, castings etc. A full protective suit made in rubberized canvas is donned by operator, and then an independent blasting helmet is applied over the head and fixed to be full suit. External clean air is supplied via a compressor with a filter, or from a compressed air supplied again with a suitable filter. Work inside a full blasting suit is very difficult work efficiency will be low,	2 2

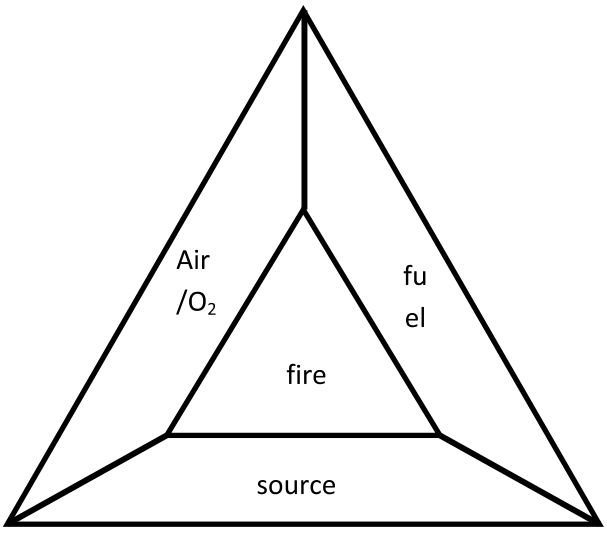
		fatigue will be high and such suit should only be used when all other precautions can not be reasonable applied.	
1-B		**Any one**	**6**
1B	a	**Chemical hazards due to Ammonia:** Heat from fire can cause a rapid build up of pressure inside the cylinders. Explosive rupture and a sudden release of large amounts of gas may result. In a fire hazardous material like flammable hydrogen may be generated. Increased risk of fire and explosion on contact with oxidizing agents, strong acids, halogens. **1.Inhalation**: Very toxic, can cause death., can cause severe irritation of the nose and throat, can cause life threatening accumulation of fluid in the lungs, coughing, shortness of breath. **2.Skin contact**: the gas irritates or burns the skin, permanent scarring can result, can chill or freeze the skin, burning sensation and stiffness, skin becomes waxy white or yellow. **3.Eye contact**: corrosive, the gas irritates or burns the eye, blindness can result, can freeze the eye,	6
1B	b	**Non respiratory equipment used for personal protection in plant.** 1. Gloves for hand and arm protection: To safeguard workers there will be purpose-made gloves, supplied by manufacturers specializing in products, capable of protecting them from the hazards. 2. Helmets, hard cap for head protection. : Industrial safety helmet can protect the worker against following objects or impact with fixed objects. Caps and helmets protect the head of contamination with toxic	1 mark each

		substance. 3. Safety boot or shoes for foot protection. : The safety boot or shoe is the most common type of safety footwear, and would normally have a steel toe cap. It helps to protect the feet from corrosive or toxic materials. 4. Goggles for eyes protection: Goggles projects the eyes from dust , gases, welding arc , lesser light, toxic or chemical substances. 5. Apron/ lab coat for body protection 6. Ear plug/ ear muff for ear protection	
2		**Answer any 4**	**16**
2	a	**Plant safety provision in an industry** 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 shoes, apron, goggles etc should be used. 6. Safety activities in the organization: Provide wire mesh guards to all rotating parts, High voltage equipment and machines which cannot be	1 mark each for any 4

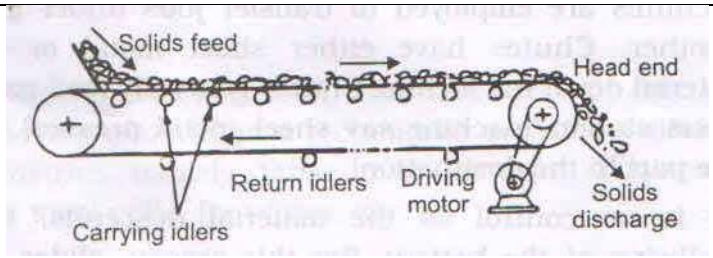
		guarded should be fenced.	
2	b	**Air Purifier type Respirator:** a. Mechanical filter respirators: These give protection against dust and particulate matters only and do not provide any protection against harmful vapours, gases or oxygen deficient atmospheres. Several types of mechanical filters are available, each designed for a specific class of air borne particulate matter, depending upon size, range, concentration and toxicity.  b. Canister gas masks: This consists of a full face mast connected to a canister through 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 marks each for any 2 type

