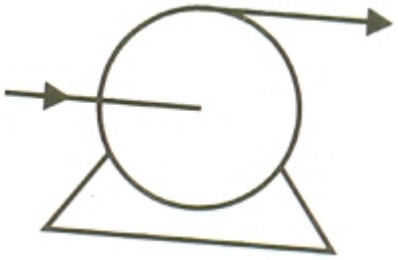
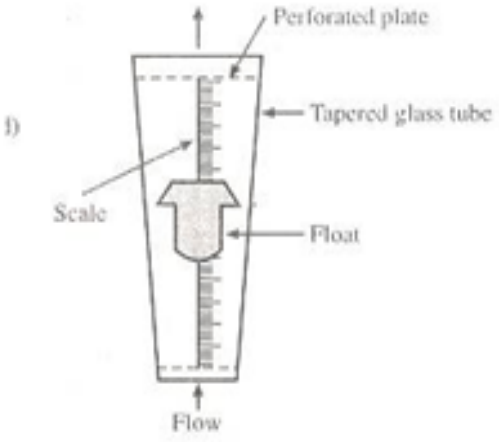
Important Instructions to examiners:

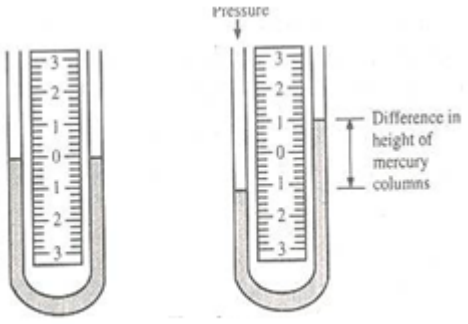
1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling 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
1	Any ten	20
1-a	**Normality:** N = gmequivalent of solute/ volume of solution in liter **Molarity:** M = gmmole of solute/ volume of solution in liter	1 1
1-b	**Dalton's law:** Daltons law states that total pressure of a gas mixture is equal to the sum of partial pressures $P=P_1+P_2+P_3$ where P is total pressure of gas mixture and P_1,P_2,P_3 are partial pressures.	 1 1
1-c	**Unit operations in chemical engineering** : 1. Size reduction 2. Size separation or screening 3. Mixing 4. Filtration 5. Sedimentation 6. Extraction 7. Distillation 8. Drying **9.** Crystallization	½ mark each for any 4

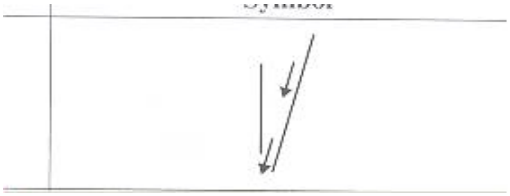
1-d	**Personal protective equipments used in Chemical industries :** **1**) Hard hat 2) Safety goggles 3)Safety shoes 4)work clothes 5)Ear muff 6)Ear plug 7)Guard cuff's 8)Face Shield	½ mark each for any 4
1-e	**Different temperature scales are**: 1. degree Celsius (^{0}C) 2. degree Farenheit (^{0}F) 3. Kelvin (K)	2
1-f	**Names of chemical industries:** Rashtriya Chemicals and fertilizers ltd. Deepak Chemicals and fertilizers ltd. Reliance Industries ltd. Supreme Petroleum ltd. Hindustan Antibiotics ltd. Mysore Paper Mills LTD. Asian Paints Limited.	1/2 mark each for any four industry
1-g	**Conversion** is the ratio of the amount of reactant reacted to the initial amount of the reactant Conversion= (moles of reactant reacted*100)/ moles of reactant fed	1 1

