Important Instructions to examiners:

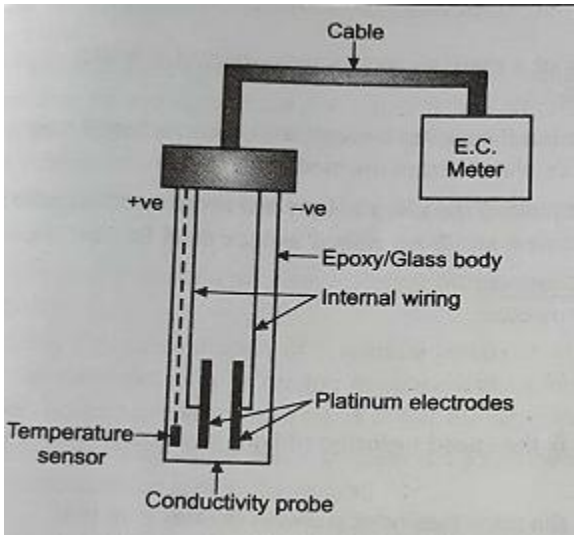
1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling 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		**Any five**	**10**
1	a	**Definition of reactor:** It is a vessel or an equipment in which a chemical reaction takes place.	2
1	b	**Names of personal protective equipment: (any 4)** 1. Helmet 2. Hard hat 3. Goggles 4. Ear plug 5. Ear muff 6. Apron 7. Hand gloves 8. Boots 9. Safety shoes	½ Mark each
1	c	**Normality of solution:** It is defines as the number of gram equivalent of solute per liter of solution Normality = Gram equivant of solute/ volume of solution in liter	2
1	d	**pH of solution**: It is defined as the negative logarithm of hydrogen ion concentration. $pH= - \log[H^+]$	2
1	e	**Different unit operations(any 4)** 1. Size reduction 2. Size separation or screening 3. Mixing 4. Filtration	½ mark each

		5. Sedimentation 6. Extraction 7. Distillation 8. Drying **9.** Crystallization **10.** Gas absorption	
1	f	**Dalton's law:** It states that the total pressure exerted by a gas mixture is equal to the sum of partial pressures of its component gases. $P = P_1 + P_2 + P_3$ Where P is total pressure of gas mixture P_1 , P_2 , P_3 are the partial pressures.	2
1	g	**Electrical conductivity:** Electrical conductivity of an electrolyte solution is a measure of the ability of the solution to conduct electricity(electric current) Unit: ohm^{-1}	1 1
2		**Any three**	**12**
2	a	**Types of chemical industries on the basis of application**: On the basis of application, Chemical industries are classified as 1. Industries manufacturing Basic chemicals 2. Industries manufacturing Fine chemicals 3. Industries manufacturing Specialty chemicals **Basic industrial** chemicals include fertilizers, organic and inorganic chemicals, dyes, resins, explosives, synthetic fibre, plastics, rubber etc. **Fine chemicals** are produced in limited volumes and at relatively high prices according to exact specifications, mainly by traditional organic synthesis in multipurpose chemical plants. Fine chemicals are used as starting material for	4

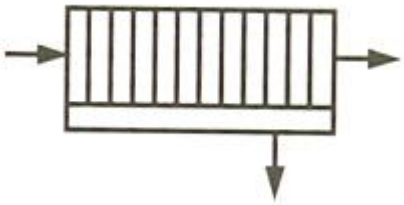
		specialty chemicals, particularly pharmaceuticals, biopharmaceuticals and agrochemicals. **Specialty chemicals** are particular chemical products which provide a wide variety of effects on which many other industry sectors rely. These are usually manufactured in batch chemical plants using batch processing techniques. Most of these chemicals are organic chemicals.	
2	b	**Hazards symbols:** i)Bio hazard  ii)Toxic material  iii) Corrosive  iv) Flammable materials	1 1 1