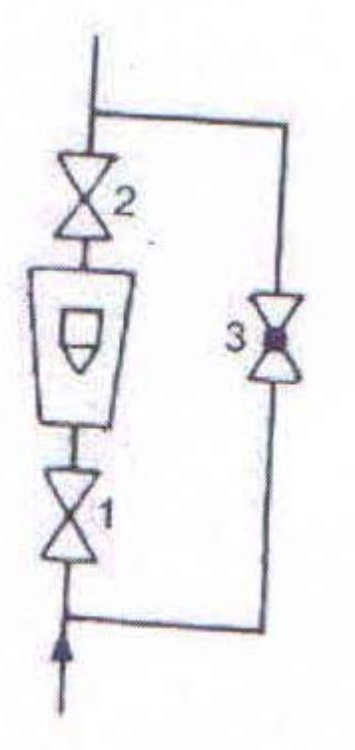
		 c. Chemical Cartridge Respirators: These are similar to canister gas masks with the difference that one or two chemical cartridges are used with a half face mask. These masks are effective only at very low concentration and cannot be used in emergency. 	
2	c	**Safety audit** is a proactive process by 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,	4

		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.	
2	d	**Different methods for liquid storage are:** **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 notbe 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	2 mark each for any 2

		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.	
2	e	**Fire Triangle:** A fire can be caused and sustained by a fuel, oxygen or oxidizer and source of heat(ignition source).These three forms three sides of a fire triangle. It requires all three should be present simultaneously to cause fire.  	2 2

3		Answer any 4	16
3	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 8. Class 8 – Liquid oxygen explosive class	4
3	b	**Belt Conveyor**	

		 **Construction and Working:** Conveyors are gravity or power devices commonly used to move uniform loads continuously from point to point over fixed paths. Belt conveyor as shown in figure consists of an endless moving belt of flexible material, stretched between two drums / pulleys and supported at intervals on idler rollers. The pulley that drives conveyor belt rotating is called drive pulley or transmission drum; the other oneonly used to change conveyor belt movement directions called bend pulley. Drive pulley is driven by the motor through reducer and conveyor belt dragging relies on the friction drag between the drive pulley and the conveyor belt. The drive pulleys are generally installed at the discharge end in order to increase traction and be easy to drag. Material is fed on the feed-side and landed on the rotating conveyor belt, then rely on the conveyor belt friction to be delivered to discharge end. Belt Conveyors are the most commonly used type of equipment for the continuous transport of solids. They can carry wide range of materials economically over long & short distances, both horizontally and at an appreciable angle.	4
3	c	**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	2

		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.  	2

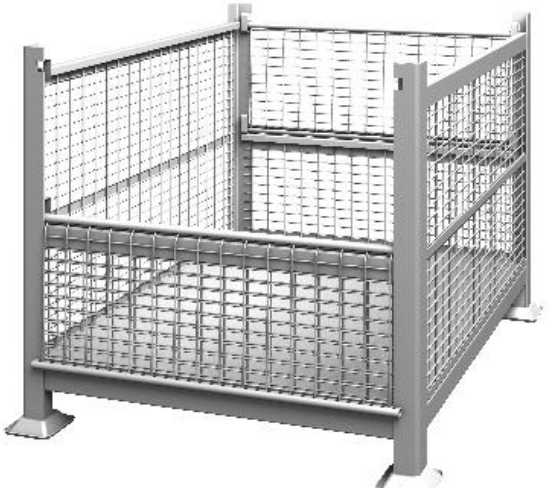
3	d	**Advantage of preventive maintenance:** 1. Reduced break down and connected down time. 2. Lesser odd time repairs and reduced over time to be maintenance work force. 3. Greater safety for workers. 4. Fewer large scale and repetitive repairs. 5. Low maintenance and repair cost. 6. Less stand by or 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. **Applications of preventive maintenance:** 1. Bearing surfaces 2. Parts under excessive vibrations 3. Reactors 4. Compressors and pumps 5. Heat exchangers 6. Valves 7. Pipings	½ mark each for any 4 ½ mark each for any 4
3	e	**Importance of record keeping in preventive/Plant maintenance:** It is very essential to keep records as they are the only reliable guides to measure the effectiveness of the preventive maintenance programme. Records give an idea regarding situation at present and where it is going. Good, updated	2

