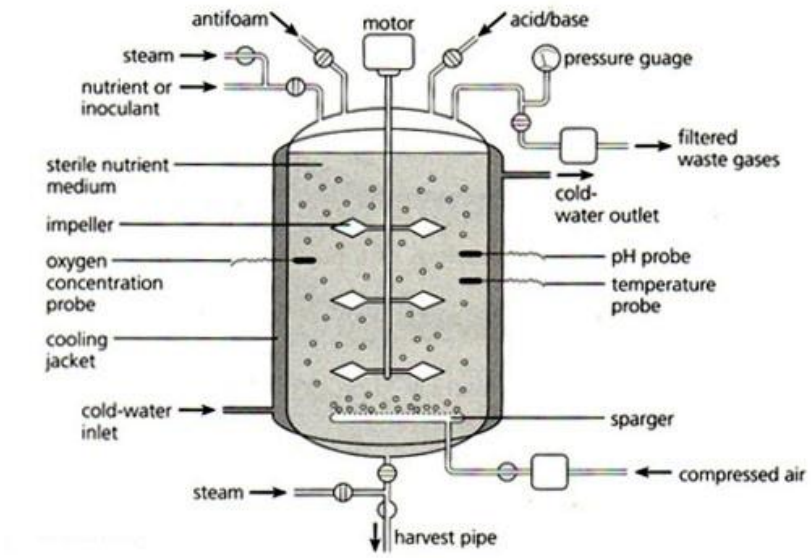
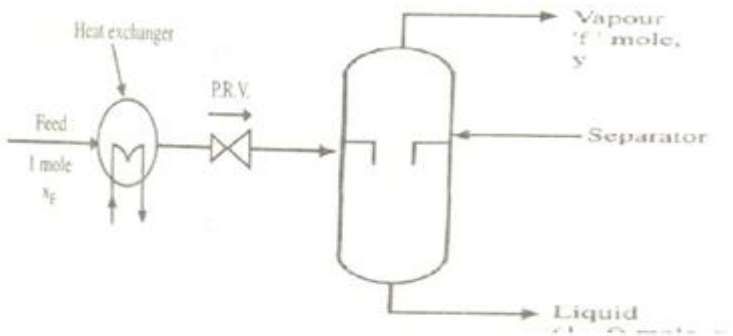
Important Instructions to examiners:

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	Marking scheme
1	Attempt any 5	20
1.a	**Evaporation Process in chemical industry:** Evaporation process is commonly used in food and fermentation industries to concentrate the feed or recover targeted products. Evaporation, in a technical sense, denotes the conversion of a liquid into a vapor for the purpose of separating it from another liquid of higher boiling point, or from a solid which is dissolved in it. In the great majority of cases, the liquid evaporated is water. If the liquid evaporated is to be recovered, the vapors are condensed, and the process then becomes one of Distillation. **Factors affecting rate of evaporation:** 1. Concentration of solution 2. Density of solution 3. Viscosity of solution 4. Temperature of solution	2 2
1.b	**Fermentor:**	

	 **Functions of:** 1. Pressure guage: To indicate the inside pressure 2. pH probe: To measure the pH value **3.** Temperature probe: To indicate the inside temperature	3 1
1.c	**Nutritional requirement of yeast:** Yeasts have relatively simple nutritional needs. They are unable to carry out photosynthesis and hence require a reduced carbon source. They require the vitamin biotin and an organic nitrogen source such as ammonium, urea and amino acids. The yeast will grow successfully if adequate supply of macronutrients and micronutrients are made. Macronutrients are the compounds that supply the needs for cell division and energy generation. They are needed in high or stoichiometric amounts. In contrast, the micronutrient vitamin and minerals are required in much lower amounts and are catalyst involved in many enzymatic reactions. The macronutrients are sources of carbon , nitrogen, phosphate and sulphate. These four elements are required for production of a	4

	new cell as well as for maintenance of a cell in stationary phase. The essential micronutrients and trace elements are the cations required universally by organisms.	
1.d	**Maintenance of yeast vessel:** 1. All the lines to the vessels are flushed with water and steam sterilized. 2. Valve should be checked at regular intervals. 3. Gasket should be changed at regularly. 4. Filter insert is to be replaced every two years.	4
1.e	**Differentiate rum and whisky:** **Rum :** • Derived from sugarcane juice or molasses • Clear rums are stored in stainless steel tanks until they are bottled while dark rums have been aged, typically in used whiskey barrels. **Whisky :** • Derived from grains such as barley, rye, wheat, and corn • Usually aged in oak casks. • Usually only comes in aged varieties although un-aged whiskeys, known as white dog, are available.	4
1.f	**Malt alcohol** **Raw materials:** 1. Barley/corn/wheat/oats/potatoes in the form of malt 2. Hops **Reaction:** $C_6H_{12}O_6$ -------→$2CH_3CH_2OH + 2CO_2$	2 2

