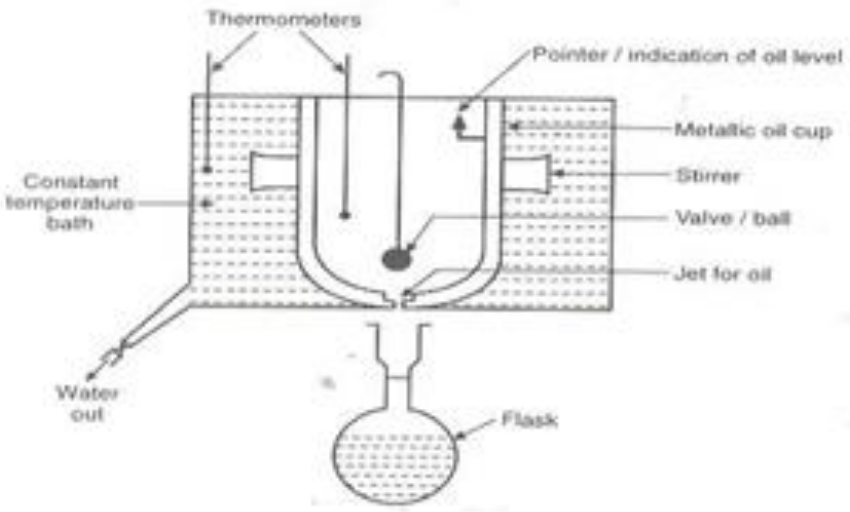
Important Instructions to examiners:

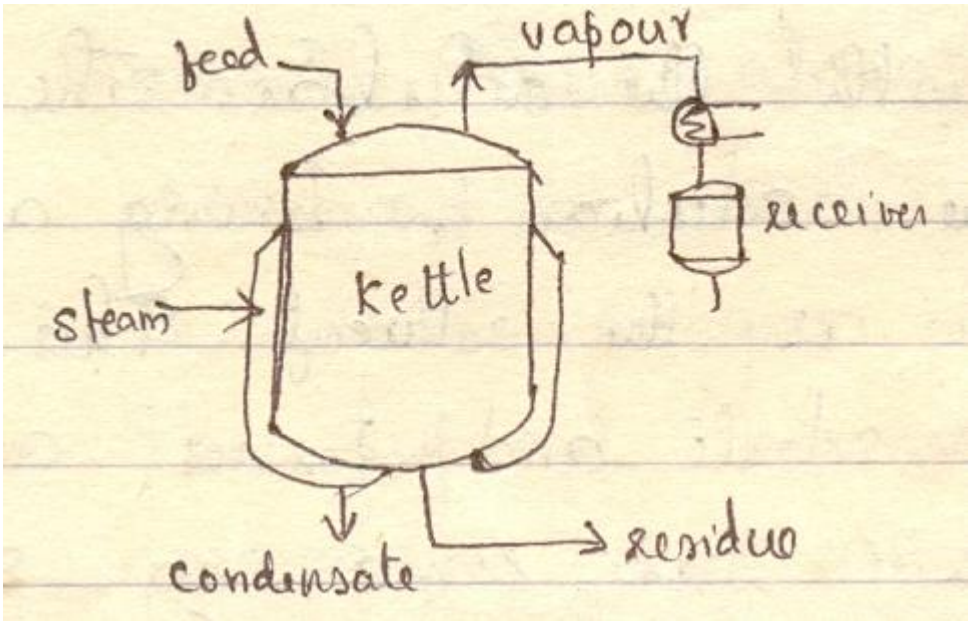
1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling 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	**Pharmaceutical Industry(any 2)** 1. Pfizer India 2. Cipla pharmaceuticals 3. Dr.Reddy's laboratories 4. Indoco Remedies Ltd. **Petrochemical Industry: (any 2)** 1. Reliance Industries Ltd 2. Supreme Petrochemical Ltd. 3. NOCIL 4. IPCL	½ mark each ½ mark each
1-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.	1 1
1-c	**Screening:**It is a method of separating solid particles according to size alone by means of screens of known aperture.	2
1-d	**Pressure:** It is force acting per unit area Unit: N/m^2 **Instrument used to measure pressure**: (any 1) 1.Manometer 2.Bourdon gauge	1 1