		records is very important in preventive maintenance programme. **Record keeping is also helpful (Benefits):** 1. When budgeting for major overhauls. 2. For finding equipment reliability 3. For determining frequency of inspection 4. To prepare maintenance schedule 5. To predict equipment life 6. For equipment replacement analysis 7. To carry out cost reduction studies	½ mark each for any 4
4-A		**Answer any 3**	**12**
4A	a	**Solids are packed in different ways as:- (any 2)** 1) Bags: The multiwall paper bags made from piles of Kraft paper are used for packaging of most palleted or powdered material. There are two commonly used bag designs, the open mouth type and the valve type. The Open-mouth bags have one end closed , while the other end is closed after filling the material. These bags are closed after filling the material mainly by sewing. The valve bags has both ends closed during the fabrication , the filling being done through a small opening in one coener of the bag.	2 marks each

2) Boxes: Bulk boxes of corrugated craft paper are used for dry, bulk products. A bulk box also called as bag in box, consists of a box within a box alongwith end pads, polythene bag liners and closing materials like tape, glue, staples etc. These boxes are reclosable but they require storage space for box components.

3) Drums: The fibre drums are used for storing dry solids and slurries, while metal drums are used for storing liquids. Advantages of drums are protection of contents, ease of enclosure and appreciable reuse-resale value.

4) Metal containers: Welded wire mesh containers are fabricated from welded wire collapsible containers having folding sides while rigid wire containers use additional vertical structural members to increase the strength of the containers.

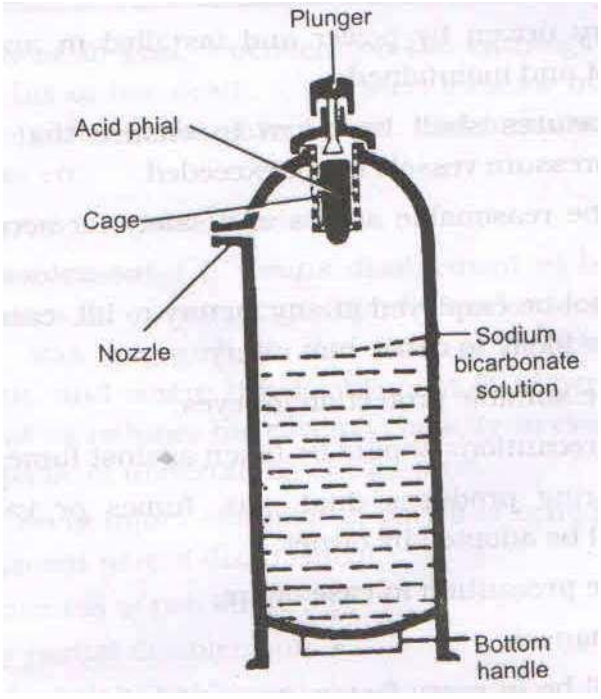


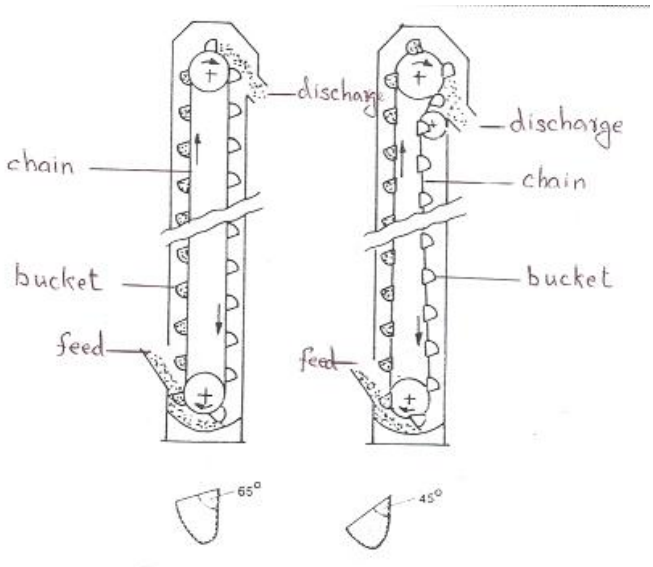
5) Wood containers: Bins , boxes or crates are made of wood, which are used for mechanized handling and storage for solids having irregular

