Reg. No.										

MANIPAL INSTITUTE OF TECHNOLOGY

MANIPAL

(A constituent institution of MAHE, Manipal)

II SEMESTER M.TECH INDUSTRIALBIOTECHNOLOGY

END SEMESTER EXAMINATIONS, APRIL/MAY 2018

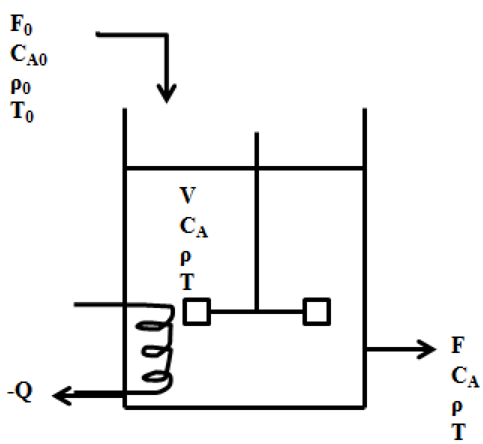
SUBJECT: BIOPROCESS MODELLING AND SIMULATION [BIO 5222]

REVISED CREDIT SYSTEM

Time: 3 Hours MAX. MARKS: 50

Instructions to Candidates:

- Answer **ALL** the questions.
- Missing data may be suitable assumed.

1A	Consider a CSTR system with a cooling coil inside the tank that can remove the exothermic heat of reaction Φ as shown in figure. Use the normal convention that Φ is negative for an exothermic reaction and positive for an endothermic reaction. The rate of heat generation (energy per time) due to reaction is the rate of consumption of A times Φ. The rate of heat removal from the reaction mass to the cooling coil is –Q (energy per time). The temperature of the feed stream is T_0 and temperature in the reactor is T. Apply energy equation and develop a model which describes a system by stating if any assumptions made. 	**6M**

1B	Define briefly all the steps involved in modeling a process with a neat block diagram	**4M**
2A	A tank contains 20 kg of a salt solution at a concentration of 4 % by weight. Fresh solution enters the tank at a rate of 4 kg/min at salt concentration of 6 % by weight. The contents are stirred well and the mixture leaves the tank at a rate of 3 kg/min. a. Express the salt concentration as a function of time. b. At what instant of time the salt concentration in the tank will reach 5% by weight.	**5M**
2B	In downstream processing of gluconic acid, concentrated fermentation broth containing 20 %(w/w) gluconic acid is cooled in a heat exchanger prior to crystallization. 2000 kg/hr liquid leaving an evaporator at 90^oC must be cooled to 6^oC. Cooling is achieved by heat exchanger with 2700 kg/hr water initially at 2^oC. If the final temperature of the cooling water is 50^oC, what is the rate of heat loss from the gluconic acid solution to the surroundings? Assume that heat capacity of gluconic acid is 0.35 cal/g^oC. h (liquid water at 90^oC) = 376.9 kJ/kg h (liquid water at 6^oC) = 25.2 kJ/kg h (liquid water at 2^oC) = 8.4 kJ/kg h (liquid water at 50^oC) = 209.3 kJ/kg	**5M**
3A	A square tank, 4m on a side and 10 m height is filled with brim of water. Tank has a 5 cm^2 hole at the bottom which is suddenly opened. Derive the dynamic model of the system and find the time required for draining the tank completely, if the flow rate through the hole is given by $F = 0.62A(2gh)^{1/2}$, where A is area of hole and ‘h’ is height of water at any time ‘t’.	**5M**
3B	Steam is used to heat nutrient medium in a continuous-flow process. Saturated stream at 150°C enters a coil on the outside of the heating vessel and is completely condensed. Liquid medium enters the vessel at 15°C and leaves at 44°C. Heat losses from the one jacket to the surroundings are estimated as 0.33 kW. If the flow rate of medium is 4250 kg/hr and its heat capacity is 0.9 cal/g/°C, how much steam is required? [h_v of water at 150^oC = 2113.1 kJ/kg].	**5M**
4A	Develop structured-segregated model with a suitable example and also list the assumptions made.	**5M**
4B	Propionibacterium species are tested for commercial-scale production of propionic acid. Propionic and other acids are synthesized in anaerobic culture using sucrose as the substrate and ammonia as the nitrogen source. Overall yields from sucrose are as follows: propionic acid 40% (w/w) acetic acid 20% (w/w) butyric acid 5% (w/w) lactic acid 3.4% (w/w) biomass 12% (w/w)	**5M**

Bacteria are inoculated into a vessel containing sucrose and ammonia; a total of 30 kg sucrose is consumed over a period of 10 days. What are the cooling requirements?

$C_{12}H_{22}O_{11}$ + bNH_3 -------→ c $CH_{1.8}O0.5N_{0.2}$ + dCO_2 +eH_2O + f_1 $C_3H_6O_2$ + f_2 $C_2H_4O_2$ + f_3 $C_4H_8O_2$ + f_4 $C_3H_6O_3$

Heat of combustion of sucrose = -5644.9 kJ/gmol

Heat of combustion of NH_3 = -382.6 kJ/gmol

Heat of combustion of biomass = -552 kJ/gmol

Heat of combustion of propionic acid = -1527.3 kJ/gmol

Heat of combustion of acetic acid = -874.2 kJ/gmol

Heat of combustion of butyric acid = -2183.6 kJ/gmol

Heat of combustion of lactic acid = -1368.3 kJ/gmol

Y_{xs} = 0.12 g/g

5A The virial equation-of-state for a real gas is expressed as :

$$Pv = RT\left[1+\frac{B}{v}+\frac{C}{v^2}+\ldots\right]$$

Where B and C are known as second and third virial coefficients, respectively. Often this equation is truncated after the second virial coefficient. The virial equation then simplifies to $Pv = RT+\frac{BRT}{v}$.This is a second order polynomial equation for molar volume v. Obtain the molar volume of a gas at temperature at T = 298 K and P = 1 atm pressure using the Newton-Raphson method. The second virial coefficient for the gas is B = 12 $L.mol^{-1}$. Take R = 0.082 (L. atm. mol^{-1} K^{-1}). Compare your result with the exact solution (which can be obtained by the quadratic formula). A good guess can be estimated from the ideal gas law: v = RT/P. **5M**

5B The following data have been obtained for an enzyme catalysed reaction.

V([E_o = 0.015g/l) g/l min	[S] g/l	([S]/V) min
1.14	20	17.5
0.87	10	11.5
0.7	6.7	9.6

The rate expression for an enzyme catalyzed reaction is given as K_m/V_m + $[S]/V_m$ = [S]/V.

a. Calculate K_m/V_m and $1/V_m$ using Gauss Jacobian method for five iterations with an initial guess K_m/V_m = 4 and $1/V_m$ = 0.1.

Calculate K_m and V_m. **5M**