1-e	$^0F = 1.8\ ^0C + 32$ $= 1.8 * 100 + 32$ $= \mathbf{212\ ^0F}$ $^0K = {}^0C + 273$ $= 100 + 273$ $= \mathbf{373\ K}$	1 1
1-f	**Partial Pressure:** Partial pressure of a component gas is the pressure that would be exerted by that component gas if it alone was present in the same volume and at the same temperature as the gas mixture.	2
1-g	**Hydration:** Hydration is the process where water is added. Eg. $CH_2=CH_2 + H_2O \rightarrow CH_3CH_2OH$	 1 1
1-h	**Conversion:** % conversion of reactant= (moles of reactant reacted/ moles of reactant fed)*100	2
1-i	**Properties of Sulphuric Acid: (any 2)** a) Molecular weight=98 b) M.P.= 10.5^oC c) B.P.=340 ^oC d) Completely miscible with H_2O with large heat of solution.	1 mark each
1-j	**Advantages of size reduction**:(any 2) 1. Easy handling 2. Easy transportation 3. Increase in reaction rate 4. For having intimate mixing of solid	1 mark each

	5. To separate various ingredients.	
1-k	(i) **Density:** Density is mass/ volume (ii) **Specific gravity:** It is the ratio of density of a liquid to density of water at 4^0C Density has unit whereas specific gravity does not have unit.	1 1
1-l	**Ball mill:**  **Plate column:** 	1 1
2	**Any four**	16
2-a	**Normality** = gram equivalent of NaOH/ volume of solution in litres 1= gram equivalent of NaOH / 0.5 ltre gram equivalent of NaOH= 0.5 gram equivalent of NaOH=weight of NaOH/molecular weight of NaOH 0.5=weight of NaOH/40 Weight of NaOH= 2**0 grams**	1 1 1 1
2-b	**i)Molarity**: gram moles of solute/ volume of solution in litres	1

	ii)Normality: gram equivalent of solute/ volume of solution in litres iii)**Molality**: gram moles of solute/ weight of solvent in kg iv) C**oncentration:** Normality * equivalent weight	1 1 1
2-c	**Redwood Viscometer:**  	4
2-d	**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. In this operation, liquid and vapour phases are involved. The vapour phase is created by supplying heat to the liquid phase. The concentration of more volatile component of the liquid mixture is higher in vapour phase than in the feed solution, while that of the less volatile component is higher in the liquid phase.	3

	When a liquid mixture containing more volatile and less volatile components are heated, more volatile component will vaporize first and the vapours are collected and condensed to get it in pure form.  	1
2-e	**Differentiate between filtration and sedimentation** **Sedimentation** | **Filtration** Gravitational force is acting | Pressure force is acting Sedimentation tanks or settling tanks are used. | Filters are used No filter medium is used | Filter medium is used	2 marks each for any 2
2-f	**Scope of chemical engineer in industry:** A chemical engineer is one who develops, designs, constructs, operates and controls any physical and/or chemical or bio chemical changing process. The segments of the chemical industry in which a chemical engineer works at various levels are- research and development, production, design, administration and management, maintenance and trouble shooting,	4