		shapes and granular materials.  6) Corrugated Cardboard containers: These containers consists of outer facing board, corrugated medium and inner facing joined by adhesive, The cardboard are usually made of fourdrinier Kraft, pulpwood or combination of reclaimed fiber and pulp. The corrugating medium is straw, reclaimed fibers or wood. 7) Tote boxes and bins: Tote boxes are used for smaller unit loads of smaller parts that can be moved manually through the operation or can be stacked in a larger container to become part of a unit load.	
4A	b	**Different modes transport of Chemicals are:** i) Pipelines: for transporting liquid chemicals. ii) Tankers: used for bulk chemical transportation. It should be properly labeled and carry appropriate hazard warning panels. Drivers must be trained in the handling of accidental spills. iii) Trucks (Drums containing chemicals)/Container: Before moving containers, check and tighten caps, taps or other	4 1 marks each for any four

		enclosures. Wherever possible, flammable liquids should be transported in rugged pressure resistant safety cans. iv) Freight elevators: used where hazardous chemicals are to be transported. v) Conveyors: For transporting solid chemicals. **OR** **Four modes transportation of solids** : 1. **Conveyors** are employed to transport materials over fixed path mostly horizontally. Screw conveyors consist of helical steel flights cut from flat sheet. As screw rotates in the material to be conveyed , the flight advances horizontally and thus material is transported. Belt conveyor can operate over short distances at speed slow enough for manual picking with low capacity. 2. **Bucket elevators:** Bucket elevators are the simplest and the most dependable unit for making vertical lifts. They are available in wide range of capacities and may operate entirely in the open or be totally enclosed. 3. **Pneumatic conveyor:** Pneumatic conveying is the transportation of granular solids through a pipe line by a stream of air or gas. It consist of the sources of compressed air, a feeder and a receiving hopper fitted with a means of separating the conveyed product from the conveying air. 4. **Trucks**: Trucks are used for transporting solids over a long distance.	2marks each for any two point
4A	c	**Functions and duties of plant maintenance department(any 8)**	½ mark

		1)Inspection 2)Engineering 3) Maintenance 4) Repair 5) Overhaul 6)Construction 7) Salvage 8) Clerical work **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	each

		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.	
4A	d	**Soda Acid type fire extinguishers:**  **Construction** :In soda acid fire extinguisher the material used are dry chemical, bicarbonate of soda designed to be dissolved in water and a liquid chemical sulphuric acid. Reaction of the acid & bicarbonate of soda produces pressure	2 1

		which expels the liquid from the extinguisher a horizontal distance of 30 to 40 feet at a rate of 2.5 gal. in one min. **Working:** When the plunger is struck, it breaks the acid bottle. The sulfuric acid and the sodium bicarbonate solution react together to release CO_2 gas. The gas generated creates pressure, which forces the water out of the extinguisher nozzle. Before using these extinguisher, it is advisable to check whether these extinguishers are upright type or turn over type. Dire the jet at the base of the fire and sweep it across the area of fire. Attack a vertically spreading fire at its lowest point and follow it up. Search out for hot spots and ensure that the fire is completely extinguished and that it is not smouldering.	1
4-B		**Answer any one**	**6**
4B	a	**Bucket elevator**  **Construction:**	2

		In spaced bucket centrifugal discharge elevator, buckets are mounted on a belt or a chain and are spaced to prevent interference in loading or discharging. In spaced bucket positive discharge elevator, the buckets are mounted on two strands of chain and are snubbed back under the head sprocket to invert them for positive discharge. In continuous bucket elevators, buckets are closely spaced with back of the preceding bucketserving as a discharge chute for the bucket which is dumping as it rounds the head pulley. **Working:** Buckets are loaded partly by material flowing directly into them and partly by scooping material from the boot. As the bucket reaches top, these will be inverted and the material will be off loaded. The empty bucket will again be loaded with material and so on.	2 2
4B	b	**Procedure of safety Auditing** : Safety audit is carried out by a team whose members are not involved in the plant or activity being audited. The expertise of the team should be compatible with the type of audit. It is beneficial to include the managers of other plants or units in an audit team as well as one previous auditor of the same unit. Audits are carried out in a formal way using a carefully drawn up checklist of items and descriptive standards for each item. A line manager or supervisor of the plant under audit should be asked to accompany the auditor inspecting it. He should be informed of all corrections and improvements required by the auditors so that he can start taking the necessary steps before the audit report is submitted to management. The main object of inspection should be to determine whether the layout design and condition of equipment and protective	03

