Enrolment No/Seat No.: _____

R.N.G.PATEL INSTITUTE OF TECHNOLOGY-RNGPIT

(An Autonomous Institute U/s UGC Act 1956)

B.Tech. SEMESTER-III, SEMESTER END EXAMINATION – WINTER 2025

SUBJECT CODE: 1CH303 **DATE: 20-12-2025**

SUBJECT NAME: MATERIAL AND ENERGY BALANCE CALCULATIONS

TIME: 11:00 AM to 01:30 PM **TOTAL MARKS: 70**

Instructions

1. It is **compulsory** for students to write **Enrolment No. /Seat No.**on the question paper.
2. Write answers of **Section A** and **Section B** in **separate answer books**.
3. Attempt all questions from both **Section A** and **Section B**.
4. Each section carries **35 marks**, with a total of **70 marks** for the examination.
5. The figures to the right of each question indicate full marks, make suitable assumptions with justification.
6. BL - Cognitive Level (As per Revised Bloom's Taxonomy) (R-Remember, U-Understanding, A –Application, N –Analyze, E – Evaluate, C -Create), CO - Course Outcomes.

SECTION A

			Marks	BL	CO
Q.1	**(a)**	Define fundamental units and give three examples from the SI system.	**03**	**R**	**1**
	(b)	Distinguish between fundamental and derived quantities with suitable examples.	**04**	**U**	**1**
Q.2	**(a)**	Differentiate between weight percent and mole percent with formulae.	**03**	**U**	**2**
	(b)	Differentiate between molarity, molality, and normality with formulas and units.	**04**	**U**	**2**
	(c)	A chemist is interested in preparing 500 ml of 1 normal, 1 molar and 1 molal solution of H_2SO_4. Assuming the density of H_2SO_4 solution to be 1.075 g/cm³, calculate the quantities of H_2SO_4, to be taken to prepare these solutions.	**07**	**N**	**2**
		OR			
Q.2	**(a)**	State Raoult's Law and mention its application.	**03**	**U**	**2**
	(b)	Define average molecular weight of a gaseous mixture and show how it can be calculated.	**04**	**U**	**2**
	(c)	Do the following conversions: (a) 294 g/l H_2SO_4 to normality. (b) 5N H_3PO_4 to g/l. (c) 54.75 g// HCl to molarity. (d) 3M K_2SO_4 to g/l. (e) 4.8 mg/ml $CaCl_2$ to normality	**07**	**N**	**2**

Q.3	**(a)**	Define recycle, bypass, and purge streams in a process.	**03**	**R**	**3**
	(b)	Explain crystallization and how material balance is applied to it.	**04**	**U**	**3**
	(c)	The dilute acid containing 25% H_2SO_4 is concentrated by commercial grade sulphuric acid containing 98% H_2SO_4 to obtain desired acid containing 65% H_2SO_4. Find the quantities of the acids required to make 1000 kg of desired acid.	**07**	**N**	**3**

OR

Q.3	**(a)**	Write the general material balance equation for a non-reactive process.	**03**	**R**	**3**
	(b)	Explain with a simple example the material balance of an absorption column.	**04**	**U**	**3**
	(c)	The waste acid from a nitrating process containing 20% HNO3, 55% H_2SO_4 and 25% H_2O by weight is to be concentrated by addition of concentrated sulphuric acid containing 95% H_2SO_4 and concentrated nitric acid containing 90% HNO, to get desired mixed acid containing 26% HNO3 and 60% H_2SO_4. Calculate the quantities of waste and concentrated acids required for 1000 kg of desired mixed acid.	**07**	**N**	**3**

SECTION B

			Marks	BL	CO
Q.4	**(a)**	Define the following terms: (1) Excess reactant (2) Percentage conversion (3) Yield	**03**	**R**	**4**
	(b)	Briefly explain how limiting reactant concept affects production cost in fertilizer and petrochemical industries.	**04**	**E**	**4**
Q.5	**(a)**	Define: Heat capacity, Standard heat of reaction, Adiabatic Process	**03**	**R**	**5**
	(b)	Calculate the standard heat of reaction of the following reaction using std. heat of formation data.	**04**	**A**	**5**

$$C_5H_{12\,(l)} + 8O_{2\,(g)} \rightarrow 5CO_{2\,(g)} + 6H_2O_{\,(l)}$$

Component	ΔH_f^0 = kJ/mol at 25 ^{0}C
$C_5H_{12\,(l)}$	-173.49
$CO_{2\,(g)}$	-393.51
$H_2O_{\,(l)}$	-28.83

	(c)	A gas mixture has the following composition on mole basis. CH_4 = 84%, C_2H_6 = 13% and N_2 = 3%. Calculate the energy to be added to heat the 15 Kmol of gas mixture from 298 K to 523 K using heat capacity data given below. $C_P^0 = a + bT + cT^2 + dT^3$ Where C_P^0 is in kJ/Kmol K	**07**	**A**	**5**

Component	A	$b \times 10^3$	$c \times 10^6$	$d \times 10^9$
$CH_{4\,(g)}$	19.25	52.11	11.97	-11.32
$C_2H_{6\,(g)}$	5.41	178.19	-67.38	8.72
$N_{2\,(g)}$	29.59	-5.41	13.18	-4.97

OR

Q.5	**(a)**	Discuss Hess's Law of constant heat summation.	**03**	**U**	**5**

(b) Pure methane is heated from 303K to 523K at atmospheric pressure. Calculate the heat added per kmole methane using Cp data. **04** **A** **5**

$C_P^0 = a + bT + cT^2 + dT^3$

Data for methane:

Component	a	$b \times 10^3$	$c \times 10^6$	$d \times 10^9$
$CH_{4\,(g)}$	19.25	52.11	11.97	-11.32

(c) (1) Using Antoine equation calculate the vapor pressure of Aniline at 380 K. Data: A=6.4450 B= 1731.50 C= -67.05 **07** **E** **5**

(2) For o-xylene, Calculate latent heat of vaporization at 298.15 K using Watson equation.Latent heat of o-xylene at 417.5 K= 36819 kJ/kmol,Critical temperature of o-xylene = 630.30 K.

Q.6 **(a)** Define fuel. Classify fuels based on physical state – solid, liquid and gaseous with two examples each. **03** **R** **6**

(b) Define GCV and NCV for fuels. Give its importance. Also give the names of the equipment used for measuring CV of solid, liquid and gases. **04** **U** **6**

(c) Calculate the Net calorific value at 298K of a sample of fuel oil having C/H ratio of 9.33 (by weight) and containing sulphur to the extent of 1.3 % by weight. **07** **E** **6**

Data: The Gross calorific value (GCV) of fuel oil at 298 K = 41785 kJ/kg. Latent heat of water vapour (25 °C) = 2442.5 kJ/kg

OR

Q.6 **(a)** What is calorific value of fuel? Explain the difference between Higher Calorific Value (HCV) and Lower Calorific Value (LCV). **03** **U** **6**

(b) Discuss proximate and ultimate analysis of coal. **04** **U** **6**

(c) The Or sat analysis of the flue gases from a boiler house chimney gives CO_2 11.2%, O_2:4.2% and N_2 84.4 % (mole %). If complete combustion has taken place, (a) calculate the % excess air and (b) find the C: H ratio in the fuel. **07** **E** **6**

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