NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR

Odd Semester Mid-Term Examination, 2023-24

Course Code: CHC301
Course Name: Process Calculations

Full Marks: 25
Time: 90 Minutes

Roll No of the Student :

Instructions: Answer all the questions. Materials to be supplied: Graph papers will be supplied, if required.

Que. No.	Body of the Question	Marks	Mapped CO
1.	The heat loss from a cylindrical pipe to the ambient is given by the following equation $$q = 7.38 \times \frac{\Delta T^{1.25}}{D_p^{0.25}}$$ Where q is the rate of heat loss in W/m^2, ΔT is the temperature difference in K, D_p is the outside pipe diameter in mm. It is desired to convert the equation into FPS system. **Write down the units of all physical quantities in FPS system.** Hence **calculate the new value of the constant (in place of 7.38)** in the equation above such that it will have a consistent unit system in FPS for all quantities. **Or** Water is flowing through a 3-inch inner dia. pipe at the volumetric flow of 0.0983 ft^3/s. Calculate the kinetic energy in $\frac{ft.lb_f}{lb_m}$. If water has a specific gravity of 0.99 and a viscosity of 1 cP, calculate the Reynolds number for the flow. **Write down the units and dimensions of all the physical quantities clearly.**	**6.5** **3+3.5**	CO1
2	2 g mol of a gas mixture contains 25 % N_2, 10 % O_2, 15% CH_4, 30 % CO_2 and rest is CO (all composition are in mass %). It is mixed with 42 g of Nitrogen at constant temperature and pressure. Calculate the following for the final gas mixture. **Show all steps of calculation with clear statements.** a) The mass and moles of the final mixture. b) Molar composition c) mass composition d) average molecular weight.	**4x1.5**	CO2
3.	**(a)** A mixture of air and water vapour contains 10^{-5} kmol of water vapor per m^3 at 40°C and 100 kPa. Calculate the (i) Pure component volume of water vapour and (ii) Partial pressure of water vapour	**3+3**	CO4

Course Outcomes
CO1: Learn fundamental of units and dimension, dimensionless groups and their implications
CO2: Graphical interpretation of experimental data, use of log-log and semi log plots for non-linear equations
CO3: Understanding of mass and energy balance for various chemical processes
CO4: understanding the Ideal gas equation, Raoult's law, Henry's law, and psychrometric property

	(b) The vapour pressure of water at 90°C is 70.1 kPa, and the mean latent heat of vaporization between 90°C and 98°C may be taken as 2270 kJ/kg. Calculate the vapour pressure of water at 98°C.		
4.	**(a)** Write the different methods for determination of vapour pressure. State their advantages and disadvantages. **(b)** 25 m^3 of an equimolar mixture of O_2 and N_2 at a temperature of 25°C and a pressure of 98 kPa is to be produced by mixing pure O_2 at 0°C and 1000 kPa with air at 40°C and 100 kPa. Calculate (i) The volumes of O_2 and air under existing conditions to be mixed to produce the desired mixture and (ii) The average molecular weight of the gas mixture. Air may be assumed to contain 21% O_2 and 79% N_2 on molar basis.	**3 +3.5**	CO4

NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR

Odd Semester Mid-Term Examination, 2023-24

Course Code: CHC 302
Course Name: Chemical Engineering Thermodynamics

Full Marks: 25
Time: 90 Minutes

Instructions: Answer all the questions.
Materials to be supplied: Graph paper shall be supplied, if required.

Question No.	Body of the Question	Marks	Mapped CO
	Group A		
1.	Prove that for steady state flow process, $\Delta H = Q - W_S$ Where, symbols have their usual meanings.	4	CO2
2.	A piston-cylinder assembly contains a gas at 0.6 MPa and 25 cm^3, which is compressed adiabatically to 2 MPa and 5 cm^3. The pressure and volume are related by the following relation: P = m + nV, where p is in MPa and V is in cm^3. a) Calculate the values of 'm' and 'n' and b) work done.	4	CO1
3.	Prove that van der Waals' constants' (a, b) can be expressed in terms of critical temperature and pressure as follows: $a = \frac{27R^2T_C^2}{64P_C}$ and $b = \frac{RT_C}{8P_C}$	3	CO2
4.	Derive an expression to estimate the work done for adiabatic expansion of an ideal gas	1.5	CO1
	Group B		
1.	What is Roult's Law? State the assumption of Roult's Law.	1.5	CO1
2.	What do you mean by saturated vapor pressure ?	1	CO3
3.	What do you mean by ideal solution ?	1	CO1
4.	Assuming Raoult's law to be valid, prepare a P-x-y diagram for a temperature of 363.15 K (90°C) and a t-x-y diagram for a pressure of 90 kPa for one of the following system: Benzene(l)/ethylbenzene (2) (Use Graph Paper. Take 5 points for each curve) Given: Antoine Equation $\ln P^{Sat}/kPa = A - \frac{B}{T+C}$ Parameters for the Antoine Equation	9	CO3

