

**B.TECH.**  
**(SEM IV) EVEN SEMESTER EXAMINATION 2025-26**  
**CHEMICAL ENGINEERING THERMODYNAMICS**

[TIME: 3 hrs.]

[Max. Marks: 70]

Note: Attempt All Questions. All Questions carry equal marks. Assume data suitably, if missing.

- Q1.** Answer ALL parts. Marks
- (a) Derive an expression for kinetic energy. 07
- OR**
- Derive an expression for the velocity of fluid at the exit of the nozzle.
- (b) A liquid mixture containing 50 mole percent each of benzene and toluene at 313 K is to be continuously flash vaporized so that 60 mole percent of the feed is vaporized. The residual liquid product contains 35 mole percent benzene. If the enthalpies per mole of feed, distillate, and the residue are 5, 30, and 2kJ/mole, respectively, calculate the heat added in kJ per mole of vapor product. 07
- Q2.** Answer ALL parts.
- (a) A new engine is claimed to have a power output of 4.5 hp while receiving a heat input of 6.25 kW and working between the source and sink temperature limits of 1000K and 500K. Determine the efficiency of the proposed engine. Is the claim for the engine admissible? 07
- (b) Discuss the PT diagram for a pure component with a neat diagram. 07
- OR**
- What is fugacity? Discuss the concept of fugacity in real and ideal gas cases.
- Q3.** Answer ALL parts.
- (a) Discuss the various activity coefficient models in detail. 07
- (b) How can we examine the thermodynamic consistency of phase equilibria? Explain in detail. 07
- OR**
- Discuss the concept of correlation and prediction of phase equilibria for a distillation process.
- Q4.** Answer ALL parts.
- (a) Develop an expression for mole fraction calculation of a species in terms of the number of moles and stoichiometric coefficients. 07
- OR**
- Develop a correlation between free energy change and chemical potential for a certain process.
- (b) n-butane is isomerised to i-butane by the action of a catalyst at moderate temperature. It is found that the equilibrium is attained at the following compositions: At 317 K and 391 K, the mole percents of n-butane have been found as 31.00 and 43, respectively. Assuming that the activities are equal to the mole fraction. Calculate the standard free energy of the reaction at 317 K and 391 K, and the average value of the heat of reaction over this temperature range. 07

**Q5.** Answer ALL parts.

- (a) Explain the vapor compression cycle with a neat diagram. Also, develop COP expression for this cycle. 07

**OR**

Discuss the gas refrigeration cycle with a neat diagram. Also discuss its T-S diagram.

- (b) It is required to freeze 1 kg of water at 273K by means of a refrigeration machine which operates in the surroundings at 300K. The latent heat of fusion of ice at 273 K is 334.11kJ/kg. Determine: 07
- (i) The minimum amount of work required.
- (ii) The heat given up to the surroundings

**B.TECH.**  
**(SEM IV) EVEN SEMESTER EXAMINATION 2025-26**  
**CO-BL Mapping**

Odd Semester Examination 2025-26			
Subject Code: ICH-403			
Subject Name: CHEMICAL ENGINEERING			
THERMODYNAMICS			
Q.No.	Marks	CO	BL
1(a)	07	1	3
1(b)	07	1	3
2(a)	07	2	3
2(b)	07	2	1
3(a)	07	3	1
3(b)	07	3	1
4(a)	07	4	3
4(b)	07	4	3
5(a)	07	5	1
5(b)	07	5	3

Institute of Engineering and Technology, Lucknow  
Department of Chemical Engineering  
Class Test-I

Subject: Chemical Engg. Thermodynamics

Sub Code: ICH 403

Branch & Semester: CH (4<sup>th</sup> Sem)

Note: Assume missing data suitably.

Session: 2025-26  
Duration: 1 hr  
Total Marks: 20

Q. No.	Questions	Marks
1.	A vessel of cylindrical shape is 50 cm in diameter and 75 cm high. It contains 4 kg of a gas. The pressure measured with a manometer indicates 620 mm of Hg above the atmosphere when the barometer reads 760 mm of Hg. Determine: (a) The absolute pressure of the gas in the vessel in bar. (b) Specific volume and density of the gas.	05
2.	Derive an expression for total energy in an open system.	05
3.	An electric current of 0.5A from a 12V supply is passed for 5 minutes through a resistance in thermal contact with saturated water at 1 atm. As a result, 0.798 gm of water is vaporised. Assuming that the water vapour behaves ideally, calculate the molar internal energy change and enthalpy change during this process.	05
4.	Discuss the P-T diagram of a pure substance in detail.	05

Institute of Engineering and Technology, Lucknow  
Department of Chemical Engineering  
Class Test-2

Subject: Chemical Engg. Thermodynamics  
Sub Code: ICH 403  
Branch & Semester: CH (4<sup>th</sup> Sem)  
Note: Assume missing data suitably.

Session: 2025-26  
Duration: 1 hr  
Total Marks: 20

Q. No.	Questions	Marks
1.	A carnot cycle operates between source and sink temperatures of $250^{\circ}\text{C}$ and $15^{\circ}\text{C}$ . If the system receives 90kJ from the source; Find (i) efficiency of the system (ii) the net work (iii) heat rejected to the sink.	05
2.	Discuss the concept of thermodynamic consistency of phase equilibria.	05
3.	Develop a correlation between equilibrium constant and standard free energy change.	05
4.	A carnot refrigerator requires 1.3kW per ton of refrigeration to maintain a region at low temperature of $-38^{\circ}\text{C}$ . Determine: (i) COP of refrigerator (ii) higher temperature of scale (iii) the heat delivered and COP when this device is used as heat pump	05

## B.Tech.

(SEM IV) EVEN SEMESTER EXAMINATION 2024-25  
CHEMICAL ENGINEERING THERMODYNAMICS

[TIME: 3 hrs.]