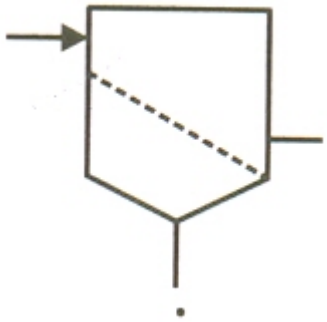
1-h	**Uses of Sulfuric acid:** a) It is used as a dehydrating agent drying agent acidifying agent and neutralizing agent. b) It is used in the manufacture of fertilizer. c) Sulphuric acid is used for pickling iron and steel before galvanizing. d) It is used in processing metals. e) It is used in the manufacture of lead acid batteries.	½ mark each for any 4
1-i	**Hydrogenation:** It is a unit process of adding hydrogen is added to organic compound. **Chemical Reaction for hydrogenation:** $CH_2= CH_2 + H_2 \rightarrow CH_3\text{-}CH_3$ $C_6H_6 + 3H_2 \rightarrow C_6H_{12}$ **Oxidation:** It is defined as the addition of oxygen or removal of hydrogenation from organic compounds. - Oxidation reaction may involve the introduction of oxygen in the molecule of a compound. Oxidation of acetaldehyde: $CH_3CHO + ½\ O_2 \text{ ----------}\rightarrow CH_3COOH$ Acetaldehyde acetic acid - Oxidation reaction may involve the removal of hydrogen from the molecule of a compound.	1 1
1-j	**Centrifugal pump:**	1

	 **Ball mill:** 	1
1-k	**Rotameter:** 	2
1-l	**Equipment used for solid mixing**: 1. Ribbon blender 2. Sigma mixer 3. Pug mill	1 mark each for any 2

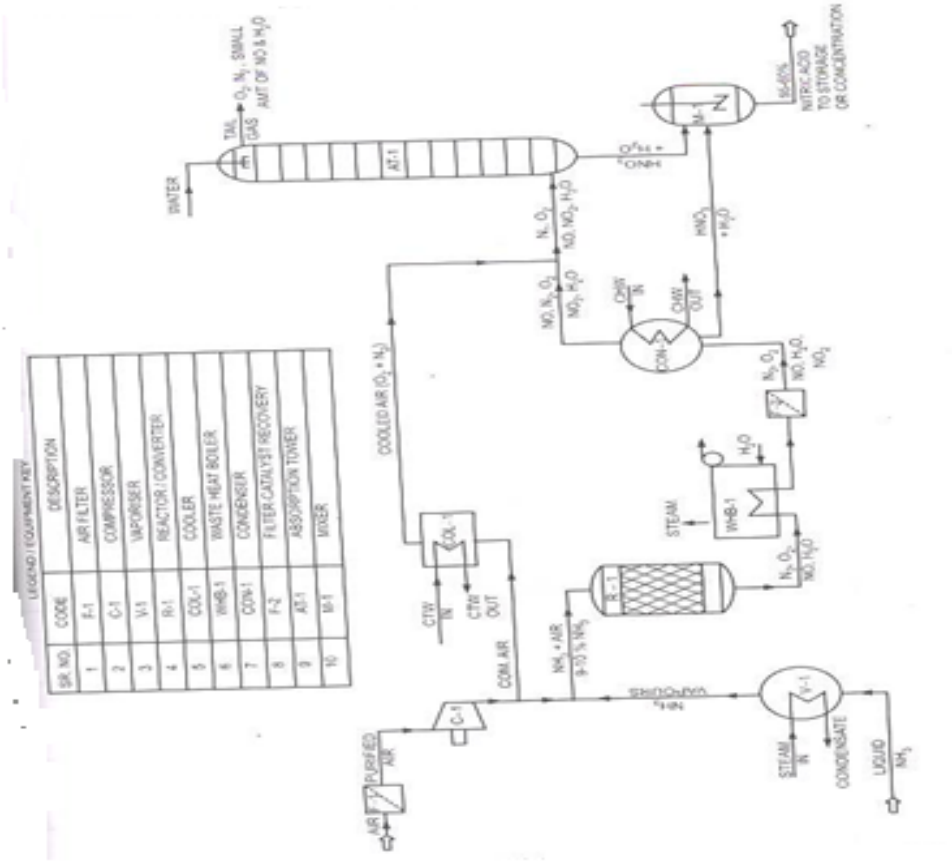
	4. Tumbler 5. Kneading machine	
2	**Any four**	16
2-a	N = gmequivalent of solute/ volume of solution in liter 1= gmequivalent of solute/ 2 lit Gram equivalent of NaOH = 2 weight of NaOH = 2*40 = 80gram To prepare 1N,2 lit NaOH solution, dissolve 80 grams NaOH in water to get 2 lit solution.	1 1 1 1
2-b	**Large scale petroleum industries:** 1.HPCL 2. Reliance Refinery 3. Bharat Petroleum 4. Indian oil **Small scale chemical industries:** 1. Royal Chemicals 2. Shiva Pharmaceuticals **3.** Alpha chemicals 4. Mayur chemicals	1 mark each for any 2 1 mark each for any 2
2-c	**U tube manometer**: 	4