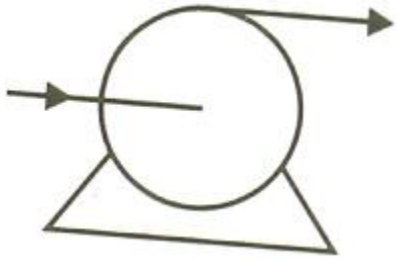
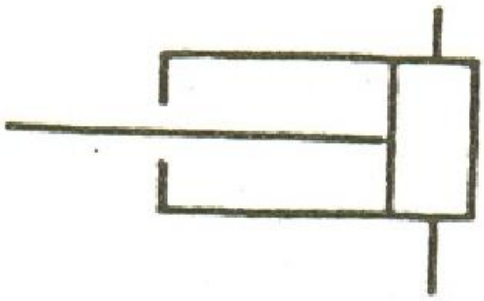
			1
2	c	**Determination specific gravity of a liquid using Specific gravity bottle:** 1) In order to determine the density by specific gravity bottle, first weigh the clean, dry, empty and stoppered bottle. 2) Then fill the bottle completely with the liquid ,stopper it ,clean the bottle from the outside with blotting paper to remove the excess liquid that spills on it outside 3) Weigh it again. Mass/Weight of empty bottle = W_1 g Mass/Weight of bottle filled with liquid = W_1 g Mass/Weight of the liquid = $W_2 - W_1$ Volume of the specific gravity bottle = V ml Density of the liquid in g/ml = $\frac{\text{Mass}}{\text{Volume}} = \frac{W_2 - W_1}{V}$ To avoid error due to the volume ,a certificate regarding the exact, accurate volume of the bottle should be taken from the supplier	4
2	d	**Conductivity meter**: It is used to measure conductivity of a solution.	2

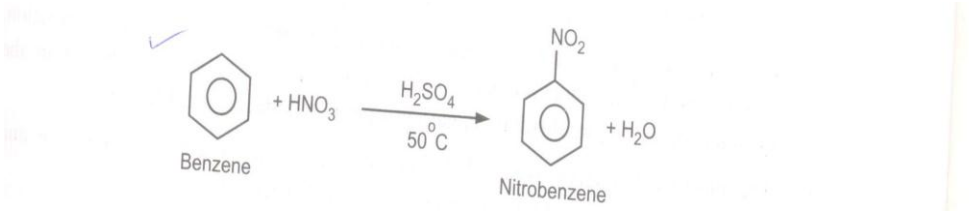
		Two electrodes (platinum plates) are placed in a sample, a potential is applied across the electrodes, and the current is measured. The meter consist of a conductivity probe and an EC meter. The probe consists of two electrodes (platinum plates) set at a constant distance from each other. The probe is connected by a cable to the meter. The probe(two electrodes) is placed in the solution such that the solution covers the electrodes and an alternating voltage is applied by the meter to the electrodes. The meter measures the resulting current that flows between the electrodes and uses Ohm's law to calculate first the conductance of the solution and then the conductivity of the solution using the conductance and cell constant.  	2
3		**Any three**	**12**
3	a	**Scale up: It is t**he migration of a process from laboratory scale to the bench scale, then to the pilot plant scale and finally to the commercial scale / industrial scale. In scale up, product and process development move in small steps from a lab scale to a commercial scale in order to reduce the risk of investment in the next step. A product is formed in grams on lab scale, in	2

		kilograms on bench scale, tens of kilograms to tons on pilot plant and tons to thousands of tons on a commercial scale. Scale up is used for market growth, introduction of new processes, modification of existing processes or reduction in making expensive errors in design and operation. **Design:** Design of a reactor is to find the size of the reactor necessary to achieve a specified conversion. It gives us the idea of which type and size of reactor and method of operation we should employ for a given duty. Design information, both chemical and mechanical is used for the fabrication / construction of the reactor.	2
3	b	**Causes of accident in a laboratory:** 1. Wet and slippery floor 2. Improper ventilation 3. Unavailability of personal protective equipment 4. Insufficient information about chemical hazard 5. Unsafe acts 6. Lack of written procedures regarding safety and emergency Improper material handling	1 mark each for any 4
3	c	**Formulas for:** 1**. weight %** Let a mixture contains components A,B & C of weights W_A, W_B & W_C Weight % of A =(Weight of A/ Total weight of mixture) * 100 $= W_A/(W_A+W_B+W_C)*100$ **2. mole %** Let the moles of the components be n_A,n_B & n_C Mol% of A = (moles of A/total moles)*100 $= (n_A/n_A+n_B+n_C) *100$	2 2

