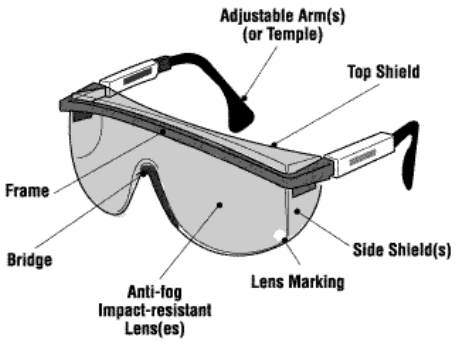
**Important Instructions to examiners:**

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 five** | **10** |
| 1-a | **Rate data**: It is the data on concentration of reactants/ products with respect to time. It is used to find out the rate of reaction<br>**Chemical Kinetics**: It is the study of the rates at which chemical reactions occur and the effect of parameters such as temperature, pressure, reactant concentration/ composition on the reaction rates. | 1<br>1 |
| 1-b | **Classification of chemical reactors**:<br>1. Based on shape of reactor<br>a) Tank reactor<br>b) Tubular reactor<br>2. Based on mode of operation<br>a) Batch reactor<br>b) Semi batch reactor<br>c) Continuous reactor | <br>1<br><br><br>1 |
| 1-c | **Unsafe conditions in a laboratory : (any 4)**<br>1. Wet and slippery floor<br>2. Improper ventilation<br>3. Unavailability of personal protective equipment<br>4. Insufficient information about chemical hazard<br>5. Unsafe acts<br>6. Lack of written procedures regarding safety and emergency<br>**7.** Improper material handling | ½ mark each |
| 1-d | Hazards symbols:<br>1. Toxic material | |

| | | |
|---|---|---|
| |  <br>2. Corrosive materials<br>  | 1<br><br><br><br><br><br>1 |
| 1-e | **Molarity of solution=** gram moles of solute/ volume of solution in litre | 2 |
| 1-f | **Dalton's law:**<br>It states that the total pressure exerted by a gas mixture is equal to the sum of partial pressures of its component gases.<br>$P = P_1 + P_2 + P_3$<br>Where P is total pressure of gas mixture<br>$P_1$ , $P_2$ , $P_3$ are the partial pressures. | 1<br><br><br><br>1 |
| 1-g | **pH of solution**: It is defined as the negative logarithm of hydrogen ion concentration.<br>$pH= - \log[H^+]$<br>**Scale:** It is a logarithmic scale ranging from 0 to 14 used to measure the concentration of hydrogen ion in a solution. Water has a pH of 7, acidic solution has a low pH value (0-7) and basic solution has a high pH value(7-14). | 1<br><br><br><br>1 |
| 2 | **Any three** | **12** |
| 2-a | **Relation between chemistry and chemical engineering**:<br>1. Chemical Engineering is the technology of Chemistry.<br>2. Chemistry deals with unit process whereas chemical engineering covers unit | 4 |

| | | |
|---|---|---|
| | operation as well as unit process.<br>3. Design of proper Reactors, stirring mechanism, energy management are needed in chemical engineering.<br>4. Chemistry gives you products in limited quantity whereas to get large quantity of products chemical engineering is needed. | |
| 2-b | **Diagram of personal protective device(any 4)**<br>  <br>Helmet<br>  <br>hand gloves<br>  <br>Ear plug<br>  <br>Apron(suit) | 1 mark each |

| | | |
|---|---|---|
| |  Goggle  Safety shoes | |
| 2-c | **Measurement of specific gravity of a liquid**:<br>**Determination specific gravity of a liquid using Specific gravity bottle:**<br>1) In order to determine the density by specific gravity bottle, first weigh the clean, dry, empty and stoppered bottle.<br>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<br>3) Weigh it again.<br>Mass/Weight of empty bottle = $W_1$ g<br>Mass/Weight of bottle filled with liquid = $W_1$ g<br>Mass/Weight of the liquid = $W_2 - W_1$<br>Volume of the specific gravity bottle = V ml<br>Density of the liquid in g/ml = $\frac{\text{Mass}}{\text{Volume}} = \frac{W_2 - W_1}{V}$<br>To avoid error due to the volume ,a certificate regarding the exact, accurate | 4 |