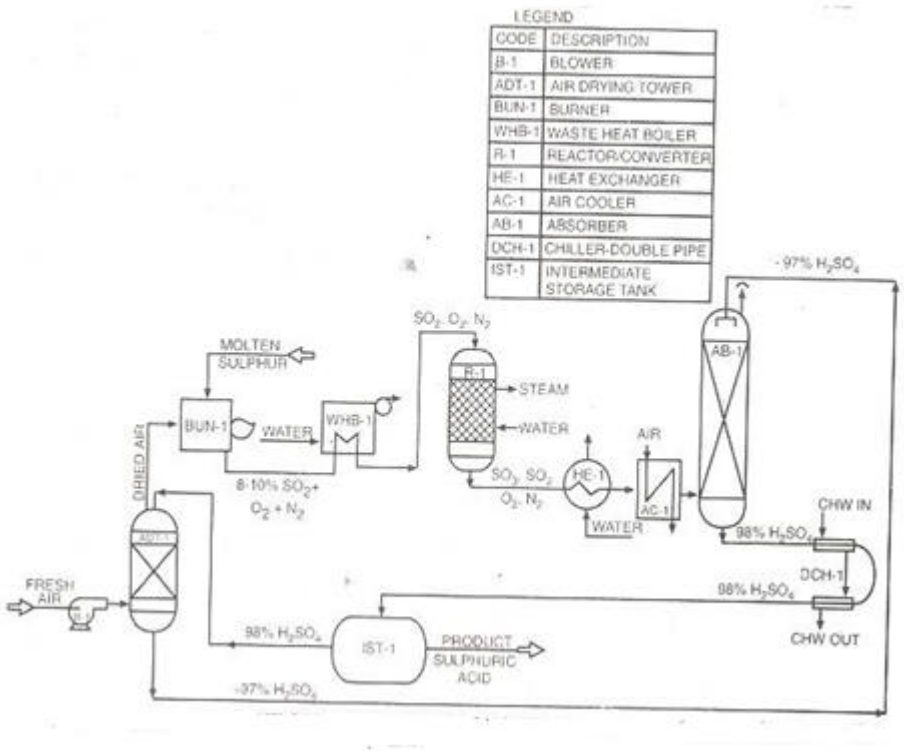
	project(erection and commissioning of plants), construction, market, sales and technical services. Chemical engineer also works in teaching and consultancy organizations, research organizations, and government departments.	
3	**Any 4**	16
3-a	**i)Molecular weight** : It is the sum of atomic weights of all elements present in a compound. **ii)Equivalent weight** Equivalent weight = molecular weight/valence. **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	Basis: 500 gm$FeSO4.7H_2O$ Mol. Wt of $FeSO4.7H_2O$ = 56+32+(16*4) +7*18= 278 G moles of $FeSO4.7H_2O$ =wt of $FeSO4.7H_2O$/ mol.wt of $FeSO4.7H_2O$ = 500/278 = 1.798 **g moles**	 1 1 1 1
3-c	Weight of NaOH = 150 kg Weight of Na_2CO_3 = 250 kg Total weight = 400 kg Weight % of NaOH = (150/ 400) * 100 =**37.5%** Weight % of Na_2CO_3= (250/ 400) * 100 = **62.5%** Molecular weight of NaOH = 40 Gram moles of NaOH = 150/40 = 3.75 Molecular weight of Na_2CO_3 = 106	 1 1

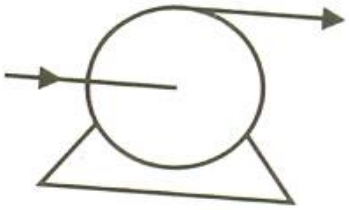
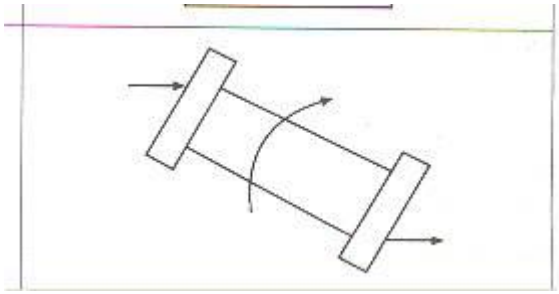
	Gram moles of Na_2CO_3 = 250/106 = 2.358 Total moles = 3.75+2.358 = 6.108 Mol % of NaOH = (moles of NaOH / Total moles)*100 = (3.75/ 6.108)*100 = **61.39%** Mol % of Na_2CO_3 = (moles of Na_2CO_3/ Total moles)*100 = (2.358/ 6.108)*100 = **38.61%**	1 1
3-d	**Gas Absorption:** -This operation is used to 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.	4
3-e	**Reactions involving in the production of Sulphuric acid:** 1000^oC Burner reaction : $S + O_2$ ----------> SO_2 450^oC Converter reaction : $2SO_2 + O_2$ ----------> $2\ SO_3$ V_2O_5 Absorber reaction : SO_3 absorbed in H_2SO_4 -------> H_2SO_4	 2