	A	B	C
Benzene	13.8594	2773.78	-53.08
Ethylbenzene	14.0045	3279.47	-59.95

Course Outcomes
CO1: Apply the laws of thermodynamics to chemical engineering processes and conversion devices
CO2: Calculate thermodynamic properties using equations of state, charts and tables
CO3: Apply the concept of phase equilibrium to multi-phase systems
CO4: Solve problems of single and multi-phase chemically reactive systems using the concept of chemical reaction equilibrium

NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR

Odd Semester Mid-Term Examination, 2023-24

Course Code: CHC 303
Course Name: FLUID MECHANICS

Full Marks: 25
Time: 90 Minutes

Instructions: Answer all the questions.
Materials to be supplied: Graph paper shall be supplied, if required.

Question No.	Body of the Question	Marks	Mapped CO
1	a) A horizontal cylindrical continuous decanter is to separate 1,500 bbl/d (day) (9.93 m^3/h) of a liquid petroleum fraction from an equal volume of wash acid. The oil is the continuous phase and at operating temperature has a viscosity of 1.1 cP and a density of 54 lb/ft^3 (865 kg/m^3). The density of the acid is 72 lb/ft^3 (1,153 kg/m^3). Compare (a) the size of the vessel and (b)the height of the acid overflow above the vessel floor. [Use any of the units] b) When the submarine Thresher sank in the Atlantic in 1963, it was estimated in the newspapers that the accident had occurred at a depth of 1000 ft (304.9) m. What is the pressure of the sea at that depth? c) A block of wood is floating at the interface between a layer of gasoline and a layer of water. What fraction of the wood is below the interface? (SG Gasoline 0.72; SG Wood 0.96)	3+3 3 3	CO1
2	a) What are the characteristics of an ideal fluid? The general relation between shear stress and velocity gradient of a fluid can be written as $\tau = A\left(\frac{du}{dy}\right)^n + B$ where A, B and n are constants that depend upon the type of fluid and conditions imposed on the flow. Comment on the value of these constants so that the fluid may behave as an ideal fluid, a Newtonian fluid and a non-Newtonian fluid. Indicate whether the fluid with the following characteristics is a Newtonian or non-Newtonian: (i) $\tau = A\,y + B$ and $u = c_1 + c_2 y + c_3 y^2$ (ii) $\tau = A\,y^{n(n-1)}$ and $u = cy^n$	1 3	CO1
3	a) What is an orifice meter? Derive an expression for the discharge through an orifice meter. b) A horizontal venture meter with an inlet diameter of 20 cm and a throat diameter of 10cm is used to measure the flow of oil of sp.gr.0.8. The discharge of oil through the venture meter is 60lit/s. Find the reading of the oil-mercury differential manometer. Take Cd = 0.98 .	3 3	CO3

Course Outcomes

- CO1: Create a fundamental understanding of fluid statistics kinematics and kinetics
- CO2: Apply mass, momentum and energy balance to hydrostatic and fluid flow problems
- CO3: Acquire knowledge of Fluid machineries and flow measuring devices

	c) A right-angled V-notch is used for measuring a discharge of 30 litres/s. An error of 1.5 mm was made while measuring the head over the notch. Calculate the percentage error in the discharge. Take C_d = 0.62	3	

NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR

Odd Semester Mid-Term Examination, 2023-24

Course Code: CHC 331 Full Marks: 25

Course Name: PROCESS CALCULATIONS & THERMODYNAMICS Time: 90 Minutes

Instructions: Answer all the questions.
Materials to be supplied: Graph paper shall be supplied, if required.