| | | |
|---|---|---|
| | volume of the bottle should be taken from the supplier | |
| 2-d | **Principle of conductivity meter**:<br>Two electrodes (platinum plates) are placed in a sample , a potential is applied across the electrodes, and the current is measured.<br>**Principle of Abbe's refractometer:**<br>The refractive index of a sample is determined by measuring the critical angle made when the sample is brought into contact with the medium of a known refractive index (measuring prism). | 2<br>2 |
| 3 | **Any three** | **12** |
| 3-a | **Temperature**:<br>Temperature is a measure of hotness or coldness of a body.<br>**Dry bulb temperature:**<br>Temperature recorded by ordinary thermometer is called dry bulb temperature.<br>**Wet bulb temperature:**<br>It is the temperature indicated by thermometer whose bulb is covered with cotton or muslin wire wetted with moisture<br>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. | 1<br>1<br>1<br>1 |
| 3-b | Weight of NaCl = 10 kg<br>Weight of $H_2O$ = 50 kg<br>Total weight = 60 kg<br>Weight % of NaCl = (10/ 60) * 100 =**16.67%**<br>Weight % of $H_2O$ = (50/ 60) * 100 = **83.33%** | 1<br>1 |

| | | |
|---|---|---|
| | Molecular weight of NaCl = 58.5<br>k moles of NaCl = 10/58.5 = 0.171<br>Molecular weight of $H_2O$ = 18<br>k moles of $H_2O$ = 50/18 = 2.78<br>Total moles = 0.171+2.78 = 2.949<br>Mol % of NaCl = (moles of NaCl / Total moles)*100<br>= (0.171/ 2.949)*100 = **5.79%**<br>Mol % of $H_2O$ = (moles of $H_2O$ / Total moles)*100<br>= (2.78/ 2.949)*100 = **94.26%** | 1<br><br>1 |
| 3-c | **Solubility**:<br>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.<br>OR<br>It is the amount of solute dissolved in a given quantity of solvent to produce a saturated solution at a specific temperature and pressure.<br>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.<br>**Effect of temperature on solubility**:<br>Solubility increases as temperature increases. | 3<br><br>1 |
| 3-d | **Size reduction:** It is an operation wherein large solid particles are subdivided to smaller ones.<br>**Importance of size reduction**:<br>1. Easy handling<br>2. Easy transportation<br>3. Increase in reaction rate<br>4. For having intimate mixing of solid | 1 mark each for any 4 |

| | | |
|---|---|---|
| | 5. To separate various ingredients. | |
| 4 | **Any three** | **12** |
| 4-a | **Types of chemical industries on the basis of application**:<br>On the basis of application, Chemical industries are classified as<br>1. Industries manufacturing Basic chemicals<br>2. Industries manufacturing Fine chemicals<br>3. Industries manufacturing Specialty chemicals<br>**Basic industrial** chemicals include fertilizers, organic and inorganic chemicals, dyes, resins, explosives, synthetic fibre, plastics, rubber etc.<br>**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 specialty chemicals, particularly pharmaceuticals, biopharmaceuticals and agrochemicals.<br>**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<br>2 |
| 4-b | **Importance of safety in chemical industries**:<br>1. To increase the rate of production<br>2. To reduce the cost of production<br>3. To reduce the damage to equipment and machinery<br>4. To protect the life and limbs of the workers | 1 mark each |
| 4-c | **Importance of Emergency exit:**<br>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 | 2 |

| | | |
|---|---|---|
| | 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 route and the EXIT sign must be able to be seen from a distance.<br>**Importance of assembly point**:<br>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 |
| 4-d | Basis: 500 ml solution.<br>Weight of solute = 20 gm<br>Molecular weight of NaOH = 40<br>Gram moles of solute = 20/40 = 0.5<br>Molarity = Gram moles/ Volume of solution in lit<br>0.5/0.5 = **1 M**<br>Normality = gram equivalent of solute/ volume of solution in lit<br>= 0.5/0.5 = **1N** | 1<br>1<br>1<br>1 |
| 4-e | **Different unit operations:**<br>1. Size reduction<br>2. Size separation or screening<br>3. Mixing<br>4. Filtration<br>5. Sedimentation<br>6. Extraction | ½ mark each for any 4 |

| | | |
|---|---|---|
| | 7. Distillation<br>8. Drying<br>**9.** Crystallization<br>**10.** Gas absorption<br>**Explanation**<br>**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. 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.<br>OR<br>**Distillation:-**<br>- Distillation is an operation in which the components of a liquid mixture are separated using thermal energy.<br>- In this operation, liquid and vapour are involved. The vapour phase is created by supplying heat to the liquid phase.<br>-This unit operation is also termed as fractionation and with this technique it is possible to separate a liquid mixture into its components in almost pure forms.<br>- In this operation mass is transferred from both the phases to one another by vaporization from the liquid phase and by condensation from the vapour phase.<br>OR<br>**Gas Absorption:** | 2 |

| | | |
|---|---|---|
| | -This operation is used to separate the components of gas mixture .<br>-It is carried out for the recovery or the removal of a soluble components of a gas mixture depending upon the situation.<br>-Absorption is an operation in which a gas mixture is contacted with a liquid solvent for the purpose dissolved a definite component of the gas mixture in the liquid.<br>- Gas absorption is usually carried out in packed columns.<br>Example:<br>1) Absorption of ammonia from an air- ammonia mixture by water<br>2) Removal of hydrogen sulfide from naturally occurring hydrocarbon gases<br>OR<br>**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.<br>***Note: Explanation of any one unit operation should be considered.*** | |
| 5 | **Any two** | **12** |
| 5-a | **Application of pH measurement in Industry:**<br>pH measurement is essential in :<br>1) Waste water treatment, municipal sewage treatments.<br>2) Boiler feed water treatment.<br>3) Drinking water purification.<br>4) Production of Ultra pure water.<br>5) Aquariums and swimming pools. | ½ mark each for any 6 |