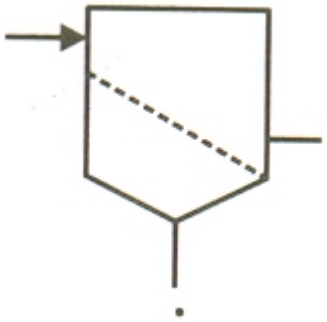
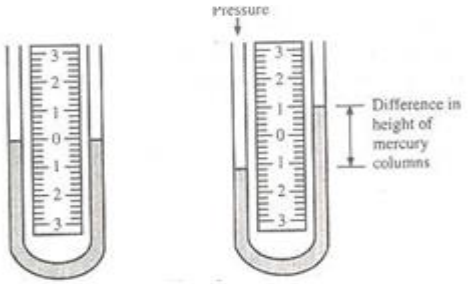
	Uses of Sulfuric acid(any 2) a) It is used as a dehydrating agent drying agent acidifying agent and neutralizing agent. b) It is used in the manufacture of fertilizer. c) Sulphuric acid is used for pickling iron and steel before galvanizing. d) It is used in processing metals. e) It is used in the manufacture of lead acid batteries.	1 mark each
3-f	**Sulfonation reactions** : It is the reaction with sulfuric acid to introduce sulfonic (SO_3H) group into a compound. $C_6H_6 + H_2SO_4 \text{----}\rightarrow C_6H_5SO_3H + H_2O$ Benzene benzene sulfonic acid	2 2
4	**Any 4**	16
4-a	**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. Drying operations may be carried out for i)reducing the transportation cost, ii)making materials more suitable for handling and storage, iii)preventing corrosion arising due to the presence of moisture and iv)providing definite properties to materials. Eg: Drying of pharmaceuticals, dyes, paper, cloth	4

4-b	N= gmequivalent of solute/ volume of solution in liter 2= gmequivalent of solute/ 1 lit Gram equivalent of HNO_3 = 2 weight of HNO_3= 2*63 = 126gram **To prepare 2N, 1lit HNO_3 solution, dissolve 126grams HNO_3 in water to get 2 lit solution**.	1 1 1 1
4-c	Convert 5 gm/cm.sec into kg/m.sec 1 kg = 1000gm 1m = 100 cm 5 gm/cm.sec = 5 *100/1000 = **0.5 kg/m.sec**	 1 1 1 1
4-d	**Differentiate between absorption and desorption(any 4)**	1 mark each
4-e	1. **Mass %** = (Individual mass/ Total Mass)* 100 2. **Weight %** = (Individual weight/ Total weight)* 100 3. **Volume %** = (Individual volume/ Total volume)* 100	1 1 1

Absorption	Desorption
It is used to separate the components of gas mixture	It is used to separate volatile component of a solution
Mass transfer takes place from gas to liquid	Mass transfer takes place from liquid to gas
Also known as scrubbing	Also known as stripping
Eg. Separation of ammonia from air-ammonia mixture using water as solvent	Eg. removal of liquid hydrocarbon from a heavy hydrocarbon oil by superheated steam
Separation is done by contacting with a liquid	Separation is done by contacting with an inert gas

	4. **Mole %** = (Individual moles/ Total Moles)* 100	1
4-f	**Flow diagram for manufacture of sulphuric acid:** 	4
5	**Any 4**	16
5-a	**Reaction and Reaction condition involving in the production of Nitric acid:** 870-900 ^oC $4NH_3 + 5O_2$ ----------> $4NO + 6H_2O$ $4NH_3 + 3O_2$ ----------> $2N_2 + 6H_2O$ $2NO + O_2$ ----------> $2NO_2$ $3NO_2 + H_2O$ ----------> $2HNO_3 + NO$ **Raw materials for nitric acid manufacture:** 1. Ammonia 2. Air	2 2

5-b	**i)Centrifugal pump**:  **ii)Packed column:**  **iii)Rotary dryer:**  **iv)Screen**:	1 mark each