Question No.	Body of the Question	Marks	Mapped CO
1	a) Explain dimensional homogeneity with proper example? b) The resisting force R of a supersonic plane during flight can be considered as dependent upon the length of the aircraft L, velocity V, air viscosity μ, air density ρ, and bulk modulus of air k. Express the functional relationship between the variables and the resisting force.	1 3	CO1
2	a) Derive the Clausius-Clapeyron equation in light of the phase change process. b) Carbon tetrachloride boils at 349.8 K at a pressure of 1 bar. Determine its boiling point at 3 bar pressure. The latent heat of vapourization of CCl4 is 30 kJ/mol. c) The Antoine constant for n-heptane are A = 13.8587, B = 2911.32 and C = 56.56. Vapour pressure is in kPa and T is in K. Calculate i) The vapour pressure of n-heptane at 325 K ii) The normal boiling point of n-heptane.	2 2 2	CO2
3	a) Define extensive and intensive property with examples. b) How does the internal energy of an ideal gas vary with pressure and temperature? c) Why is specific heat at constant pressure Cp always greater than that at constant volume Cv? d) Prove that for one mole of ideal gas $C_P - C_V = R$. e) Air is compressed from 2 atm absolute and 28°C to 6 atm absolute and 28°C by heating at constant volume followed by cooling at constant pressure. Calculate the heat and work requirements and change in internal energy of the air. Data Cv = 0.718 kj/kg °C, C p = 1.005 kj/kg °C respectively. f) Write the expression for work done in a polytrophic process.	1 2 1 2 3 2	CO4
4	a) Write Van-der Waal's equation of state. b) Determine the molar volume of gaseous methane at 300K and 600 bar by the following methods. i) Using the ideal gas equation ii) Using the van der walls equation given that a = 0.2285 Nm4/mol2, b= 4.27 ×10–5 m3 /mol. iii) Using Redlich – Kwong equation given that Tc = 191.1K and Pc = 46.4 bar.	1 3	CO2

Course Outcomes

- CO1: To develop the concept of dimension and unit conversion to check dimensional consistency of balanced equation
- CO2: Learn basic laws about the behavior of gases, liquids and solids and some basic mathematical tools.
- CO3: To Establish mathematical methodologies for the computation of material balances and energy balances with and without chemical reaction
- CO4: To apply knowledge of the laws of thermodynamics to solve physical and chemical problems encountered in chemical and biochemical industries.
- CO5: To analyze and interpret data, to identify, formulate, and solve engineering problems.

Bimal Das 16/8/23

NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR

Odd Semester Mid-term Examination, 2023-24

Course Code: CHC 501 Full Marks: 25

Course Name: Chemical Reaction Engg. Time: 90 mins

Question Paper No.: NITDGP/CHC501/1 Date of Exam:

Instructions: Answer the questions as per direction

Materials to be supplied: Graph paper shall be supplied, if required.

Answer **Q1** and any **one** from the rest

Question No.	Body of the Question	Marks	Mapped CO
1	Answer the followings: 1. Define order and molecularity of a reaction. State the difference. 2. Deduce the expression of conversion with time for an irreversible and bimolecular second order reaction. 3. Explain different types of multiple reactions with basic rate expression	3+6+3	CO1
2	i) Find the conversion after 1 hour in a batch reactor for **A-->R**, where $-r_A = 3C_A^{0.5}$ mol/litre/hr, $C_{A0}=1$ mol/litre. Deduce the expression as required for calculation. ii) Gaseous reactant A decomposes as follows: **$A \rightarrow 3R$ $-r_A = (0.6\ min^{-1})C_A$** Find the conversion of A in a 50% A & 50% inert feed (v_o=180 litre/min, C_{A0}=300 mmol/litre) to a 1 m^3 mixed flow reactor.	7+6	CO1 CO3
3	i) Pure A (C_{A0}=100) is fed to a mixed flow reactor and R and S are formed. The following outlet concentrations are recorded. Find a kinetic scheme to fit this data.	5+8	CO3 CO4

Run	C_A	C_R	C_S
1	75	15	10
2	25	45	30

ii) Explain different types of biochemical reaction

In a number of separate runs different concentrations of substrate and enzyme are introduced into a batch reactor and allowed to react. After a certain time, the reaction is quenched and the vessel contents analysed. From the results found below find a rate equation to represent the action of enzyme on substrate.

Course Outcomes
CO1: CO2: CO3: CO4

[P. T. O.]