1.g	**Pollution:** **Pollution** is the introduction of contaminants into the natural environment that cause adverse change. Pollution can take the form of chemical substances or energy, such as noise, heat or light. Pollutants, the components of pollution, can be either foreign substances/energies or naturally occurring contaminants. Pollution is often classed as point source or nonpoint source pollution. **Methods of pollution control:** Different processes covering anaerobic, aerobic as well as physico-chemical methods have been employed to treat this effluent. Anaerobic treatment is the most attractive primary treatment due to over 80% BOD removal combined with energy recovery in the form of biogas. Further treatment to reduce residual organic load and color includes various: (i) biological methods employing different fungi, bacteria and algae, and (ii) physico-chemical methods such as adsorption, coagulation/precipitation, oxidation and membrane filtration.	2 2
2	Attempt any 2	16
2.a	**Continuous Distillation:** **Single stage continuous distillation(Flash distillation)**  This occurs where a liquid mixture is partially vaporized. The vapour produced	4

and the residual liquid are in equilibrium in the process and separated and removed. The feed is preheated before entering the separator, the heated mixture then flows through a pressure reducing valve to the separator. In the separator, separation between the vapour and liquid takes place.

Consider one mole of liquid mixture having x_f mole fraction , f moles of feed that is vapourized and of composition y. Then (1-f) will be the moles of residual liquid obtained. Let x be the mole fraction of more volatile component in liquid.

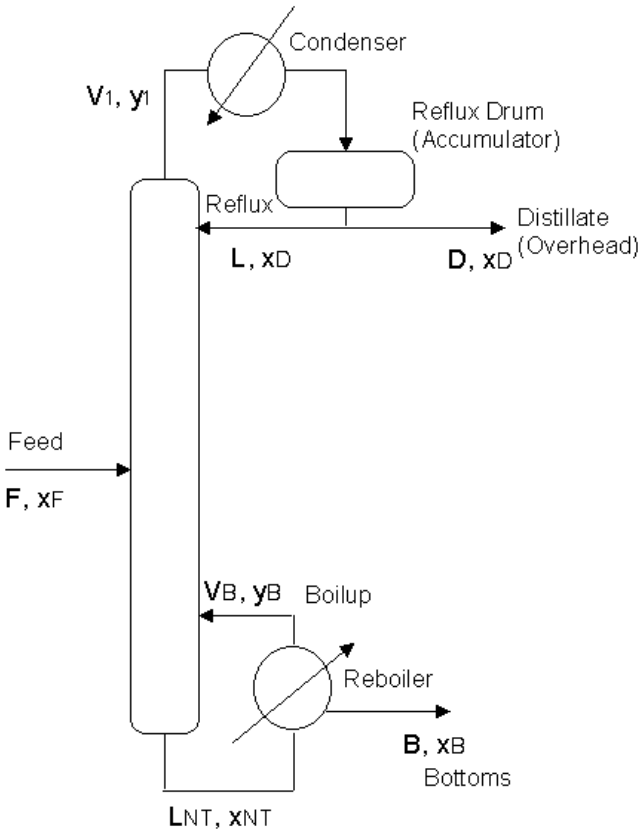
Material balance for more volatile component is

$x_F = fy+(1-f)x$

OR $y= -(1-f)x/f+(x_f/f)$

The above equation is operating line for flash distillation with slope = $-(1-f)/f$ and y- intercept = x_F/f

The value of f varies from 0 to 1

	Multi stage continuous distillation: The operation consist of a column containing the equivalent number of theoretical stages arranged in a two section cascade , a condenser in which the overhead vapours leaving the top stage is condensed to give a liquid distillate product and liquis reflux that is returned to the top stage, a reboiler in which liquid from the bottom stage is vaporized. The feed enters the column at feed stage. Feed may be liquid, vapour or mixture of liquid and vapour.The section above the feed plate is rectifying section and that below including feed plate is called stripping section.  	4