2-d	**Size reduction:** It is an operation wherein large solid particles are subdivided to smaller ones. **Size separation(Screening):** It is a method of separating solid particles according to size alone by means of screens of known aperture **Sedimentation:** The separation of solids from a suspension in a liquid by gravity settling is called sedimentation. **Filtration:** The separation of solid from a suspension in a liquid with the help of a porous medium which retains the solid and allows the liquid to pass through it is termed as filtration	1 1 1 1
2-e	**Gas Absorption:** -This operation is used to separate the components of gas mixture . -It is carried out for the recovery or the removal of a soluble components of a gas mixture depending upon the situation. -Absorption is an operation in which a gas mixture is contacted with a liquid solvent for the purpose of dissolving a definite component of the gas mixture in the liquid. Example: 1) Absorption of ammonia from an air- ammonia mixture by water 2) Removal of hydrogen sulfide from naturally occurring hydrocarbon gases. **Drying:** Drying is an operation in which the moisture of a substance is removed by means of thermal energy. In this operation, moisture is removed by circulating hot air or gas over the material in order to carry away the water vapour. In this operation, heat and mass transfer occur simultaneously. Heat is transferred from the gas phase to the solid phase and mass is transferred from	1 1 1

	the solid phase to the gas phase. Usually a solid or nearly solid materials are processed in dryer. Eg: Drying of pharmaceuticals, dyes, paper, cloth	1
2-f	**Packed column**  **Jaw crusher**  **Plate column:**  **Screen**	1 mark each

		
3	**Any 4**	16
3-a	**(i)Molecular weight** : It is the sum of atomic weights of all elements present in a compound. **(ii)Equivalent weight** : Equivalent weight = molecular weight/ valency. **(iii)Gram mole** Gram mole = weight in grams /molecular weight. **(iv)Gram equivalent:** Gram equivalent = weight in gram/ equivalent weight	1 1 1 1
3-b	**Amagat's law:** Amagats law states that total volume of a gas mixture is equal to the sum of pure component volumes $V=V_1+V_2+V_3$ where V is total volume of gas mixture and V_1,V_2,V_3 are pure component volumes. **Vapor pressure** : It is the pressure exerted by vapor on the surface of liquid at equilibrium conditions. OR	 1 1 2

	It is the absolute pressure at which the liquid and its vapour are in equilibrium at a given temperature	
3-c	0.6 gm/cm^3 1 kg=1000gm $1m^3=100^3cm^3$ 0.6 gm/cm^3= $0.6*100^3$ / 1000 = 600 Kg/m^3	 1 1 1 1
3-d	**Modes of heat transfer are:** Conduction Convection Radiation 1. Conduction: It is the transfer of heat without the movement of particles. Eg: heating of a metal rod 2. Convection: It is the transfer of heat within a fluid by the actual migration of particles of hot fluid with cold fluid because of change of density of molecules of fluid by application of heat. Eg. Boiling of liquid 3. Radiation: It is the transfer of heat through space by electromagnetic waves. When radiation passes through matter, it is transmitted, reflected or absorbed. Eg. Transport of energy from the sun to earth.	2 2 marks for explanation of any one
3-e	**Sulfonation reactions** : It is the reaction with sulfuric acid to introduce sulfonic (SO_3H) group into a compound. $C_6H_6 + H_2SO_4 \text{----}\rightarrow C_6H_5SO_3H + H_2O$	1 1

	Benzene benzene sulfonic acid **Nitration reactions** : It is the reaction with nitrating mixture to introduce nitro(NO_2) group into an organic compound. $C_2H_6 + HNO_3$ ------>$C_2H_5NO_2 + H_2O$	1 1
3-f	**Flow sheet for manufacturing of Nitric acid:**  	4
4	**Any 4**	16