Run	C_{EO} (mol/m^3)	C_{AO} (mol/m^3)	C_A (mol/m^3)	t, hr
1	3	400	10	1
2	2	200	5	1
3	1	20	1	1

NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR

Odd Semester MID-TERM Examination, 2023-24

Course Code: CHC 502 Full Marks: 25

Course Name: Mass Transfer II Time: 2 Hours

Question Paper No.: NITDGP Date of Exam: xx/xx/xxxx

Instructions: Follow as given under Group-A & Group-B separately

Materials to be supplied: **Psychometric charts and graph papers (normal) will be provided**, if required.

GROUP-A

Answer all questions. All parts of a question should be answered in sequential order in one place.

Question No.	Body of the Question	Marks	Mapped CO
1	(a)What type of distillation is described by Rayleigh Equation? How will you deduce Rayleigh Equation and solve the same? (b) How will you interpret the relation between Henry's law and Raoult's law? How will you apply these laws? (c) What happens to the pressure inside an oxygen cylinder and an LPG cylinder when 50% of the contents of the initially filled two cylinders are consumed at constant temperature? Explain your logic.	3+1+2	CO1, CO2
2	(a)How will you apply Sorel-Lewis method in design of a distillation column? (b) Explain role of vapour flow rate in efficient operation of a distillation column having sieve plates. How will you arrive at the optimum vapour flow rate? Use diagram to explain.	4+3	CO2, CO3
	GROUP-B		
3	Define Range for cooling tower. What is the importance of wet bulb depression for cooling tower design? Explain about adiabatic saturation temperature. What is psychrometer?	5	CO1, CO2
4	A sample of air has a dry bulb temperature of 33 ^{0}C and wet bulb temperature of 23 ^{0}C. Total pressure is atmospheric. a) Determine its psychrometric properties – humidity, enthalpy, dew point, humid volume and humid heat b) If the sample of air is heated to 50 ^{0}C, what will be its wet bulb temperature?	7	CO2, CO3

Course Outcomes(CO)

CO1: Enhancement of capability of critical thinking & analysis

CO2: Ability to perform experiment on mass transfer systems towards betterment

CO3: Ability to apply laws of mass and heat transfer in design and operation of mass transfer systems