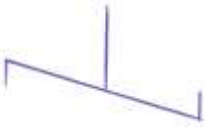
| | | |
|---|---|---|
| | 6) Cooling tower water.<br>7) Checking freshness of raw incoming milk.<br>8) Desulphurization process that removes sulfur from oil in oil refineries.<br>9) Process of drying in textile industries.<br>10) Checking chemical reaction in production of drugs.<br>11) Determining plant nutrients in soil.<br>12) Digestion and bleaching processes in the manufacturer of pulp and papers.<br>**Effect of pH on electrical Conductivity:**<br>The conductivity of solution depends upon the concentration of all the ions presents. The conductivity increases with increase in concentration of ions. These ions contribute differently to the conductivity depending upon their mobilities through the solution. The most mobile cation is the hydrogen ion [$H^+$]. pH is measurer of the concentration of the hydrogen ions for an acidic solution, Thus solutions having lower pH values are having higher conductivity values. | 3 |
| 5-b | **i)Tray dryer**:<br>  | 1 mark each |

**ii)Plate column:**

**iii)Packed column:**

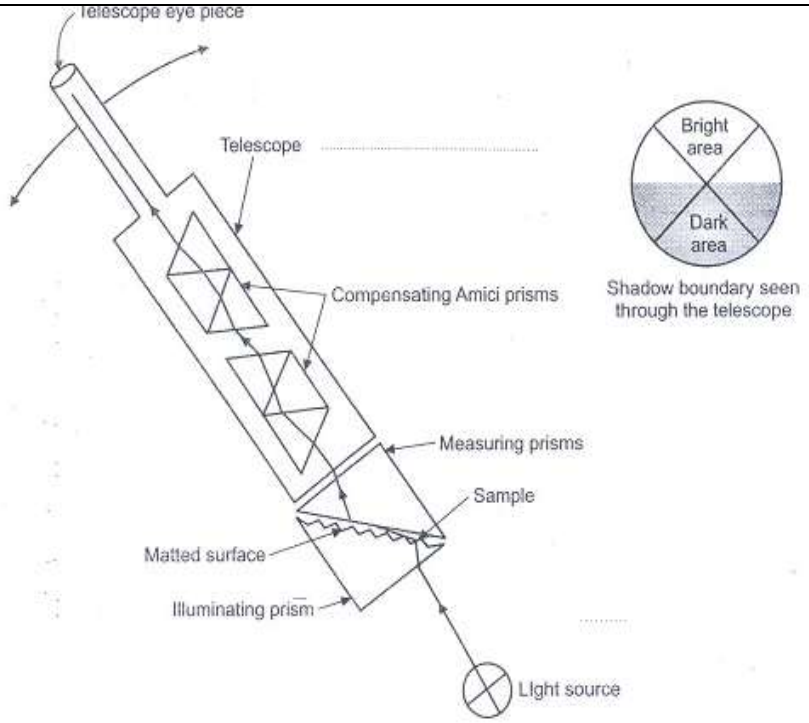
**iv) Jaw crusher**:

**v) Stirrer:**



| | | |
|---|---|---|
| | vi) Ball mill  | |
| 5-c | **(i) Sulfonation reactions** :<br>It is the reaction with sulfuric acid to introduce sulfonic ($SO_3H$) group into a compound.<br>$C_6H_6 + H_2SO_4 \text{----}\rightarrow C_6H_5SO_3H + H_2O$<br>Benzene benzene sulfonic acid<br>**(ii) Hydrogenation:**<br>Hydrogenation may be defined as the chemical reaction of an organic with molecular hydrogen in the presences of a catalyst.<br>It is a unit process by which an organic compound reacts with molecular hydrogen in the presences of catalyst.<br>**1)** Ethylene can be hydrogenated to ethane under pressure in the presence of Ni catalyst<br>$CH_2= CH_2 + H_2 \xrightarrow[\text{Heat}]{\text{Ni}} CH_3\text{-}CH_3$<br>Ethylene Ethane<br>2) Cyclohexane can be produced by hydrogenation of benzene at 150 $^oC$ using Ni catalyst<br>$C_6H_6 + 3H \xrightarrow[150\ ^oC]{\text{Ni}} C_6H_{12}$<br>**(iii) Esterification**: **T**he reaction of an alcohol with a carboxylic acid to | 1<br>1<br>1<br>1 |