2.b	**Pre fermentation practices for yeast propagation:** **1.Construction:** The plant consist of a specially designed and manufactured propagation vessel with a unique top plate comprising all the necessary equipment for complete operations such as pressure regulator, pressure relief valve, anti-vacuum valve, valve probe and aeration lance with air dissolve or for larger tanks hollow shaft mixer. The plant is pre erected in the workshop and dry tested before dispatch, making local erection very easy and simple. The plants are only supplied as turnkey modules. The plant can be supplied with an integrated CIP station. **2.Operation**: After CIP and steam sterilization, the propagation vessel is filled with hot or cold wort. Wort is then sterilized by means of the heating jacket on the cone and thereafter cooled by means of the cooling jacket on the culindrical part. Before inoculation, the wort is aerated with sterile air.The vessel is hereafter inoculated with pure yeast culture from a Carlsberg Flask under sterile and aseptic conditions.During propagation, temperature is maintained at a set level and the propagating yest is aerated according to the particular strains requirement. When the yest has reached the required cell concentration, it is pitched into an intermediate fermentor or directly into a brew in a fermentor. **3.Cleaning**: Before any operation or transport, all lines are flushed with water and steam sterilized. The plant is cleaned from an integrated or external CIP plant. **4.Mounting:** The plant is pre erected and dry tested before dispatch. It is marked in the workshop for easy assembly at the brewery according to enclosed	2 2 1 1

	manual. **5. Maintenance:** The valve should be checked and gaskets changed at regular intervals. The filter insert is to be replaced every two years as a minimum. **6.Aplication:** For batch-wise propagation of yeast culture under sterile conditions with the purpose of renewing the yeast supply. The single vessel propagation plant requires inoculation with laboratory- propagated yeast at each propagation.	1 1
2 c	**Manufacture of Vodka** **Raw materials:** 1.Vegetable or grains: Potato,corn,wheat 2.Water 3.Malt meal 4. Yeast- Sacchasomyces Cereviscal 5. Flavourings- herbs,grasses, spices,fruit essence **Process:** ***1. Mash preparation*** The grain or vegetables are loaded into an automatic mash tub. The tub is fitted with agitators that break down the grain as the tub rotates. Aground malt meal is added to promote the conversion of starches to sugar. ***2. Sterilization and inoculation*** Preventing the growth of bacteria is very important in the manufacture of distilled spirits. First, the mash is sterilized by heating it to the boiling point. Then, it is injected with lactic-acid bacteria to raise the acidity level needed for fermentation. When the desired acidity level is reached, the mash is inoculated once again.	2 4

3. Fermentation

The mash is poured into large stainless-steel vats. Yeast is added and the vats are closed.Over the next two to four days, enzymes in the yeast convert the sugars in the mash to ethyl alcohol.

4. Distillation and rectification

The liquid ethyl alcohol is pumped to stills, stainless steel columns made up of vaporization chambers stacked on top of each other. The alcohol is continuously cycled up and down, and heated with steam, until the vapors are released and condensed. This process also removes impurities. The vapors rise into the upper chambers (still heads) where they are concentrated. The extracted materials flow into the lower chambers and are discarded. Some of the grain residue may be sold as livestock feed.