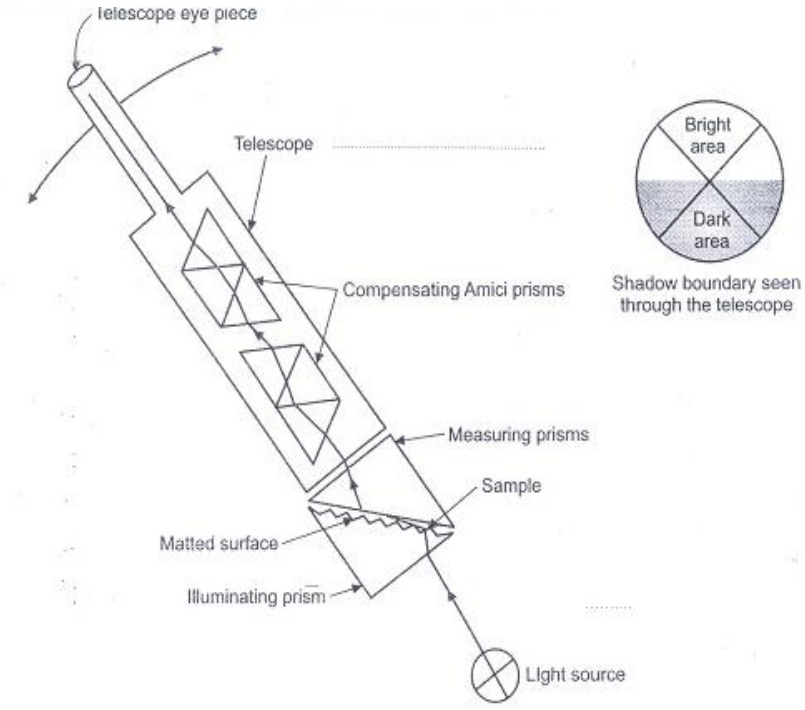
3	d	**Refractive index:** Refractive index of a medium is defines as the ratio of speed of light in vacuum to the speed of light in the medium. Refractive index = (speed of light in vacuum/ speed of light in medium) Refractive index measurement is widely used in analytical chemistry to determine the concentration of solutions. The speed of light in vacuum is the same but if it moves through any other medium it travels more slowly as it is constantly being absorbed and re emitted by the atoms of the medium. It determines how much light is bent or refracted, when entering a medium. **Dependence of refractive index on temperature:** Refractive index depends on temperature. An increase in temperature of a liquid decreases its density. This allows light to travel faster through liquid medium and as a result the refractive index of the liquid decreases. **Dependence of refractive index on composition:** Increasing the concentration of a solution results in an increase in the density of the solution. Speed of light through the solution decreases as the solution is denser and as a result of this refractive index of the solution decreases.	2 1 1
4		**Any three**	**12**
4	a	**Dry bulb temperature:** Temperature recorded by ordinary thermometer is called dry bulb temperature. **Measurement of DBT:** The temperature of air measured by an ordinary thermometer without cover of bulb by wet cloth. **Wet bulb temperature:** It is the temperature indicated by thermometer whose bulb is covered with cotton or muslin wire wetted with moisture. **Measurement of WBT:** The temperature of air measured by an ordinary thermometer with cover of bulb	1 1 1 1

		by wet cloth or wick and is exposed to the air. The readings of Dry bulb and wet bulb temperatures are used to predict weather. A large difference between the readings of dry and wet bulb temperatures indicates a dry weather. A small difference indicates a sultry weather or possible rain. One condition for rain is abundance of water vapour in the atmosphere.	
4	b	i)Jaw crusher  **ii) Filtration**  **iii) Ball mill**  **iv) pump** Centrifugal pump	1 1 1

		 OR Reciprocating pump 	1
4	c	**Solubility**: Solubility of a solute is the maximum amount of solute that can be dissolved in a given amount of solvent at a specific temperature and pressure. OR It is the amount of solute dissolved in a given quantity of solvent to produce a saturated solution at a specific temperature and pressure. It is expressed as parts by weight of solute per 100 parts by weight of the solvent at a given temperature. Another way to express solubility in in gm/ litre of solution. **Effect of temperature on solubility**: Solubility increases as temperature increases.	3 1
4	d	**Oxidation:** It is defined as the addition of oxygen or removal of hydrogenation	1