| | | |
|---|---|---|
| | produce an ester is termed as esterification | 1 |
| | Example : Esterification of an acid such as acetic acid by an alcohol such as ethyl alcohol results in the production of ethyl acetate. Sulphuric acid and hydrochloric acids are the catalysts used for esterification. | |
| | $CH_3COOH + C_2H_5OH \underset{\leftarrow}{\overset{N^+}{\rightarrow}} CH_3COOC_2H_5 + H_2O$ <br> Acetic acid Ethanol Ethyl acetate | 1 |
| 6 | **Any two** | **12** |
| 6-a | **Abbes Refractometer:** <br> **Principles:** <br> 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. <br> **Diagram:** | 1 |




1

**Construction:**

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.

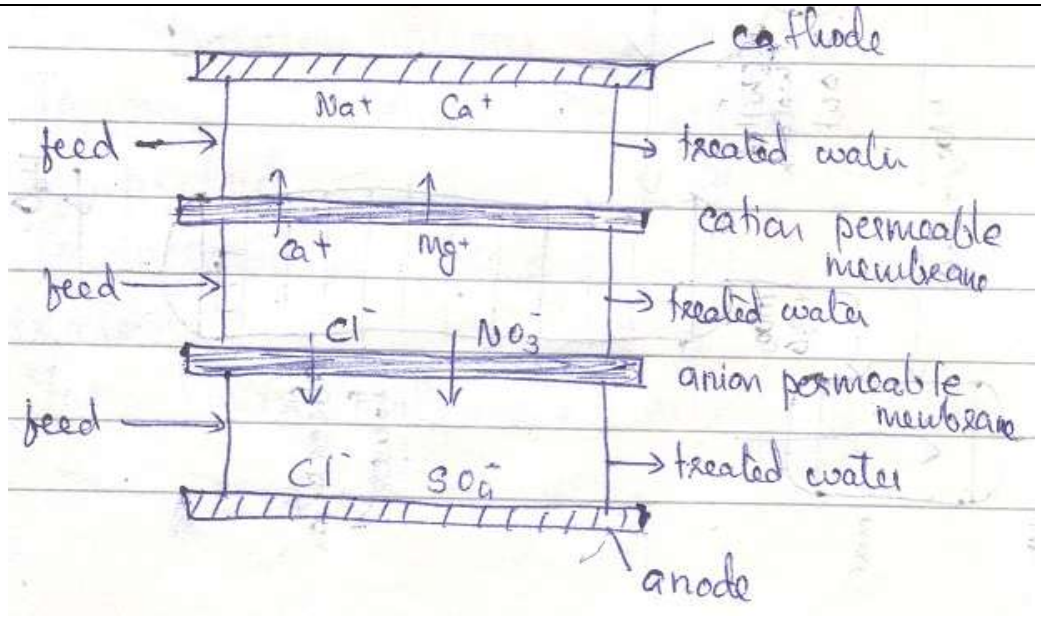
v) two compensating Amici prisms.

2

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.<br>The lower face of the measuring prism (also known as the refracting prism)is highly polished.<br>Two compensating Amici prisms are provided to prevent the dispersion of light and thus to get a shadow boundary clear<br>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.<br>**Working:**<br>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 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.<br>The accuracy of this instrument is about $\pm$ 0.0002 . | 2 |
| 6-b | **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.<br>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 | 3 |

| | | |
|---|---|---|
| | 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.<br>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.<br>**Leaching:**<br>-Leaching is an operation in which a solid mixture is contacted with a liquid solvent for the removal of one or more constituent of the solid mixture.<br>-The process of removing a solute from the solid by treating it with a liquid solvent is called leaching.<br>-This operation is also called as solid-liquid extraction.<br>-Leaching involves the transfer of soluble component of a solid phase into a relatively non-volatile liquid solvent. The soluble solid from an insoluble solid matter dissolves in the solvent used.<br>-Leaching may be used either for the production of a concentrated solution of a valuable solid material, or in order to free an insoluble solid from a solute material with it is contaminated.<br>-Examples of leaching<br>1) Leaching of gold from its ores by using sodium cyanide solution.<br>2) Extraction of oil from oilseeds by using hexane as solvent.<br>3)Extraction of sugar from sugar beats using hot water. | 3 |
| 6-c | **Electro- dialysis:** | 6 |


cathode
Na+
Ca+
feed
treated water
cation permeable membrane
Ca+
Mg+
feed
treated water
Cl⁻
NO3⁻
anion permeable membrane
feed
Cl⁻
SO4⁻
treated water
anode