4-a	**Filtration:** The separation of solid from a suspension in a liquid with the help of a porous medium which retains the solid and allows the liquid to pass through it is termed as filtration. Filtration involves the separation of solids from a liquid and is effected by passing the slurry through a porous medium. **The pressure difference** set up across the filter medium causes the fluid to flow through the small holes of a filter cloth or screen which blocks the passage of the larger solid particles. **Application**: Separation of suspended impurities from water, separation of organic or inorganic materials from their slurry. **Sedimentation:** The separation of solids from a suspension in a liquid by gravity settling is called sedimentation. The force responsible for sedimentation is **gravitational force**. **Application:** Removal of solids from liquid sewage waste, removal of suspended impurities from water.	1 1 1 1
4-b	Basis: 100 gm solution. Density of solution=1.1gm/cc Volume of solution = 100/1.1 = 90.90 cc = 0.0909 lit Weight of solute = 15 gm Molecular weight of H_2SO_4 = 98 Gram moles of solute = 15/98 = 0.153 Molarity = Gram moles/ Volume of solution in lit 0.153/0.0909 = **1.68 M** Normality = gram equivalent of solute/ volume of solution in lit = 0.306/0.0909 = **3.36N**	 1 1 1 1
4-c	Basis: 20 kg C_2H_5OH and 120 kg H_2O	

	Total weight of mixture = 140 kg Weight fraction of C_2H_5OH = (wt of NaCl/ Total wt) = (20/140) = 0.**143** gmoles of C_2H_5OH = Weight/ mol.wt = 20/46= 0.435 gmoles of H_2O = Weight/ mol.wt = 140/18 = 7.78 Total moles = 0.435+7.78 =8.213 Mol fraction of C_2H_5OH = (Moles of C_2H_5OH /Total mole) = (0.435/80213) = **0.053**	1 1 1 1
4-d	**Mixing :** Mixing is a process in which at least two separate materials such as two different fluids, fluid and a powdered solid or two different or same solids are taken and forced them to be randomly distributed through one another by some mechanical means **Necessity of Mixing in process industry** Mixing is carried for producing simple mixtures, accomplishing dispersions, and promoting chemical reactions **Fluid transportation:** In industry, pumps, fans , blowers and compressors , pipelines, ducts, valves and fittings are the essential components of a system used for transportation of fluids from one location to another. Pumps are used for handling liquids, solutions and slurries, while fans, blowers and compressors are used for handling gases. In these machines, mechanical work is transformed into fluid energy and the energy input to a fluid by means of any these machines causes	1 1 2

	the fluid to be transported through piping systems.The machines commonly used in in the chemical process industries include centrifugal pumps, rotary pumps and reciprocating pumps for handling liquids and fans, blowers and compressors for gases.	
4-e	**Distillation:-** Distillation is an operation in which the components of a liquid mixture are separated using thermal energy. It depends upon the difference in boiling points of the individual components. The difference in vapour pressure of the components of a liquid mixture at the same temperature is responsible for separation by distillation. **Example:** separation of crude into different fractions, Separation of methanol-water **Drying:** Drying is an operation in which the moisture of a substance is removed by means of thermal energy. In this operation, moisture is removed by circulating hot air or gas over the material in order to carry away the water vapour. In this operation, heat and mass transfer occur simultaneously. Heat is transferred from the gas phase to the solid phase and mass is transferred from the solid phase to the gas phase. Usually a solid or nearly solid materials are processed in dryer. **Example:** drying of food, chemical, pharmaceutical	1 1 1 1
4-f	**Saponification:** The alkaline hydrolysis of an ester to form sodium salt and alcohol is referred to as saponification. $CH_3COOC_2H_5$ + NaOH ---------> CH_3COONa + C_2H_5OH Ethyl acetate sodium acetate **Esterification reaction:-**The reaction of an alcohol with a carboxylic acid to produce an ester is termed as esterification. Esterification of an acid such as acetic acid by an alcohol such as ethyl alcohol	2 2

