BIRLA INSTITUTE OF TECHNOLOGY, MESRA, RANCHI
(END SEMESTER EXAMINATION)

CLASS: M TECH **SEMESTER: II**
BRANCH: BIOTECHNOLOGY **SESSION: SP/2025**

SUBJECT: BE506 BIOPROCESS PLANT DESIGN

TIME: 3 Hours **FULL MARKS: 50**

INSTRUCTIONS:
1. The question paper contains 5 questions each of 10 marks and total 50 marks.
2. Attempt all questions.
3. The missing data, if any, may be assumed suitably.
***4*. Before attempting the question paper, be sure that you have got the correct question paper.**
5. Tables/Data handbook/Graph paper, etc., to be supplied to the candidates in the examination hall.

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Q.1	Manufacture of Ethanol from Molasses: Ethanol is a volatile, flammable, clear, colourless liquid. Ethanol is a good solvent. It is also used as a germicide, beverage, antifreeze, fuel, and chemical intermediate. It can be made by fermentation of material containing sugar or from the compound, which can be converted to sugar. Sterile operation is of utmost importance in fermentation processes. Yeast enzymes readily ferment sucrose to ethanol. ➢ A process diagram for ethanol production is given at the end of this paper. From the diagram given, explain the functions of: **1.** Scrubber **2.** Beer still **3.** Rectifying column Answer the following: 4. Identify the faulty pipe connection /s in this fermentation process. Justify your answer. 5. Why is yeast storage required?	[2x5= 10]	1	4,5
Q.2(a)	The equation for Reynold number is given as Re = $D\upsilon\rho$ / μ, where D is the diameter for a pipe, u is the fluid flow rate; ρ is the density of the fluid that passes through the pipe; μ is the viscosity of the fluid that pass through the pipe. Starch solution (carbon source) was pumped into a bioreactor at a rate of 1 ml/min. The temperature for the starch solution at 37°C is 0.72 centipoise (1 cP = 1.00 x 10^{-3} kg/m.s), and the density at that temperature is 1.54 g/cm^3. The diameter of the tubing attached to the inlet of the bioreactor is 0.19 inches. Is the flow inside the tubing behaving as laminar (Re<2100) or turbulent?	[4]	2	3
Q.2(b)	Explain the challenges in designing piping systems for cryogenic applications.	[4]	2	4,5
Q.2(C)	You are working on a project to design piping for a cryogenic application. You are handling the task of branching a vertical pipeline. Will you choose to branch the pipeline from the bottom or the top? The fluid in the pipe is in the liquid state. Explain your decision.	[2]	2	4,5

PTO

Q.3 A fermenter with a diameter and liquid height of 1.4 m is fitted with a Rushton impeller with a diameter of 0.5 m and off-bottom clearance of 0.35 m, operated at 75 rpm. The fermentation broth is sparged with air at a volumetric flow rate of 0.28 m^3 min^{1}. Half-way through the culture, some bearings in the stirrer drive began to fail, and the stirrer speed had to be reduced to a maximum of 45 rpm for the remainder of the process. 3 3

(a) Under normal operating conditions, is the gas completely dispersed? [5]

(b) After reducing the stirrer speed, is the impeller flooded or loaded? [5]

Data:

1. Gas flow number, $Fl_g = F_g / N_i D_i^3$
2. Froude No, $Fr = Ni^2 D_i / g$
3. $Fl_g = 30 (D_i / D_T)^{3.5} Fr$ - flooding - loading transition
4. $Fl_g = 0.2 (Di / D_T))^{0.5} Fr^{0.5}$ - for complete gas dispersion

Q.4(a) You are a young entrepreneur looking to build a startup company to manufacture non-sparking tool kits. There may be projects that will require your workers to work in highly flammable areas or magnetic equipment. In this task, 4 4,5

i) What chemical property mentioned below can tell you whether a liquid is flammable at room temperature? Explain your answer. [2.5]

a) Lower explosive limit,
b) Flashpoint,
c) Auto-ignition temperature,
d) Upper explosive limit.

ii) What would be your choice of material of construction (MOC) among the below-mentioned MOC of a non-sparking tool used in a flammable atmosphere? Explain your answer. [2.5]

a) Copper- Beryllium alloy
b) Aluminum
c) Forged Steel
d) All the above materials

Q.4(b) If you are in a team planning industrial safety tasks, what are some crucial factors you will consider implementing in your company? [5] 4 4,5

Q.5(a) A production company incurs the following costs in the production/running of the business. Classify them under direct and indirect costs. Give your answer in a tabular format. [4] 5 4,5

1. Raw materials used in manufacturing
2. Depreciation of assets
3. Wages and benefits of employees involved in production
4. Manufacturing Supplies cost
5. Rent, utilities, insurance
6. Marketing and Promotion Costs
7. Costs associated with legal services
8. Cost of the specific software license for the automation of machinery
9. Wages paid based on exigencies.
10. General Office Supplies
11. Utilities like costs of electricity, water, and gas.
12. Wages and benefits of employees involved in administration

Q.5(b) The Chairman of a construction company directs his team to compare two potential real estate development projects. He also reminds them that the company's financial health is deteriorating, so he has to select one of them. The team works and lists below each project's potential income and costs. [6] 5 3

Project 1

- 500 housing units will be constructed.
- 400 of them will be sold, and 100 of them will be rented for 20 years.
- The Rental Price of each unit is 4,000 USD per year
- Rented 100 units will be sold at 70,000 USD after 20 years.
- The Construction Cost of each unit is 100,000 USD.
- The sale price of each unit is 120,000 USD.
- The project needs a luxury sales office priced at 2,000,000 USD.
- The sales personnel cost is 300,000 USD per year.
- The project duration is 3 years.
- The project financing cost is 3,000,000 USD per year

Project 2

- 400 housing units will be constructed.
- 350 of them will be sold, and 50 of them will be rented for 15 years.
- Rented 50 units will be sold for 80,000 USD after 15 years.
- The Rental Price of each unit is 4,500 USD per year
- The Construction Cost of each unit is 90,000 USD.
- The sale price of each unit is 135,000 USD.
- The project needs a luxury sales office with a price of 3,000,000 USD.
- The sales personnel cost is 250,000 USD per year.
- The project duration is 2 years. – Project financing cost is 2,500,000 USD per year

Perform the Cost-benefit Analysis for the above projects and make your recommendations.

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