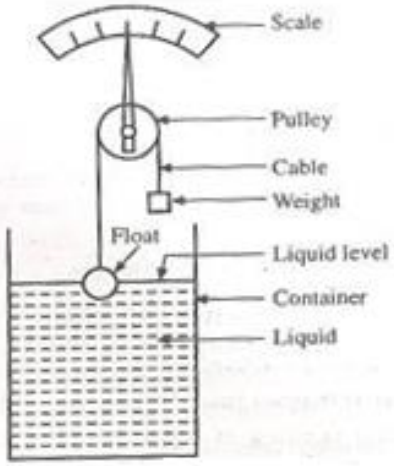
		
5-c	**U tube manometer**: 	4
5-d	**(i)Chlorination:** It refers to the process in which one or more chlorine atoms are introduced into an organic compound. **Chlorination of methane:** Chlorination of methane in presences of ultraviolet light or at a temperature of 300 – 400 C results in the formation of polyhalogen derivatives. 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	2 2

	form chlorobenzene $C_6H_6 + Cl_2 \xrightarrow[30\text{-}60^oC]{FeCl_3} C_6H_5Cl + HCl$ Benzene Chlorobenzene **Note : Any other suitable example**	
5-e	**Rotameter:** **Construction:** Rotameter consists of a tapered glass tube and float with scale. Tapered glass is mounted vertically with large diameter end at top and small diameter end at bottom. The tapered tube is placed in the casing which is made up of metal. A float stop is provided at top to prevent driving out of float with liquid. A nearly linear flow scale is marked on the glass tube or it is mounted close to the tube. **Working:** In Rotameter as flow varies, the float rises or falls, thus altering the flow area, which is the annular space/opening between the float and tube. As the flow increases, the float moves upward, thus increasing the area. At a given flow rate, float stabilizes at a certain fixed position in the tube and at steady-state, it is recorded as rotameter reading from the scale provided. It is used for flow measurements of liquids and gases.	2 2
5-f	**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	4

	solid particles. Filter aids are used as a pre coat to the filter medium before the slurry is filtered. This will prevent small particles from plugging the filter medium and also give a clearer filtrate. **Equipment used for filtration :** 1. Plate and frame filter press. 2. Drum filter	
6	**Any 4**	16
6-a	**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: $CH_3CHO + ½ O_2 \dashrightarrow CH_3COOH$ Acetaldehyde acetic acid - Oxidation reaction may involve the removal of hydrogen from the molecule of a compound. **Reduction:** Reduction is defined as the addition of hydrogen, removal of oxygen, addition of metallic element or addition of electrons. Eg. Reduction of ethyl bromide $CH_3CH_2Br + 2H \dashrightarrow C_2H_6 + HBr$ ***Any other suitable example***	2 2
6-b	**Chemical reaction for manufacture of nitric acid:** $4 NH_3 + 5 O_2 \dashrightarrow 4 NO + 6 H_2O$	2

	$4\ NH_3 + 3\ O_2 \rightarrow 2\ N_2 + 6\ H_2O$ $2\ NO + O_2 \rightarrow 2NO_2$ $3NO_2 + H_2O \rightarrow 2\ HNO_3 + NO$ **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 to undesired or by product produced in a side reaction.	1 1
6-c	**Nitration reactions** : It is the reaction with nitrating mixture to introduce nitro(NO_2) group into an organic compound. $C_2H_6 + HNO_3$ ------> $C_2H_5NO_2 + H_2O$	2 2
6-d	**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 **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	1 mark each

	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-e	**Mercury thermometer:** **Principle:** All liquids expand with rise in temperature and this volumetric expansion of liquid is proportional to rise in temperature. **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 2
6-f	**Float and tape method:** It consists of a float which is a hollow metal ball. It is connected to a light weight cable , the other end of the cable is connected to a counter weight. The cable is wound around a pulley, to which an indicating pointer is attached. The movement of the float is thus transferred to the pointer, which indicates the level of liquid. Because of the buoyancy, the float will follow the changing level of the liquid. As the level rises or falls, the movement of the float is transferred to the pointer that indicates the level. It is a continuous direct level measurement used in open vessels/ containers.	2

	 Scale Pulley Cable Weight Float Liquid level Container Liquid	2