Reg. No.										

MANIPAL INSTITUTE OF TECHNOLOGY
MANIPAL

(A constituent institution of MAHE, Manipal)

III SEMESTER B.TECH. (BIOTECHNOLOGY)
END SEMESTER EXAMINATIONS,

SUBJECT: Bioprocess Calculations [BIO 2152]

Time: 2 Hours MAX. MARKS: 40

Instructions to Candidates:

- Answer **ANY FOUR** full questions.
- Missing data may be suitable assumed.

1A.	Discuss the different steps involved in Bioprocess development with a neat flow diagram.	**5**
1B.	A solution of potassium chloride in water contains 384 g KCl (MW = 74.5) per litre of the solution at 300 K. The specific gravity of the solution is 1.6. Calculate the following: (a) The concentration in weight percent (b) The mole fraction of KCl (c) The molarity of the solution (d) The molality of the solution	**5**
2A.	The average molecular weight of an off – gas sample from a fermenter is calculated by two different engineers. One engineer used the correct molecular weight of N_2 as 28, while the other used an incorrect value of 14. They got the average molecular weight as 30.08 and the incorrect one as 18.74. Calculate the mole % of N_2 in the off-gas, if the remaining gases are CO_2 and O_2.	**5**
2B.	It is desired to prepare a 40 % solution of NaCl in water at 300K. (a) How many Kg of anhydrous sodium chloride should be added to 0.05 cubic meter of pure water having a density of 0.998 g/mL at 300K. (b) If the salt contains 10 % water, how many kg of salt is required	**5**
3A.	A gaseous mixture produced from an anaerobic fermentation is found to contain CH_4 - 45%, C_2H_6 - 10%, C_2H_4 - 25%, C_3H_8 - 7%, C_3H_6 - 8%, and C_4H_{10} - 5%. Find (a) Average molar mass of the mixture (b) Composition by mass (c) Specific gravity of the gaseous mixture	**5**

3B.

A mass flow rate m (g/s) is measured as a function of temperature T(ºC) as follows:
$m = aT^{1/2} + b$.

T	10	20	40	80
m	14.76	20.14	27.73	38.47

Use a straight – line plot to verify this formula and determine a and b.

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4A.

Production of recombinant protein by a genetically $CH_{1.77}O_{0.49}N_{0.24}$ engineered strain of *E.coli* is proportional to cell growth. Ammonia is used as nitrogen source for aerobic respiration of glucose. The recombinant protein has an overall formula $CH_{1.55}O_{0.31}N_{0.25}$. The yield of biomass from glucose is measured as 0.48g/g the yield of recombinant protein from glucose is about 20% that for cells.

(a) How much ammonia is required?

(b) What is the oxygen demand?

(c).If the biomass yield remains at 0.48 g/g, how much different are the ammonia and oxygen requirements for wild-type *E.coli* unable to synthesize recombinant protein?

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4B.

Xanthan gum is produced using *Xanthomonas campestris* in batch culture. Laboratory experiments have shown that for each gram of glucose utilised by the bacteria, 0.23 g oxygen and 0.01 g ammonia are consumed, while 0.75 g gum, 0.09 g cells, 0.27 g gaseous CO_2 and 0.13 g H_2O are formed. Medium containing glucose and ammonia dissolved in 20, 000 litres water is pumped into a stirred fermenter and inoculated with X. *campestris. Air* is sparged into the fermenter; the total amount of off-gas recovered during the entire batch culture is 1250 kg. Because of the high viscosity and difficulty in handling xanthan-gum solutions, the final gum concentration should not be allowed to exceed 3.5 wt%. Assume complete conversion of glucose and Ammonia

(a) How much glucose and ammonia are required?

(b) Calculate wt% of components in off gas

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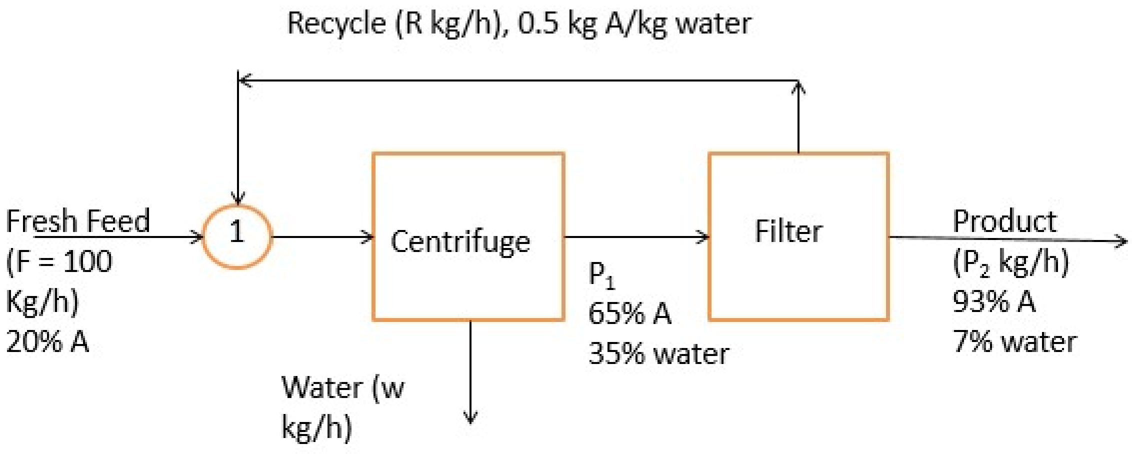
5A.

Final purification stage in the preparation of certain pharmaceutical product 'A' from natural sources required centrifuging and continuous filtration as depicted in figure. Determine the flow rate of the recycle stream and product leaving the filter in kg/h.



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5B.

An electric heating coil is immersed in a stirred tank. Solvent at 15 ºC with heat capacity 2.1 $\frac{kJ}{kg.^{o}C}$ is fed into the tank at a rate of 15 kg/h. Heated solvent is discharged at the same flow rate. The tank is filled initially with 125 kg cold solvent at 10 ºC. The rate of heating by the electric coil is 800 W. Calculate the time required for the temperature of the solvent to reach 60 ºC. Assume that heat capacity is independent of temperature

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6A.	The enzyme, glucose oxidase, is used commercially to remove glucose from dehydrated egg to improve colour, flavour and shelf-life. The reaction is: $C_6H_{12}O_6 + O_2 + H_2O \rightarrow C_6H_{12}O_7 + H_2O_2$ (glucose) (gluconic acid) A continuous-flow reactor is set up using immobilised-enzyme beads which are retained inside the vessel. Dehydrated slurry containing 2% glucose, 20% water and the remainder unreactive egg solids, is available at a rate of 3,000 kg/h. Air is pumped through the reactor contents so that 18 kg oxygen are delivered per hour. The desired glucose level in the dehydrated egg product leaving the enzyme reactor is 0.2%. Determine: (a) Which is the limiting substrate; (b) the percentage excess substrate; (c) the composition of the reactor off-gas; and (d) the composition of the final egg product.	**8**
6B.	In determining the rate of heating of a tank of 20% sugar syrup, the temperature at the beginning was 20°C and it took 30 min to heat to 80°C. The volume of the sugar syrup was 50 ft^3 and its density 66.9 $lbft^{-3}$. The specific heat of sugar syrup is 0.9 Btu lb^{-1} F^{-1} (a) Convert the specific heat to kJ kg^{-1} C^{-1} (b) Determine the average rate of heating, that is the heat energy transferred in unit time, in SI units (kJs^{-1})	**2**