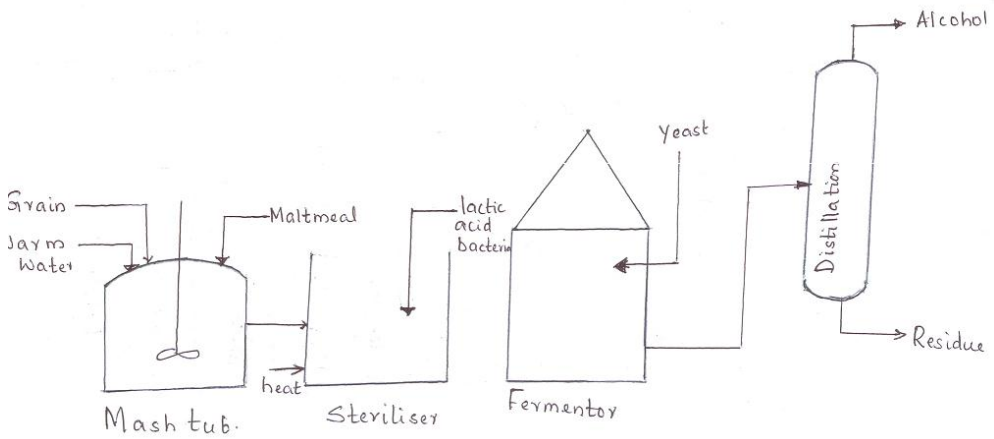
5. Water added

The concentrated vapors, or fine spirits, contain 95-100% alcohol. This translates to 190 proof. In order to make it drinkable, water is added to the spirits to decrease the alcohol percentage to 40, and the proof to 80.

6. Bottling

Alcoholic beverages are stored in glass bottles because glass is non-reactive.

Flow diagram:

		2
3	Attempt any 2	16
3.a	**(i) Yeast:** It is a one celled fungus that converts sugar and starch into carbon dioxide and alcohol Eg: beer yeast, dry yeast, wine yeast **(ii) Nutritional requirement of yeast:** Yeast require carbon source as it can not do photosynthesis. They also required vitamins, minerals and organic nitrogen source. The micronutrient are the source of carbon, nitrogen, phosphate and sulphate **Nutrients required for yeast:** 1. Glucose 2. Fructose 3. sucrose 4. Amino acids 5. Ammonia	1 7

6. Peptides
7. Organic phosphates
8. Inorganic phosphates
9. Inorganic sulphur compounds
10. Organic sulphur compounds

Sugars

Of the nutrients needed by yeast, sugars are by far the most abundant in raw material typically being in the range 180 – 250 g/L. The sugars present are glucose and fructose. In this range the sugars are well in excess of the yeast's needs. It is unlikely that sugars are ever a limiting factor in yeast fermentations in grape juice.

Vitamins

Yeasts do need a number of vitamins to be able to produce a healthy fermentation. These include biotin, folic acid, inositol, niacin, pantothenate, pyridoxine, riboflavin and thiamin.

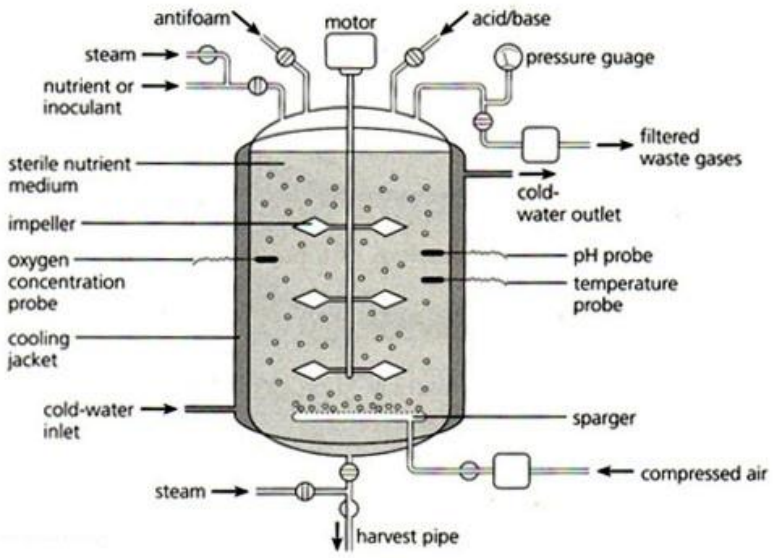
Raw material is not usually deficient in vitamins unless the vitamin content is depleted by winemaking practices such as cold settling, filtration, fining, pasteurisation, ion exchange, sulfiting and uncontrolled growth of other organisms such as non-Saccharomyces yeasts and lactic acid bacteria during fermentation.