[Max. Marks: 70]

Note: Attempt All Questions. All Question carry equal marks.

- Q1. Answer ALL parts. Marks
- (a) Explain the first law of thermodynamics. Write the general energy balance equation for open system and explain each term involved. 7

OR

Write a short note on any TWO of the following

- (i) Phase rule for non reacting systems
- (ii) 0<sup>th</sup> law of thermodynamics
- (iii) Equilibrium
- (iv) Maxwell relationships
- (b) Air is compressed from an initial condition of 1 bar and 25 °C to a final state of 5 bar and 25 °C by two different mechanically reversible processes. 7
- a) Heating at constant volume followed by cooling at constant pressure
- b) Adiabatic compression followed by cooling at constant volume
- Assume air as an ideal gas with  $C_p = (7/2)R$ . Calculate work required, heat transferred and the changes in internal energy and enthalpy of the air for each process.

Q2. Answer ALL parts.

- (a) What do you mean by heat engine? Explain Carnot engine and its steps using P-V and T-S diagrams. Also, discuss Carnot theorem. 7
- (b) A nuclear power plant generates 750 MW; the reactor temperature is 588.15 K (315 °C) and a river with water temperature of 293.15 K (20°C) is available. Calculate - 7
- (i) The maximum possible thermal efficiency of the plant, and the minimum rate at which heat must be discarded to the river?
- (ii) If the actual thermal efficiency of the plant is 60% of the maximum, at what rate must heat be discarded to the river, and what is the temperature rise of the river if it has a flow rate of 165 m<sup>3</sup>/s?

OR

For Acetone, at 20 °C and 1 bar,

 $\beta = 1.487 \times 10^{-3} \text{ K}^{-1}$ ,  $\kappa = 62 \times 10^{-6} \text{ bar}^{-1}$ ,  $V = 1.287 \times 10^{-3} \text{ m}^3/\text{kg}$ . Calculate :

- (i) The value of  $(\partial P/\partial T)_V$
- (ii) The pressure generated when acetone is heated at constant volume from 20 °C to 30 °C
- (iii) The volume change when state of acetone is changed from 20 °C, 1 bar to 0 °C, 10 bar

Q3. Answer ALL parts.

- (a) The need arises in a laboratory for 2000 cm<sup>3</sup> of an antifreeze solution consisting of 30 mol-% methanol in water. Estimate the volume of pure methanol and pure water, which must be mixed so as to obtain the antifreeze solution. Given - 7

Component	$\bar{V}$ (cm <sup>3</sup> /mol)	V (cm <sup>3</sup> /mol)
Methanol (1)	38.632	40.727
Water (2)	17.765	18.068

OR

The enthalpy of binary liquid system of species 1 and 2 at fixed T and P is represented by the equation

$H = 400x_1 + 600x_2 + x_1x_2(40x_1 + 20x_2)$ , where  $H$  is in J/mol.

Determine expressions for  $\bar{H}_1$  and  $\bar{H}_2$  as a function of  $x_1$ . Also find numerical values for partial enthalpies at infinite dilution  $\bar{H}_1^\infty$  and  $\bar{H}_2^\infty$ .

(b) Write a short note on ANY TWO of the followings

- Residual property and Excess property
- Roult's law and activity coefficient
- Partial molar property and chemical potential
- Fugacity coefficient and Lewis/ Randall rule

Q4. Answer ALL parts.

(a) Discuss the general criteria for reaction equilibrium. Also prove that

$$K \equiv \exp\left(\frac{-\Delta G^0}{RT}\right)$$

OR

Determine the degree of freedom for following systems

(i) Two miscible non reacting species which exist as an azeotrope in vapour-liquid equilibrium

(ii) Partial decomposition of  $\text{CaCO}_3$  into an evacuated space

(b) Write a short note on ANY TWO of the followings

- Standard Gibbs-energy change of reaction
- Law of mass action
- Van't Hoff equation
- Duhem's Theorem

Q5. Answer ALL parts.

(a) What do you mean by "Refrigeration"? Describe "Carnot refrigerator". Explain the vapour compression cycle and draw T-S diagram for it.

(b) A domestic food freezer maintains a temperature of  $-15^\circ\text{C}$ . The ambient temperature is  $30^\circ\text{C}$ . If the amount of the heat to be taken out from the freezer is  $1.75 \text{ kJ/s}$ , what shall be the minimum power required to drive the freezer.

OR

A Carnot engine operates between temperature levels of  $600 \text{ K}$  and  $300 \text{ K}$ . It drives a Carnot refrigerator, which provides cooling at  $250 \text{ K}$  and discards heat at  $300 \text{ K}$ . Determine a numerical value for the ratio of heat extracted by the refrigerator ("cooling load") to the heat delivered to the engine ("heating load").

### CO-BL Mapping

Even Semester Examination 2024-25			
Subject Code: ICH-403			
Subject Name: Chemical Engineering Thermodynamics			
Q.No.	Marks	CO	BL
1(a)	7	1	2
1(b)	7	1	4
2(a)	7	2	1
2(b)	7	2	3
3(a)	7	3	2
3(b)	7	3	4
4(a)	7	4	3
4(b)	7	4	4
5(a)	7	5	2
5(b)	7	5	5