		from organic compounds. - Oxidation reaction may involve the introduction of oxygen in the molecule of a compound. Oxidation of acetaldehyde: $CH_3CHO + ½ O_2 \longrightarrow CH_3COOH$ Acetaldehyde acetic acid - Oxidation reaction may involve the removal of hydrogen from the molecule of a compound. **Nitration** is defined as unit process where one or more nitro groups are introduced into an organic compound. OR It is the reaction with nitrating mixture to introduce nitro(NO_2) group into an organic compound. Nitrating mixture is a mixture of con.Sulfuric acid and con. Nitric acid. Nitrating mixture is used in nitration reaction. $C_2H_6 + HNO_3 \text{------>} C_2H_5NO_2 + H_2O$ Ethane nitro ethane  	1 1 1
4	e	**Emergency exit:** An emergency exit is an exit other than regular exit in a workplace which is used for prompt evacuation of employees from the workplace during emergencies such as fire, explosion etc. Exit route must be unobstructed by materials, equipment etc., it must be separated from explosives and flammable materials and it must not be locked. Adequate lighting must be provided for exit	2

		route and the EXIT sign must be able to be seen from a distance. **Assembly point**: Assembly point is a predetermined safe area outside the building where all occupants of the building should assemble / gather and remains there till the end of the emergency. In the event of a fire or emergency, whenever it is necessary to evacuate the building, people must move promptly to the assembly point of the building. Assembly point should be easily and safely accessible and must have sufficient space to accommodate all occupants. It should have unobstructed pathway to them and should be located away from power lines.	2
5		**Any two**	**12**
5	a	**Unit Operation**: It is the operation in which only physical changes occur, but no chemical changes **Classification of Unit operation:** 1. Mechanical Operations: Transportation of materials, size reduction, screening, filtration, conveying, mixing, froth floatation 2. Electro mechanical operations: Magnetic separation, electrostatic separation, electro dialysis 3. Thermal operations: Evaporation, condensation, drying, distillation, crystallization, gas absorption etc. **Classification of Unit processes:** Different unit processes are: 1. Oxidation 2. Reduction 3. Nitration 4. Sulphonation 5. Hydration 6. Hydrogenation	3 ½ mark each for any 6

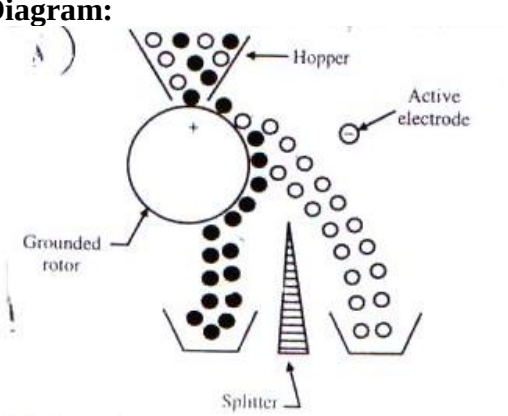
		7. Dehydrogenation 8. Esterification 9. Calcination 10. Pyrolysis 11. Halogenation	
5	b	**Abbes Refractometer:** **Diagram:**  **Principle:** The refractive index of a sample is determined by measuring the critical angle made when the sample is brought into contact with the medium (measuring prism) of a known refractive index. **Construction:**	1 1

		The abbe refractometer is the critical angle refractometer the essential parts of this refractometer are : i) light sources. ii) illuminating prism. iii) measuring prism. iv) telescope. v) two compensating Amici prisms. The illuminating and measuring prisms are right angle prism, usually of 30-60-90^0 construction and made of flint glass. The refractive index of this prism (1.75) is higher then the upper limit of the instrument range (i.e., the refractometer is designed to use with samples having the refractive index smaller than that of the prism, i.e., smaller than 1.75). The surface of illuminating prism is matted so that the light enters the sample (from the prism) at all possible angles , including that almost parallel to the surface. The lower face of the measuring prism (also known as the refracting prism)is highly polished. Two compensating Amici prisms are provided to prevent the dispersion of light and thus to get a shadow boundary clear An eyepiece of telescope is provided with cross hairs. For controlling temperature during measurements, water from the thermostat is circulated through jackets surrounding the prisms. **Working:** The sample is put between illuminating and measuring prisms in the form of film of thickness of about 0.10 to 0.14 mm. Light from a light source is directed towards the prisms. It enters the sample from illuminating prism and get refracted at critical angle at the bottom surface of the measuring prism, and then	2 2