Nitrogen compounds

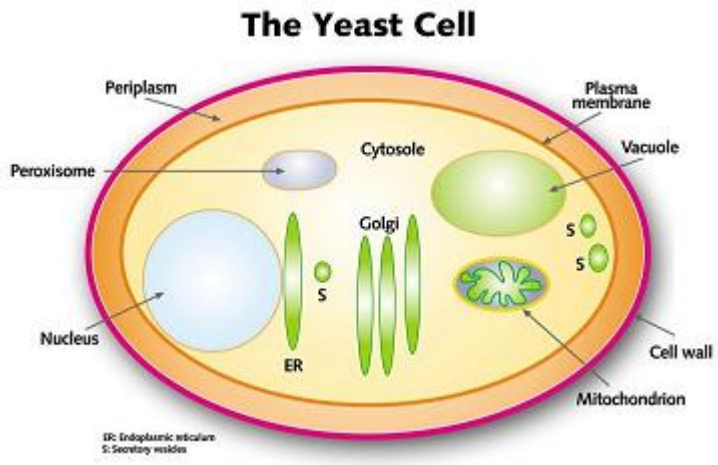
Nitrogen compounds are the second most important macronutrients for yeast, after sugars. Nitrogen is a limiting factor in most juice fermentations and normally needs to be supplemented if a clean and uninterrupted fermentation is desired. A deficiency of nitrogen can lead to slow or stuck fermentations. Fermentation rate and total fermentation time are related to initial must nitrogen

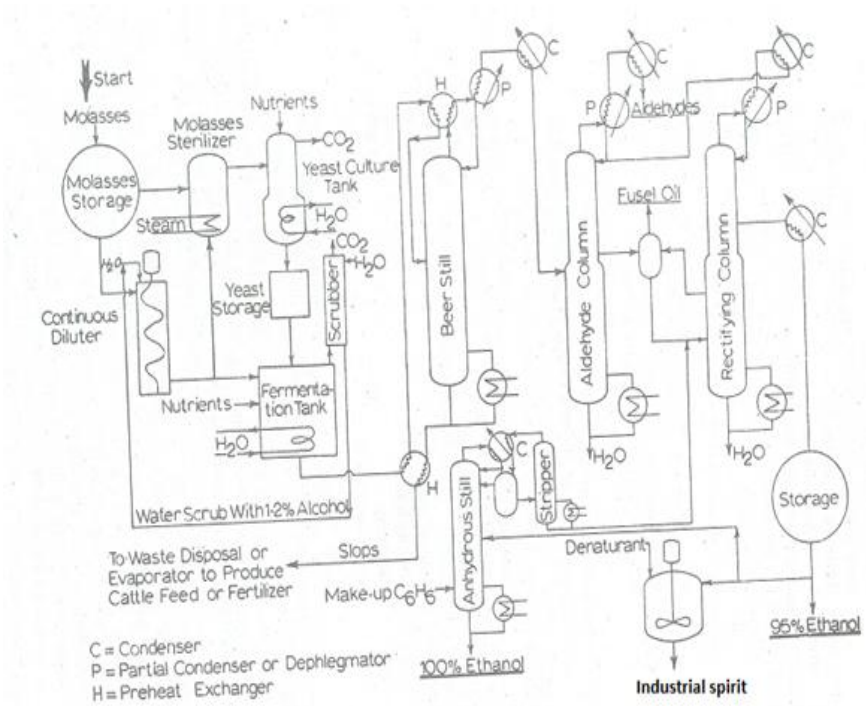
	content. The strain of yeast used and the fermentation conditions determine the nitrogen content needed. **Nitrogen Supplements** As previously mentioned, DAP is a commonly used nitrogen supplement as it is a cheap nitrogen source. It does, however, only provide a source of ammonium ions and not any amino acids or other nutrients apart from the phosphate ion. The supplements used for amino acids are products derived from yeast. These yeast products are known by several names such as hydrolysed yeast, autolysed yeast or yeast extract. The products can be composed of the entire yeast at the time of drying the yeast cells, or sometimes only the soluble part. They can contain proteins, amino acids, carbohydrates lipids, vitamins and minerals. It is hard to be specific on composition because the production methods vary and so the product compositions can be quite different.	
3.b	**Propagation of yeast:** It is the process where a pure culture of brewer's yeast is propagated in sterile wort usually continuously under aseptic condition. **Reasons for propagating yeast culture:** 1. Yeast picks up and spreads infection to the wort. 2. Yeast character changes due to genetic mutation 3. Reduction in viability and vitality of the yeast over time and re-pitching 4. Dead cells contribute proteases and unwanted flavor notes to the beer 5. Ageing of yeast causes slowing down in the rate of reproduction 6. Ageing of yeast causes changes to cell surface and flocculation	1 3

