

KATHMANDU UNIVERSITY
End Semester Examination
July/August, 2024

Marks Scored:

Level : B.E.

Year : III

30 JUL 2024

Course : CHEG 305

Semester : II

Exam Roll No. :

Time: 30 mins.

F. M. : 10

Registration No.:

Date :

SECTION "A"

[20 Q. \times 0.5 = 10 marks]

Choose and encircle in the most appropriate option from each set of choices

1. If you are given with a system and the desired output, and you need to find the input, what type of model is used?
a. control b. design c. prediction d. analysis
2. Which model may not give us confidence that the model will be applicable outside the range used in developing the model?
a. mechanistic b. deterministic c. empirical d. process-based
3. If the variable such as temperature is varying along the spatial coordination, it may be desirable to develop _____ model.
a. lumped b. stochastic c. distributed d. empirical
4. In an EOS, molecular structure was asymmetric considered by adding:
a. acentric factor b. a factor c. b factor d. skew factor
5. An adsorption model has a form of $n = \gamma c / (1 + Kc)$. Which model is this?
a. Langmuir b. Monod c. Freundlich d. Michaelis-Menten
6. Both the solute and the solvent migrate by molecular or _____ diffusion in the membrane polymers.
a. turbulent b. Fickian c. laminar d. binding
7. How much oxygen in mol fraction will be dissolved in water at 298 K when the solution is in equilibrium with air at 1 atm total pressure? The Henry's law constant is 4.38×10^4 atm/mol fraction.
a. 0.9198 b. 0.21 c. 0.0004 d. 4.80×10^{-6}
8. Calculate the heat loss in watts per m^2 of surface area for an insulating wall composed of 25.4-mm thick fiber insulating board, where the inside temperature is 352.7 K and the outside temperature is 297.1 K. Thermal conductivity of fiber insulating board is 0.048 W/m·K.
a. 2.19×10^{-5} b. 0.034 c. 105.1 d. 45603
9. What condition is used in Navier-Stokes equations?
a. constant viscosity, variable density b. variable viscosity, constant density
c. variable viscosity, variable density d. constant viscosity, constant density

10. For tubular reactor with axial dispersion model, what can be neglected in boundary condition?
 - a. convection, dispersion
 - b. reaction, dispersion
 - c. reaction, convection
 - d. reaction
11. Which model is generally used to simulate nucleation and growth of particles?
 - a. mass
 - b. energy
 - c. population balance
 - d. momentum
12. Which one of the following is a special case of the general population balance?
 - a. ADR equation
 - b. adsorption theory
 - c. RTD theory
 - d. prey-predator model
13. In crystallization modeling, the growth of the crystal mass is:
 - a. discrete
 - b. steady-state
 - c. continuous
 - d. completely mixed
14. If a neural network overestimates the importance of noisy data, it is known as:
 - a. overfitting
 - b. underfitting
 - c. white noise
 - d. generalization
15. What type of learning is used to find a structure or the probability distribution in the provided data?
 - a. supervised
 - b. unsupervised
 - c. reinforcement
 - d. regression
16. ANN is used in the development of soft sensors, which are nothing but ANNs trained to predict a variable quickly using easily measurable variables as inputs. What domain of chemical engineering do you find this application?
 - a. process modeling
 - b. pattern recognition
 - c. process control
 - d. process design
17. Which method is more useful to check if a model runs beyond the prescribed range of parameter?
 - a. local sensitivity
 - b. global method
 - c. DDM
 - d. FDM
18. What is essential for design validation and process integrity testing?
 - a. lumped model
 - b. dynamic simulator
 - c. stochastic model
 - d. static simulator
19. Which method studies the variation of parameters by transforming all the parameters into periodic functions of a search variable?
 - a. Monte Carlo
 - b. DDM
 - c. Green's function
 - d. FAST
20. If the normalized sensitivity is found to be 2 for x by u , which one of the following is true?
 - a. 1% increase in u causes 2% change in x
 - b. 1% increase in x causes 2% change in u
 - c. 1% increase in u causes 0.5% change in x
 - d. 1% decrease in u causes 0.5% change in x

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F. M. : 40

SECTION "B"
[40 marks]

Attempt ALL questions. The data or information not given in the questions should be assumed properly.

1. What is the advantage of simulation in process design and process safety? Explain with suitable software available to chemical engineers for these kinds of simulation. [2.5+2.5]
2. What are the main steps that are employed in development of a model that can simulate chemical processes? How do you simplify a complex model? [2.5+2.5]
3. NH₃ gas is diffusing through N₂ under steady-state conditions with N₂ nondiffusing since it is insoluble in one boundary. The total pressure is 1.013×10^5 Pa and the temperature is 298 K. The partial pressure of NH₃ at one point is 1.333×10^4 Pa and at the other point 20 mm away it is 6.666×10^3 Pa. D_{AB} is 2.30×10^{-5} m²/s. Calculate the flux of NH₃ in kg mol/s·m². [5]
4. Water is flowing at 0.11 m/s at 26.1°C past a flat plate of solid benzoic acid where $L = 0.40$ m.
 - a. Calculate the mass-transfer coefficient k_c . The solubility of benzoic acid in water is 0.02948 kg mol/m³. The diffusivity of benzoic acid is 1.245×10^{-9} m²/s. Properties of water: $\mu = 8.71 \times 10^{-4}$ Pa·s; $\rho = 996$ kg/m³; $D_{AB} = 1.245 \times 10^{-9}$ m²/s. $N_{sc} = \mu/\rho D_{AB}$, $J_D = 0.99 N_{Re}^{-0.5}$, $k_c = J_D \nu N_{sc}^{-2/3}$. [3]
 - b. Using the film model, calculate the equivalent film thickness. [2]
5. In a model to find concentration response in a continuous stirred tank with chemical reaction, liquid flows through a tank of constant volume V , with volumetric flow-rate F and feed concentration C_0 . Assume a chemical reaction in the tank, in which the rate of reaction is proportional to concentration. k is the chemical rate coefficient (1/s), C_1 is exit concentration.
 - a. Derive the component balance equation in terms of the system time constant. [2]
 - b. Find the final steady-state value of C . [1]
 - c. Illustrate the effect on the process response of increasing values of k . [2]
6. Explain how you can apply population balance model to analyze flocculation for purifying drinking water. Use population balance equation to explain the process. [5]
7.
 - a. What is reinforcement learning? [1]
 - b. Provide an example of the application of reinforcement learning in chemical engineering. [2]
 - c. What is the difference between reinforcement learning and supervised learning? [2]

P.T.O.

8. A simplified but realistic model for waste-water treatment process is represented by a

first order nonlinear equation:
$$\frac{dx}{dt} = \left[\frac{(c_f - x)}{\tau} \right] + k_1 u (c_s - x) - k_2 \alpha$$

where x = dissolved Oxygen concentration (DO), mg/L; u = air flow rate, l/h; t = hydraulic time constant, h; c_f = inlet dissolved Oxygen concentration, mg/L; c_s = maximum dissolved Oxygen concentration (saturation limit), mg/L; k_1 = mass transfer coefficient, 1/L; k_2 = oxygen uptake rate, mg/L/h. The factor α ensures that the oxygen uptake is zero when the dissolved oxygen concentration is zero. The nominal operating conditions are: $c_s = 9$ mg/L; $u = 0.5$, $k_1 = 0.05$ 1/L; $k_2 = 2.06$ mg/L/min; $x = 2.714$ mg/L. Derive the expression for the sensitivity of x by u under the steady state condition and find its value. [5]