		passes into a fixed telescope. The field of view gets divided into bright and dark areas. Using a rotating knob, the shadow boundary (border line)separating the bright and dark areas is placed exactly on the cross hairs of an eyepiece of the telescope and the refractive index is then read from the scale provided. The accuracy of this instrument is about $\pm$ 0.0002 .	
5	c	**i)Mixing:** Mixing is carried out for producing simple mixtures, accomplishing dispersions and promoting chemical reactions. It is a process in which two separate materials such as two different fluids, a 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. Mixing involves gases, liquids and solids in any possible combination. For liquid- liquid mixing agitated vessels are used, for solid-solid mixing kneading machines, ribbon blenders are used. **ii) 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 **iii) Evaporation:** It is a unit operation in which a weak solution is concentrated by boiling off the solvent. The product is concentrated solution. In this	1.5 1.5

		operation, the solvent to be evaporated is generally water and concentrated solution or thick liquor is the product. Evaporation is carried out by supplying heat to a solution to vaporize the solvent. A common heating medium is low pressure steam. The heat is utilized to increase the temperature of the solution to its boiling point and supply the latent heat of vaporization of the solvent. **iv) 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.	1.5 1.5
6		**Any two**	**12**
6	a	**Safety measures for:** **i)Eye injury :** a) Have the person immediately rinse the eye with clean water. b) Flush with lukewarm water for 15-30 minutes c) Flush the eye to remove contact lenses. d) Do not rub the eye or place a bandage over the eye. e) While waiting for medical care, have the person wear sun glasses. f) Get doctor's help immediately. g) Make sure you know what chemical got into the eye. **ii)Burn:** a) Most chemical burns of the skin are treated first by rinsing the chemical	1.5

		off your body with a large amount of room temperature water. b) Flood affected area with cool water for 20 minutes. c) Make sure water doesnot flow into other parts of the person s body or onto you. d) Remove the chemical causing burn. e) Remove contaminated clothing or jewellery. f) Loosely apply a bandage. g) Consider a tetanus shot. **iii) Skin contact:** a) Remove contaminated clothing b) Flush skin with water for atleast 10 minutes. c) Seek medical treatment d) Powdered chemicals should be carefully brushed off first, then flush with water. e) If there is any injury, cover with clean, non fluffy material to protect from infection. f) Transfer casualty to hospital. **iv)Inhalation of toxic fumes:** a) Close containers, open windows and move to fresh air. Do not turn on air conditioning or fans. b) Remove affected person to safe area. c) Apply CPR if breathing has stopped. d) Closely monitor airway and breathing e) If symptoms such as head ache, nose or throat irritation, dizziness or drowsiness persists, seek immediate medical attention.	1.5 1.5 1.5
6	b	**Electrostatic Separator** **Principle**: ”If one or more of the materials of a granular mixture can acquire a	2

		surface charge on or just before entering an electrostatic field, the particles of that material will be attracted towards the active electrode or repelled from it depending on the charge on the particles." It is the method of separation of solid particles based on differential attraction or repulsion of charged particles under the influence of an electric field. The difference in electrical properties of different materials is responsible for such a separation. **Diagram:**  **Construction**: It consists of rotating drum, a hopper for feed, an active electrode & collecting bin **Working:** The charged particles fed on drum from hopper. Conductive particles assume potential of drum, opposite to that of active electrode, hence attracted towards active electrode. Non-conductive particles get repelled by electrode ,attracted by drum, falls straight in collecting bin due to gravity.	2 1 1
6	c	**i)Pyrolysis:** The decomposition of a compound by heat is called pyrolysis. Large alkane molecules are broken down to give lower molecular weight alkanes, alkenes and hydrogen.	1

		Eg: When ethane is heated to 500 ^{0}C in the absence of air, it gives a mixture of methane, ethylene and hydrogen. $C_2H_6 \rightarrow C_2H_4 + CH_4 + H_2$	1
		ii)Hydration: It refers to a unit process of adding a water molecule to an Organic Compound.	1
		Hydration of Ehtylene : Ethanol can be produced by hydration of ethylene in presence of a phosphoric acid at about 300^{o}C $C_2H_4 + H_20 \xrightarrow{H_3PO_4} C_2H_5OH$ **Hydration of propylene :** $CH_3CH = CH_2 + H_2O \dashrightarrow CH_3CH(OH)CH_3$ Or any other example student can write	1
		iii)Hydrogenation: It refers to the chemical reaction of an organic compound with molecular hydrogen in the presence of a catalyst.	1
		Chemical Reaction for hydrogenation: $CH_2= CH_2 + H_2 \rightarrow CH_3\text{-}CH_3$ $C_6H_6 + 3H_2 \rightarrow C_6H_{12}$	1