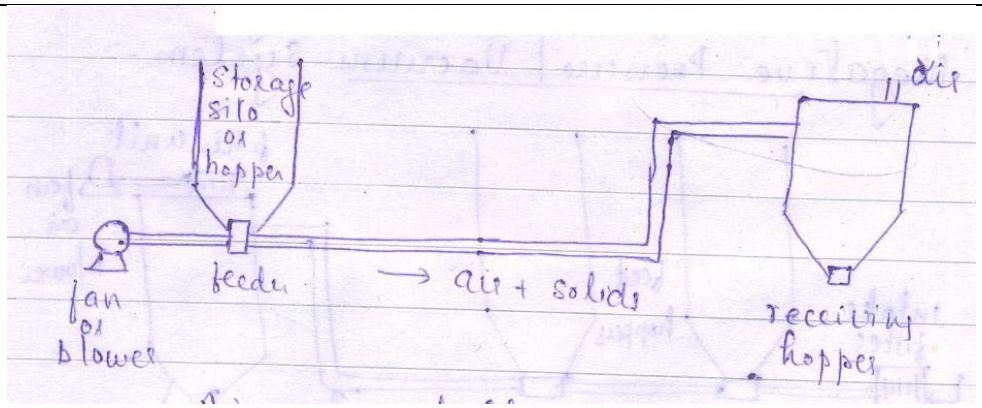
		features are upto standard and to ensure that the protective features will work in an emergency. The auditing should give a verbal report to the management on completion of audit followed by a clear and concise written report within two weeks. **Various records to be examined during safety auditing:** 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.	03
5		**Answer any 2**	**16**
5	a	Fire buckets**:** For immediate firefighting, the fire buckets are to be located in conspicuous are inside the shop. These should be kept filled with water or fine	02

		sand depending upon the fire hazard in the area. Fire buckets must not be used for any purpose other than firefighting.  **Fire hydrants** with high pressure water available through opening of the hydrant valve are also located in conventional locations inside the plant. Fire hose boxes with spraying nozzle and hose which are provided with instantaneous coupler, attachments are also provided near the hydrant points, which are to be used as necessary. Similarly the fire hydrant points, hoses and nozzles should also not be used for any other purpose without taking approval from appropriate authority. The canvas hose after use should be laid on the ground to dry up before being rolled back to the place into the hose boxes. The nozzle should also be put back inside the fire hose box immediately after use.	02 02

			02
5	b	**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	4

		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 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
5	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.	3

		Advantages of breakdown maintenance: 1. It is economical for non criticalequipments whose down time and repair costs are less this way than any other type of maintenance. 2. It involves less administrative work 3. Requires few records 4. Requires small staff. **Disadvantages of breakdown maintenance**: 1) Breakdown generally occurs at in opportunate time. This leads to poor, hurried maintenance and excessive delays in production. 2) Reduction of output. 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.	1 mark each for any 2 1 mark each for any 3
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	**Shutdown maintenance :** Shutdown maintenance is the maintenance work carried out when machine, equipment or plant is not working or is shut down. During shut-down maintenance generally chemical plants are closed half yearly or yearly for carrying out major maintenance work of total plant equipment. The sugar cane factory is stopped, once the sugar cane supply is over. During	4

		shut down of the plant, maintenance work like changing of parts, lubrication, overhauling of all the equipment in the plant, cleaning of equipment and plant are done. Maintenance department and process plant people are involved in the process. **Important steps in shutdown process are :** 1) Identify material storage and laydown areas . 2) Designate equipment wash areas. 3) Establishing crew- marshalling areas in the event of an emergency . 4) Determine what lunch, lavatory and change room facility requirements are required. .Planning and scheduling are concurrent activities for shutdown.	4
6	c	**Predictive maintenance**: Predictive maintenance makes use of human sense or other sensitive instruments such as audio gauges, vibration analyser, amplitude meter , pressure , temperature and resistance strain gauges etc. to predict trouble before the equipment fails. Unusual sounds coming out of a rotating equipment predict a trouble , an electric cable excessively hot at one point predict a trouble. Simple hand touch can point out many unusual conditions and thus predict a trouble. In predictive maintenance, equipment conditions are measure periodically or on a continuous basis and this enables maintenance men to take a timely action such as equipment adjustment , repair or overhaul. Predictive maintenance extends the service life of equipment without fear of failure. **Scheduled maintenance:** Scheduled maintenance is a stich-in-time procedure which is aimed at avoiding	4 4

		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.	