	results in the production of ethyl acetate.Sulphuric acid and hydrochloric acids are the catalysts used for esterification. **Chemical Reaction for esterification:** $CH_3COOH + C_2H_5OH \rightarrow CH_3COOC_2H_5 + H_2O$ Esterification is the reaction where ester is produced whereas saponification is a reaction where sodium salt of ester is produced.	
5	**Any 4**	16
5-a	**(i) Cracking:** When Pyrolysis applied to alkanes is known as Cracking. When alkanes are heated well above their boiling points in the absence of air, a thermal decomposition occurs. Large alkane molecules are broken down to yield lower molecular weight alkanes, alkanes and hydrogen. Pyrolysis generally required temperature of the order of 500-800 ^{O}C. $CH_3CH_3 \xrightarrow{500^{O}C} C_2H_4 + CH_4 + H_2$ Ethane ethylene methane hydrogen $CH_3CH_2CH_3 \xrightarrow{600^{O}C} CH_3\text{-}CH{=}CH_2 + CH_2{=}CH_2 + CH_4 + H_2$ Propane Propylene ethylene methane Hydrogen (ii) **Chlorination:** It refers to the process in which one or more chlorine atoms are introduced into an organic compound. **Chlorination of methane:** Chlorination of methane in presences of ultraviolet light or at a temperature of 300 – 400 C results in the formation of polyhalogen derivatives.	2 2

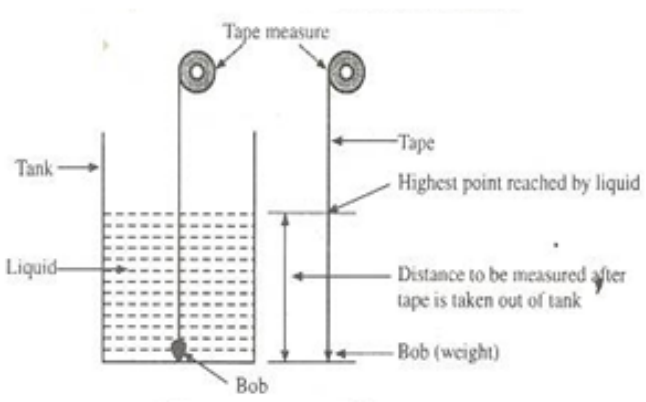
	U.V.light $CH_4 + Cl_2$ ----------> $CH_3Cl + CH_2Cl_2 + CHCl_3 + CCl_4 +$ HCl 300-400 C **OR** **Manufacturing of Chlorobenzene:** Benzene reacts with chlorine gas in the presence of catalyst at about 30-60 ^oC to form chlorobenzene $FeCl_3$ C_6H_6 + Cl_2 ---- ------> C_6H_5Cl + HCl Benzene 30-60^oC Chlorobenzene **Note : Any other suitable example**	
5-b	**Compare Gas absorption And Desorption** **Gas Absorption :** 1) Absorption is an operation in which a mixture of gases is brought in contact with a liquid in which a vapour solute is dissolved. 2) The vapour solute is absorbed in the solvent depending upon the solubility of the solute in the solvent. 3) This operation is sometime also termed as Scrubbing. 4) This operation is generally carried out in industry for the recovery of solute or the removal of solute depending upon the situation. 5) Gas Operation is usually carried out in packed column. 6) Example : Absorption of ammonia from an air- ammonia mixture by water. **Desorption:**	2

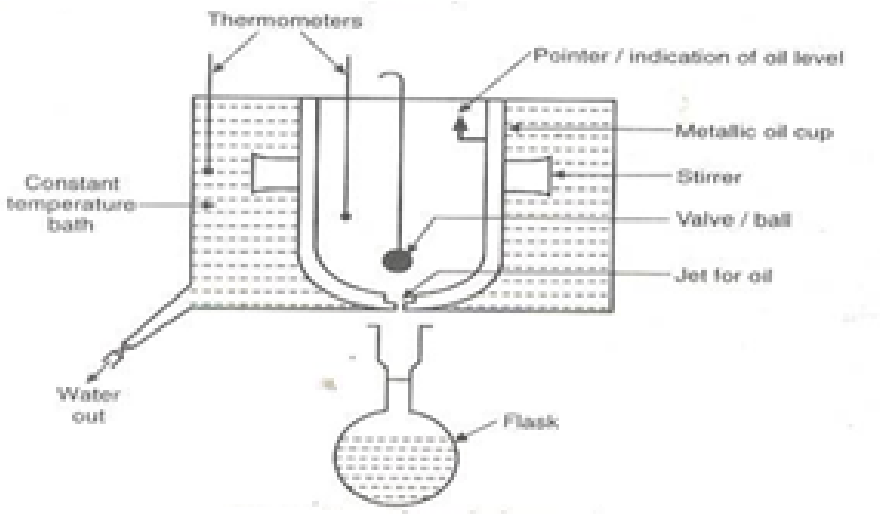
	1) Desorption is an operation in which a volatile component of a solution is removed by contacting the solution with gas. 2) The process of desorption is the reverse of absorption. 3) This operation is sometime also termed as Stripping. 4) In desorption ,the mass transfer is in the opposite direction than absorption. 5) Desorption is also carried out in packed column. 6)Example : The removal of a liquid hydrocarbon from heavy hydrocarbon oil by means of superheated steam.	2
5-c	**Difference Between Conversion and Yield :**	1 mark each