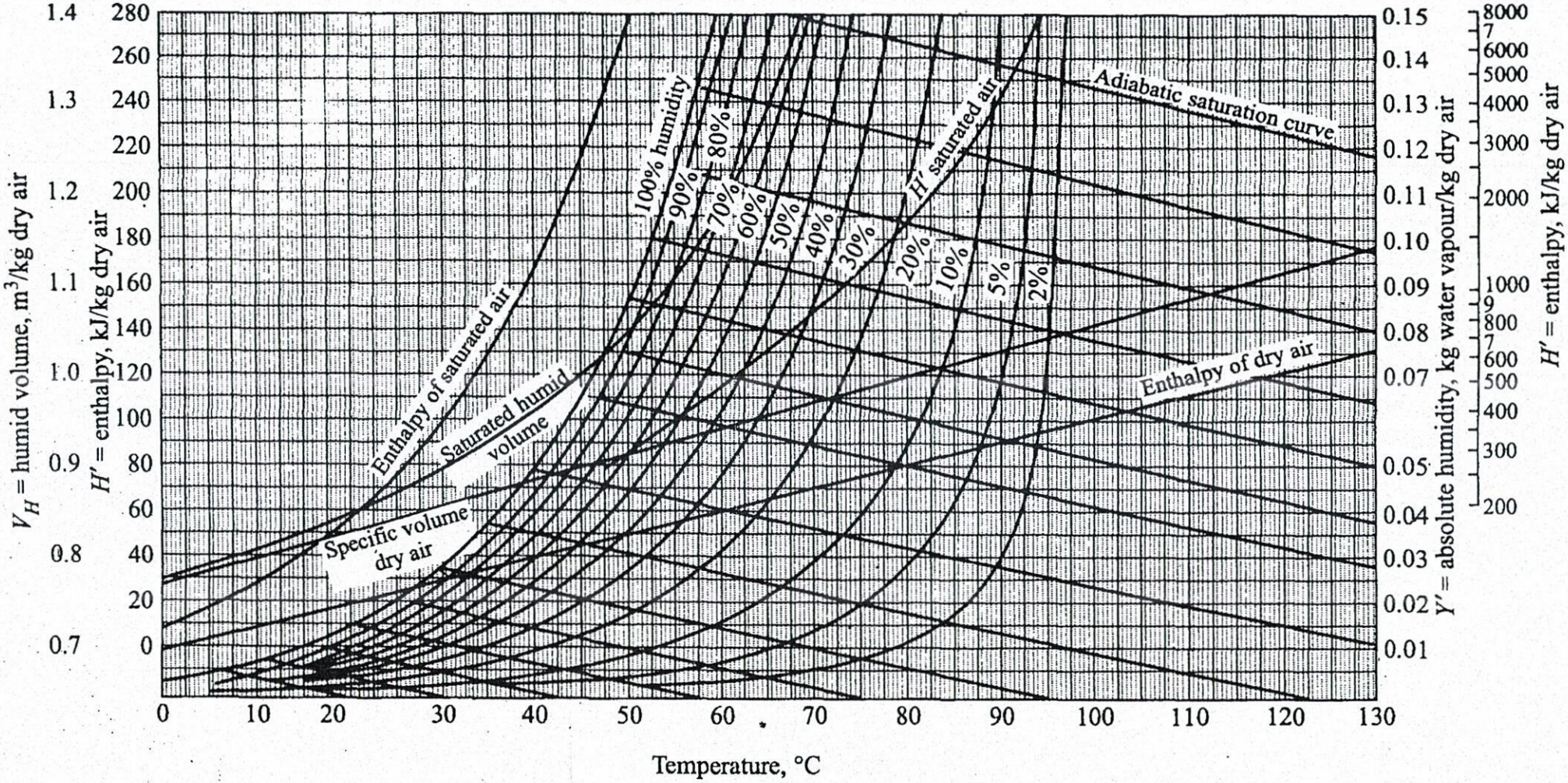


Figure 10.6 (a) Psychrometric chart for the air–water system at 1 atm total pressure.

NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR

Odd Semester Mid-Term Examination, 2023-24

Course Code: CHC503 Full Marks: 25

Course Name: Chemical Process Technology Time: 90 Minutes

Instructions:
Materials to be supplied: Graph paper shall be supplied, if required.

Question No.	Body of the Question	Marks	Mapped CO
1	(a) i) **Explain** conventional Linde Frankl cycle with process flow diagram for the production of oxygen. (ii) Briefly **discuss** about the engineering problems associated in the oxygen production unit. Or (b) (i)**What** are the challenges in scaling up steam reforming and partial oxidation processes for large-scale hydrogen production? (ii) Can you **explain** how recent technological advancements have been designed to improve the efficiency or sustainability of these hydrogen production method?	[4+2] [3+3]	CO1, CO2
2	(a) (i) **Discuss** about the characteristics of cement kilns. (ii) **What** parameters are strictly monitored during kiln feed operation? (iii) **Discuss** the dry and wet process for manufacturing of Portland cement. Or (b)(i) **Illustrate** the role of piping and instrumentation diagram in industry. (ii) **Explain** the process of demineralization or deionization as a part of water conditioning?	[1+2+3] [3+3]	CO1, CO2
3	(a) (i) **Analyze** the economic and environmental trade-offs associated with sugarcane as a sugar and ethanol production bioresource, considering factors such as land use, resource allocation, and market demand. (ii) **Assess** the use of SO_2 as a bacteriostatic agent in the steeped tank during starch production from a technological and health perspective. Suggest alternative methods for achieving the same purpose. Or (b) (i) **Propose** innovative ways to utilize waste streams generated during starch production, such as hulls and fiber, as feedstock for biogas production. How can this align with SDG 7 and SDG 13 (Climate Action)? (ii) **Compare** and contrast the advantages and disadvantages of using bagasse from sugar industries as a raw material for paper industries versus its utilization as a fuel for electricity generation.	[4+3]	CO3, CO4

Course Outcomes

CO1: Ability to understand the manufacturing of various inorganic and organic chemicals.

CO2: Ability to understand the process flow diagram and various process parameters.

CO3: Ability to identify and solve engineering problems during production.

CO4: Knows current scenario of chemical & allied process industries.