	behavior 7. Ageing of yeast causes changes to metabolic behavior 8. Ageing of yeast results in a general increase in cell size **Process**: 1. Yeast culture is usually stored in a test tube or flask on a culture medium in a fridge .It is sometimes kept in a freezer or under liquid nitrogen. 2. The yeast cells are grown up in a series of laboratory steps ensuring purity at each step by aseptic transfer and selecting single colonies. They are aerated and shaken at around 20^{o}C to maximise yeast cell growth upto 5- 6 times. 3. Sterile wort is collected in a small yeast propagation vessel. The cool wort is pitched with the laboratory cultured yeast. Again the culture is maintained at around 20oC with oxygenation at high level to encourage cell mass growth. 4. The content of the smaller yeast propagation vessel is used to inoculate sterile wort in the next vessel. This is repeated until sufficient yeast has been produced to pitch a standard brew or fermentation vessel.	4
3.c	**Government stipulated conditions for alcohol industry wastewater:** Effluent standards: BOD-100mg / l for land disposal 30 mg / l for disposal in streams pH – between 5.5 and 9 Total dissolved solids: 2100 mg / l Oil and grease: less than 10 mg / l Sodium : < 60% Ammoniacal nitrogen: < 50 mg/l. Disposal of molasses in the environment is to be done only after prior approval of the concerned state water pollution control board. Fermented sludge should be allowed to mix with the spent wash. this sludge should be	4 4

	dewatered, dried, and used as manure or cattle feed. Necessary treatment to bring BOD concentration is done by dilution and ensure that it would not cause ground water pollution.	
4	Attempt any 2	16
4.a	**Batch fermentation:** The reactor is filled with sterile nutrient substrate and inoculated with the microorganism. In the course of the entire fermentation, nothing is added except oxygen, an antifoam agent, and acid or base to control the pH. The fermentation process begins and continue until the number of cells in the fermenter is such that some of the contents of the fermenter can be removed without altering the number of cells in the fermenter. The culture is removed to grow until no more of the product is being made at which point the reactor is harvested and cleaned out for another run e.g. For the production of ethanol form molasses  	4 4
4.b	**1) Morphology:** It is a branch of biology dealing with the study of the form and structure of organisms and their specific structural features. This includes	2

	aspects of the outward appearance (shape, structure,colour,pattern,size), i.e. external morphology (or eidonomy), as well as the form and structure of the internal parts like bones and organs, i.e. internal morphology (oranatomy). Morphology is a branch of life science dealing with the study of gross structure of an organism or taxon and its component parts. **2) Taxonomy:** **Taxonomy** is the science of defining groups of biological organismson the basis of shared characteristics and giving names to those groups. Organisms are grouped together into taxa (singular: taxon) and these groups are given a taxonomic rank; groups of a given rank can be aggregated to form a super group of lower rank, thus creating a taxonomic hierarchy. The Swedish botanist Carl Linnaeus is regarded as the father of taxonomy, as he developed a system for categorization of organisms and binomial nomenclature for naming organisms. (ii) **Morphology of yeast:** It is the description of – 1. the shape, size and internal structure of the yeast cells 2. changes during the reproduction of vegetative cells and the position of the newly formed cells to their parent 3. the changes the cells undergo when forming resting cells, ballistospores or asco spores 4. the size, shape, surface of spores, their number per ascus and mode of germination	2 4

		
4.c	**(i) Definition and uses of** **1) Industrial spirit** It is distilled ethyl alcohol (C_2H_5OH), normally of high proof, produced and sold for other than beverage purposes. Uses: 1. Pure ethyl alcohol is used in laboratories and in industry for its sanitizing, cleaning and solvent properties. 2. Many medicines, food products, flavorings and cosmetics are made with ethyl alcohol. 3. It is also used to process vaccines, syrups, tinctures, liniments and antiseptics and in the manufacture of pharmaceuticals such as chloroform and barbiturates. 4. It may be used in the production of adhesives, cosmetics, detergents, explosives, inks, hand cream, plastics and textiles **2) Absolute alcohol:** It is ethanol containing less than one per cent of water by weight. Uses: 1. Ethanol is used in medical wipes and most common antibacterial hand	2 2