Conversion	**Yield**
1.Conversion is the ratio of the amount of reactant reacted to the initial amount of the reactant	**1. Yield** of a desired product is the ratio of the quantity of the desired product actually obtained to its quantity maximally obtainable.
2. Conversion gives us idea regarding how efficient a given chemical process is from the point of view of utilization of the starting materials.	**2.** The **Yield** of a desired product tell us how efficient is a given chemical process is in terms of the reaction product.
3. Higher values of **Conversion** is the indication of minimum amount of the limiting reactant left unreacted.	**3.** Higher values of **Yield** is the indication of minimum occurrence of side reactions.
4. Conversion is applicable to	**4. Yield** is applicable to Complex

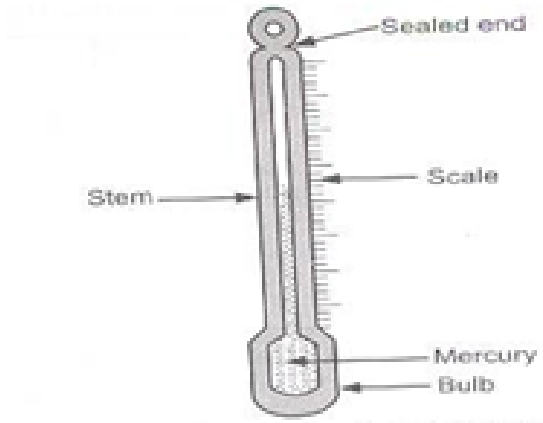
	single reactions as well as to Complex reaction.	reaction
5-d	**i) Oxidation:** It is defined as the addition of oxygen or removal of hydrogenation from organic compounds. - Oxidation reaction may involve the introduction of oxygen in the molecule of a compound. Oxidation of acetaldehyde: $CH_3CHO + ½\ O_2 \xrightarrow{----------} CH_3COOH$ Acetaldehyde acetic acid - Oxidation reaction may involve the removal of hydrogen from the molecule of a compound. Oxidation of methane: $CH_4 + O_2 \xrightarrow[\text{Heat}]{\text{Metal oxide}} HCHO + H_2O$ Methane Formaldehyde **Note : Any other suitable example** **ii) Reduction:** It is defined as the addition of hydrogen to an organic compound or replacement of Oxygen of an organic compound by hydrogenation. Example : Nitrobenzene can be reduced to aniline by using Fe+ HCl or Zn + HCl $C_6H_5NO_2 + 2Fe + 6HCl \xrightarrow{------} C_6H_5NH_2 + 2H_2O + 2FeCl_3$ **Note : Any other suitable example**	2 2