4	Answer ***any two*** questions: (a) **Design** a flow diagram for the Kraft pulping process, indicating the leading equipment used (e.g., digester, evaporator, recovery boiler) and the flow of chemicals. (b) **Interpret** the role of various chemicals (e.g., white liquor, black liquor) in the chemical recovery process, and discuss their impact on the overall economy of the paper mill. (c) **Explain** the importance of black liquor concentration and the challenges associated with scaling and fouling in black liquor evaporators.	[3+3]	CO1, CO2

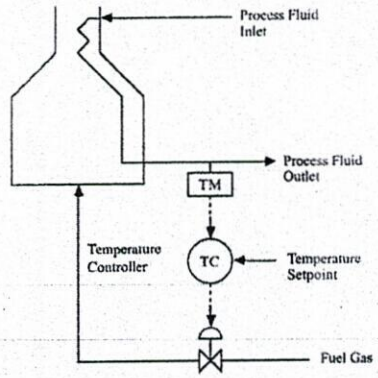
NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR

Odd Semester Mid-Term Examination, 2023-24

Course Code: CHC504 Full Marks: 25

Course Name: Process control and Instrumentation Time: 90 Minutes

Instructions: Answer any five questions.
Materials to be supplied: Graph paper shall be supplied, if required.

Question No.	Body of the Question	Marks	Mapped CO
1	 A process furnace heats a process stream from near ambient temperature to a desired temperature of 300°C as shown above. Answer the following: a) Objective of this control system b) What are the CV, MV and DVs for this scheme? c) Should the control valve fail-open or fail-closed? d) For the strategy you chose, is the valve gain positive or negative? Why? e) Draw the control block schematic diagram and label all signals and blocks on the diagram.	5x1=5	CO2
2	Write down the equations of the first order and second order process in time domain and Laplace domain and explain each terms in the equations.	5	CO2
3	Explain the working principle of thermocouple, thermistor and RTD and compare them.	5	CO1
4	Explain the following : Underdamped, overdamped and critically damped response, sensor and transmitter, time constant	5	CO2
5	Explain the cascade control with a schematic diagram. What is the benefit of cascade control over normal feedback control.	5	CO2
6	Define Laplace transform. What's the benefit of Laplace transform? Derive the Laplace transform of the following functions : $L\left[\frac{df(t)}{dt}\right]$ and $L\left[e^{-at}\right]$	5	CO2

CO1: Understanding the working principle of various measuring instruments like, level, temperature, pressure, flow and concentration etc.
CO2: Process modeling fundamentals: Differential equation models, Laplace transforms, linearization, idealized dynamic behavior, transfer functions, block diagram, and process optimization.
CO3: Evaluate stability, frequency response, and other characteristics relevant to process control.

14.09.23

NITDGP/BTECH/Reg/Odd/2023-24

NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR

Odd Semester Mid-Term Examination, 2023-24

Course Code: CHC 531BT Full Marks: 25

Course Name: Unit Operations of Chemical Engineering-II Time: 90 minutes

Instructions: **Answer all the questions sequentially.**
Materials to be supplied: Graph paper shall be supplied, if required.

Question No.	Questions	Marks	Mapped CO
1.	Differentiate between mass average and molar average velocities.	2	CO1, CO2
2.	Fluxes are commonly used to describe the diffusion rates. Define the three ways to define the mass and molar fluxes	6	CO2
3.	What is molecular diffusion? State Fick's law of diffusion for the binary mixtures and specify all the terms clearly.	2+2	CO2
4.	Derive the total molar flux expression for the equimolar counter diffusion	3	CO3
5.	Oxygen (O_2) is diffusing through carbon monoxide at 0°C (steady-state condition, non-diffusing). The total pressure is 100kPa. The partial pressure of oxygen at two planes 2 mm apart is 13kPa and 6.5 kPa, respectively. The diffusivity is 1.87×10^{-5} m^2/s. Calculate the molar flux of A (N_A). How many kgs of oxygen diffuses in one hour if the diffusing area is 10 m^2?	3+2	CO5
6.	What are the dimensionless groups in Mass Transfer? Describe the physical significance of any two dimensionless groups.	2+1	CO1, CO2
7.	Discuss about the two-resistance film theory.	2	CO2

Course Outcomes

- CO1: To learn different types of mass transfer phenomena.
- CO2: Understanding the fundamentals of mass transfer operations.
- CO3: To learn design parameters, their effects and calculations.
- CO4: To compare different types of mass transfer operations and their applications.
- CO5: To solve related problems of different difficulty levels through tutorials.