	sanitizer. 2. As an antidote to methanol and ethylene glycol poisoning. 3. Medicinal solvent 4. Feed stock for ethyl esters, ethyl halides etc **(ii)Flow sheet for the manufacture of industrial spirit**  	4
5	Attempt any 2	16
5 a	**Bacteria:** They are microscopic organisms whose single cell have neither a membrane enclosed nucleus nor other membrane enclosed organelles like mitochondria and chloroplast. **Use of bacteria in fermentation with eg.** Fermenting bacteria have characteristics sugar fermentation patterns ie they can	1

	metabolize some sugars but not others. For eg Neisseria meningitides ferments glucose and maltose, but not sucrose and lactose, while Neisseria gonorrhea ferments glucose but not maltose, sucrose or lactose. Such fermentation patterns can be used to identify and classify bacteria. In fermentation, the organic compound serves as both electron donor and acceptor, and adenosine triphosphate is synthesized by substrate level phosphorylation. Eg. Streptococcus, Lactobacillus, and Bacillus produces lactic acid, Escherichia and Salmonella produce ethanol Lactic acid fermentation : Lactate is a common end product of fermentations. Some organisms, collectively called the lactic acid bacteria, form large amounts of lactate. Lactic acid bacteria are subdivided according to their fermentation products. The homo fermentative species produce a single end product, lactic acid, whereas the hetero fermentative species produce other compounds, mostly ethanol and carbon dioxide, along with lactate. These differences are due to the employment of different pathways for glucose oxidation: in homo fermentative organisms glucose breakdown is via glycolysis according to: Glucose $\rightarrow$ 2 lactate Heterofermentative bacteria breaks glucose by a series of reactions in to Glucose $\rightarrow CO_2$ + lactate +ethanol Lactic acid bacteria are nutritionally very versatile and grow not only on glucose but also on other substrates such as fructose, galactose, mannose, saccharose and pentoses. With these substrates, certain variations of the fermentation pathways occur. For example, Citrate, an ingredient of milk, is converted to diacetyl, the typical flavour of butter	7

5 b	**Yeast vessel** This is a cylindrical vessel in which all the reaction take place. The cylindrical section is cut from hollow stainless steel pipe. It is 20cm diameter and 30cm long. A hemispherical shaped bottom is welded to it. Two holes3cm diameter and 0.5cm diameter were bored on the bottom of the cylinder for product harvest valve and air inlet valve respectively. Six rectangular bar (baffle) were welded to the vessel chamber, this help to reduce vortices and increase the aeration efficiency. The chamber top is made of flange cover to be joined temporarily with the use of bolts and nuts which is attached with a rubber seal to aid air tight sealing. The agitator is connected through the cover to the main chamber. **Material of construction of yeast vessel:** 1.Plastics: Light, inexpensive, not resistant to heat and chemicals, low thermal conductivity. 2. Ceramics: Inert, easily worked, inexpensive, fragile and only suitable for small scale domestic brewing. 3. Stainless steel (most preferred) : Strong, very durable, expensive, excellent cleaning properties, corrosion resistant, high thermal conductivity. 4. copper: strong, easily cleaned, very expensive, very high thermal conductivity. 5. Concrete: Durable, can be formed in to any shape, relatively heavy but can be used for large vessels, requires inert lining material. 6. Aluminium: Light, durable, easily worked, can be used as lining material or as main fabric of vessels, susceptible to attack by alkalies, subjected to electro chemical corrosion.	4 4
5 c	**Toxological Effects of waste water from alcohol industry:**	8

	1.Effluent from alcohol industry causes severe land pollution(foul smell and dark colour) 2. Distillery effluent causes decrease in dissolved oxygen and prove dangerous to aquatic life. 3.If the effluent from the alcohol industry is used for irrigation, high BOD water results in crop failure 4.Seapage of coloured liquids can adversely affect ground water as well as land quality. 5. Soil condition will be deteriorated in course of time.	
6	Attempt any 4	16
6.a	**Minimum boiling azeotrope**: Minimum boiling azeotrope will boil at a temperature lower than the boiling points of pure components. **Maximum boiling azeotrope**: Maximum boiling azeotrope will boil at a temperature higher than the boiling points of pure components. **Example of azoetropic distillation:** The binary system containing 96% by weight ethanol and water forms minimum boiling azeotrope. The separation is done by adding benzene as an entrainer. The feed is fed to first column, benzene forms low boiling ternary azeotrope which is removed as top product and pure alcohol is taken out as bottom product. The overhead from first column is condensed, phase separation is achieved. The benzene rich phase is returned to first distillation column and water rich phase is send to the second distillation column. The overhead from second column containing benzene in major proportion is fed back to the first column.The bottom product from first column is fed to the third distillation column which gives alcohol-wateras an overhead product and pure water as bottom product.	1 1 2
6.b	**Process of pretreatment of enzyme** Firstly, there is a liquefaction process. A starch suspension containing 30-40%	4