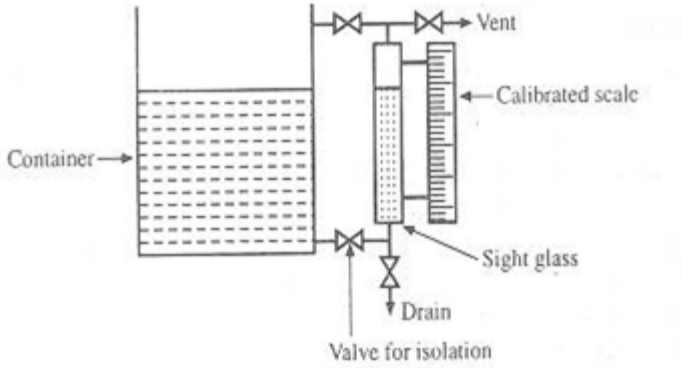
5-e	**Yield:** -Yield of desired product is the ratio of the quantity of product actually obtained to its maximally obtainable quantity. OR Yield of desired product is defined as the ratio of amount of a limiting reactant reacted to form the desired product to total reacted quantity of limiting reactant by all possible reaction. -The term yield is applicable to the desired product of a chemical process. - This term is applicable to desired product of reaction. **Selectivity:** Selectivity may be defined as the ratio of the moles of the desired product of undesired or by product produced in a set reaction. -Selectivity are applicable to a set of chemical reaction-complex reaction.	2 2
5-f	**One Industrial example of each** **1)Size Reduction:** a) Size reduction operation is carried out in Ore processing industries, copper ores, nickel ores are grounded before chemical processing. b) In cement industry, raw material lime and silica are grounded before calcinations. **2)Mixing:** Mixing of specialty chemicals, explosives, fertilizers, dry powdered detergents, glass or ceramics, and rubber compounds. **3)Size Separation:** screens are used for handling variety of dry powder, granular and dry foods. **4)Filtration:** a)Separation of suspended impurities from water . b)Separation of solid organic and inorganic material from their slurry.	 1 1 1 1

	Note : Any other suitable example	
6	**Any 4**	16
6-a	**Bob and tape Method**  1) Bob and tape is the most simple direct liquid level measurement devices. 2) It is consist of a bob (Weight) suspended from a tape marked in centimeter and meter. 3) Bob is lowered to the bottom of a tan or vessel containing liquid. 4) The liquid in the tank wets the part of the tape that is dipped into the pool of liquid. The bob and tape assembly is then removed from the tank and a reading of liquid level is made by noting the point on the tape reached by the liquid	2 2
6-b	**Personal protective equipments used in Chemical industries (any 4)** The purpose of PPE is to provide a safety barrier a hazard and the body of a person working in a hazardous environment. **1) Hard hat** : It is used for protection of head	1 mark each

	2) Safety goggles : It is used for protection of eye **3)Safety shoes:** It is used for protection of legs and foot **4)work clothes:** It is used for protection of whole body **5)Ear muff:** It is used for protection of ear **6)Ear plug :** It is used for protection of ear **7)Guard cuff's :** It is used for protection of body **8)Face Shield:** It is used for protection of face	
6-c	**Redwood Viscometer:**  **Working of Redwood Viscometer:** 1) Oil at given temperature is filled into the oil cup upto the tip of the pointer. 2) The temperature of oil is kept at a constant temperature by the addition of hot water in the heating bath. 3) When the oil temperature remains constant at a desired value for	2 2

	five minutes, the oil is allowed to flow through the jet by lifting the metal ball. 4) The time in seconds required to fill the oil in the flask up to the Mark is noted accurately with the help of a stop-watch. 5) The viscosity of oil is described in seconds	
6-d	(i) $^0F = 1.8\ ^0C + 32$ $= 1.8 * 200 + 32$ $^0F = \mathbf{392}$ $^0K = {}^0C + 273$ $= 200 + 273$ $^0K = \mathbf{473}$ (ii) $^0F = 1.8\ ^0C + 32$ $= 1.8 * 150 + 32$ $^0F = \mathbf{302}$ $^0K = {}^0C + 273$ $= 150 + 273$ $^0K = \mathbf{423}$	1 mark each
6-e	**Mercury thermometer:** **Construction:** It consists of a glass stem having fine capillary and glass bulb. The bulb is at lower end of glass stem. Mercury is filled in the bulb; after filling, open end of capillary is sealed under vacuum so that no air is left in capillary.	2

	 **Working:** When the thermometer bulb gets heated after immersion in a bath .The mercury expands much more than the glass and is therefore forced to rise up the stem to indicate the temperature .For each particular temperature, the mercury rises to a certain point in the stem.	2
6-f	**Sight Glass :** It is a level indicator. Sight glass level indicator consists of a simple vertical glass tube connected at both ends of a container or vessel containing liquid. The glass tube is connected to the vessel through valves which enable it to be isolated from the vessel .As the level of the liquid in a container rises or fall ,so does the level of liquid in the sight glass. The height of liquid in the tube always equalizes with the level of liquid in the container. The level of liquid is measured by simply reading the position of the liquid level on a calibrated scale attached to the sight glass.	2

	 **Sight glass level indicator**	2