	dry matter is first gelatinised and liquefied. By using heat-stable bacterial alpha amylase, 'maltodextrin' is obtained which contains mainly different oligosaccharides and dextrins. Maltodextrins are only slightly sweet and they usually undergo further conversion. In most starch conversion plants, starch liquefaction takes place in a jet-cooking process. The heat stable alpha amylase is added to the starch slurry after pH adjustment, and the slurry is pumped through a jet cooker. Live steam is injected here to raise the temperature to 105^{o}C, and the slurry is then passed through a series of holding tubes for 5-7 minutes, which is necessary to gelatinise the starch fully.Then the temperature of the partially liquefied starch is reduced to 90-100^{o}C by flashing, and the enzyme is allowed to react further at this temperature for 1-2 hours until the required DE (Dextrose Equivalent) is obtained	
6.c	**Pre-fermentation:** A pre-ferment (or fermentation starter) is a dough or batter prepared prior to mixing the final dough and composed of a portion of the total formula's water, yeast (natural or commercial) and sometimes salt. The dough (or batter) is allowed to ferment for a controlled period of time and then added to the final dough.This process is known as prefermentation **Sterile air in pre fermenter:** In addition to contaminants such as dust, pollen, water or oil aerosols and hydrocarbon or other vapours, compressed air contains bacteria with the potential to spoil product. Sanitary applications in the food, beverage, pharmaceutical and electronic industries require compressed air that is free of all the above contaminants. Sterile means free from live bacteria or other microorganisms. Most fermentations are operated under high aeration and the	2 2

	air supplied to the fermentor must be sterilized. Aerobic fermentation process require significant quantities of sterile air. The sterilization of air in the strict bacteriological sense means the complete elimination of all viable microorganisms	
6.d	**Important role of yeast and enzymes in alcohol making :** Yeast metabolic activity, especially amino acid metabolism, has a crucial contribution to flavor. All ethanol contained in alcoholic beverages including ethanol produced by carbonic maceration is produced by means of fermentation induced by yeast. Enzymes are needed for the degradation of starch into fermentable sugars. Addition of exogenous enzymes at various steps during the brewing process can therefore make brewing easier, faster and more consistent. By the use of exogenous enzymes more can be extracted from the raw materials, more local raw materials can be used, and more unmalted grains can be used, saving significant amounts of energy and transport.	4
6.e	**Definitions** (i) **Malt alcohol:** It is beer with high alcohol content. It refers to beers containing high alcohol content, generally above 6%, which are made with malted barley. **(ii) Brandy: It** is a spirit produced by distilling wine or fermented fruit juice. Brandy generally contains 35–60% alcohol by volume. (iii) **Vodka:** An alcoholic drink originating in Russia, made from grain, potatoes, etc, usually consisting only of rectified spirit and water **(iv) Denatured alcohol:** It is ethanol that has additives in it to make it poisonous to discourage recreational consumption and at the same time can be used for diversified industrial applications.	1 1 1 1
6.f	**Merits of biological treatment for effluents from alcohol industry**	4

	Stillage, fermenter and condenser cooling water and fermenter wastewater are the primary polluting streams of a typical distillery. 1. Biological treatment using aerobic processes like activated sludge, biocomposting etc. is presently practiced by various molasses-based distilleries. Due to the large volumes generated, only a part of the total spent wash gets consumed in biocomposting. Biocomposting utilizes sugarcane pressmud as the filler material; thus it is typically employed by distilleries attached to sugar mills. 2. Anaerobic treatment is characterized by biological conversion of organic compounds by anaerobic microorganisms into biogas which can be used as a fuel-mainly methane 55-75 vol% and carbon dioxide 25-40 vol% with traces of hydrogen sulfide. 3. Several pure cultures of fungi, bacteria and algae have been investigated specifically for their ability to decolorize the effluent.	