

GUJARAT TECHNOLOGICAL UNIVERSITY

BE-3 SEMESTER –OLD PAPER– W22 TO S25- QUESTION BANK

Subject Name & Code:

Chemical Engineering Thermodynamics-1- 3130507

Chapter 1: INTRODUCTION AND FIRST LAW OF THERMODYNAMICS

Repeated Questions:

1. Derive the First Law of Thermodynamics for a closed system.
 - SUMMER 2024 (q1c) - 07 Marks
 - WINTER 2024 (q1c) - 07 Marks
 - SUMMER 2025 (q1c) - 07 Marks (Derived for *steady state flow process*)
2. Explain (i) System and Surroundings (ii) Macroscopic and Microscopic aspect.
 - SUMMER 2024 (q1b) - 04 Marks
 - WINTER 2022 (q1b) - 04 Marks
3. Define equilibrium and state the Phase Rule.
 - SUMMER 2024 (q1a) - 03 Marks
 - WINTER 2024 (q2a) - 03 Marks
4. What is an adiabatic process? Write the expression for work done during a reversible adiabatic process.
 - WINTER 2022 (q3a) - 03 Marks
 - WINTER 2024 (q1a) - 03 Marks
5. Distinguish between the terms 'state function' and 'path function'.
 - WINTER 2022 (q3b) - 04 Marks
 - WINTER 2024 (q1b) - 04 Marks

Other Important Questions:

6. Show that $C_P - C_V = R$ for an ideal gas.
 - SUMMER 2024 (q2a) - 03 Marks
 - SUMMER 2023 (q1a) - 03 Marks
7. What is the scope and limitations of thermodynamics?
 - WINTER 2022 (q1a) - 03 Marks
8. State and explain the zeroth law of thermodynamics.
 - WINTER 2023 (q1a) - 03 Marks
9. A system undergoes a series of processes. Determine ΔU and work done for each step.
 - SUMMER 2024 (q2b) - 04 Marks (Numerical on applying 1st Law to a cyclic process)
10. Calculate Q , W , ΔU , and ΔH for a specified process (e.g., compression, heating).
 - SUMMER 2025 (q2c) - 07 Marks (Numerical: Air compressed and heated)
 - WINTER 2022 (q3c) - 07 Marks (Numerical: Change in U & H for N_2)
 - WINTER 2023 (q1c) - 07 Marks (Numerical: Adiabatic compression of ideal gas, find T , W , ΔU , ΔH)
 - SUMMER 2023 (q1c) - 07 Marks (Numerical: Isothermal compression of vdw gas, find Q & W)

Chapter 2: VOLUMETRIC PROPERTIES OF PURE FLUIDS

Repeated Questions:

1. Calculate molar volume/pressure using different Equations of State (Ideal, van der Waals, R-K, Virial).
 - WINTER 2022 (q2c) - 07 Marks (Methane volume at high P/T)
 - WINTER 2023 (q2c) - 07 Marks (Ammonia pressure in a vessel)
 - SUMMER 2023 (q2c) - 07 Marks (Ammonia volume using vdw and RK)
 - SUMMER 2025 (q2c) - 07 Marks (Volume & Z for Isopropanol using Virial Eq.)
 - SUMMER 2024 (q3c) - 07 Marks (Compressibility factor for Methanol using Virial Eq.)
2. What is an equation of state? Give the expression for any three equations of state.
 - WINTER 2022 (q3b) - 04 Marks
 - WINTER 2024 (q3b) - 04 Marks
3. Explain/Derive the van der Waals equation of state.
 - WINTER 2022 (q2b) - 04 Marks
4. Write a short note on the virial equation of state.
 - SUMMER 2023 (q2b) - 04 Marks
5. Discuss the Redlich-Kwong-Soave (RKS) equation of state.
 - WINTER 2023 (q2a) - 03 Marks
 - SUMMER 2025 (q2a) - 03 Marks
6. Explain the principle of corresponding states and the generalized compressibility chart. Discuss Pitzer's modification.
 - WINTER 2023 (q2b) - 04 Marks
 - WINTER 2024 (q4c) - 07 Marks

Other Important Questions:

7. Explain the physical significance of the triple point and the critical point.
 - WINTER 2024 (q2b) - 04 Marks
8. With a neat sketch, explain PVT behaviour of a pure substance using PT and PV diagrams.
 - WINTER 2024 (q2c) - 07 Marks
9. Determine van der Waals constants at the critical point.
 - WINTER 2023 (q2c-OR) - 07 Marks (Numerical for Ethane)
10. Discuss PVT behavior of pure fluids.
 - SUMMER 2025 (q5c) - 07 Marks

Chapter 3: HEAT EFFECTS

Repeated Questions:

1. Explain Hess's law of constant heat summation. How is it useful?
 - SUMMER 2024 (q3a) - 03 Marks
 - WINTER 2022 (q3a-OR) - 03 Marks
 - SUMMER 2023 (q3a) - 03 Marks
 - SUMMER 2025 (q1b) - 04 Marks
 - WINTER 2024 (q3a) - 03 Marks
2. Calculate the standard heat of reaction at a different temperature using Cp data.
 - SUMMER 2024 (q3c-OR) - 07 Marks (For $\text{CO}_2 + 4\text{H}_2 \rightarrow \text{CH}_4 + 2\text{H}_2\text{O}$ at 773K)
 - WINTER 2024 (q3c) - 07 Marks (Same reaction at 500°C)
3. What is the adiabatic flame temperature? How is it estimated? Effect of excess air?
 - WINTER 2023 (q3b) - 04 Marks
 - SUMMER 2023 (q3b) - 04 Marks
 - WINTER 2024 (q4a) - 03 Marks
4. Define: (a) standard heat of reaction (b) standard heat of formation (c) standard heat of combustion.
 - WINTER 2023 (q3a) - 03 Marks
 - WINTER 2024 (q4a-OR) - 03 Marks

Other Important Questions:

5. Calculate the theoretical flame temperature.
 - SUMMER 2025 (q3c-OR) - 07 Marks (Numerical for CO combustion)
6. Discuss the effect of temperature on the standard heat of reaction.
 - SUMMER 2023 (q3c-OR) - 07 Marks

Chapter 4: SECOND LAW OF THERMODYNAMICS

Repeated Questions:

1. Calculate the entropy change for a system (typically a quenching problem - metal in oil/water).
 - SUMMER 2024 (q2c) - 07 Marks (Steel in oil)
 - WINTER 2022 (q2c-OR) - 07 Marks (Same as above)
 - WINTER 2023 (q3c) - 07 Marks (Copper in water)
 - SUMMER 2023 (q3b-OR) - 07 Marks (Steel in oil, find mass of oil)
 - SUMMER 2025 (q3c) - 07 Marks (Steel in water)
 - WINTER 2024 (q2c) - 07 Marks (Steel in oil)
2. Write various statements of the second law of thermodynamics.
 - SUMMER 2024 (q2b) - 04 Marks
 - SUMMER 2025 (q2b) - 04 Marks
 - WINTER 2024 (q5a) - 03 Marks
 - SUMMER 2023 (q3a-OR) - 03 Marks (Kelvin-Planck & Clausius)
3. Explain the concept of entropy. / Define entropy.
 - WINTER 2022 (q4a) - 03 Marks
 - WINTER 2023 (q3b-OR) - 04 Marks
 - SUMMER 2025 (q4a) - 03 Marks
4. Explain in brief: Clausius inequality.
 - WINTER 2023 (q3a-OR) - 03 Marks
 - SUMMER 2025 (q3b) - 04 Marks
5. A heat engine operates between two reservoirs. What is its maximum efficiency?
 - SUMMER 2024 (q4a) - 03 Marks
 - WINTER 2022 (q4a-OR) - 03 Marks
 - WINTER 2024 (q3a-OR) - 03 Marks
6. Briefly explain the Third law of thermodynamics. / Write on the Third law.
 - SUMMER 2024 (q3a-OR) - 03 Marks
 - SUMMER 2025 (q1a) - 03 Marks
 - WINTER 2024 (q5b) - 04 Marks

Other Important Questions:

7. Calculate the change in entropy for an ideal gas for a given process.
 - WINTER 2022 (q4c) - 07 Marks (For const V, P, T processes)
 - SUMMER 2023 (q4a) - 03 Marks (For irreversible expansion)
8. Show that entropy is a state function.
 - WINTER 2024 (q5a-OR) - 03 Marks
9. Determine the minimum work required for a refrigeration process (e.g., freezing water).
 - SUMMER 2025 (q4c) - 07 Marks (Numerical)

Chapter 5: THERMODYNAMIC PROPERTIES OF FLUIDS

Repeated Questions:

1. **Derive/List all Maxwell's relations.**
 - WINTER 2022 (q4c) - 07 Marks
 - WINTER 2024 (q3b) - 04 Marks (Using mnemonic diagram)
2. **Using Maxwell's relations, prove a given thermodynamic relation.**
 - WINTER 2023 (q4a) - 03 Marks (Prove $dh = C_p dt + V(1-\beta t)dp$)
 - SUMMER 2025 (q4b) - 04 Marks (Prove ds relation)
3. **Explain residual properties.**
 - WINTER 2023 (q4b) - 04 Marks
4. **Derive the Clausius-Clapeyron equation from the Clapeyron equation. State assumptions.**
 - SUMMER 2023 (q4c-OR) - 07 Marks
 - WINTER 2024 (q3c) - 07 Marks
5. **Calculate a property change (e.g., melting point) using Clapeyron/Clausius-Clapeyron equation.**
 - WINTER 2023 (q4b-OR) - 04 Marks (Melting point of Hg at 10 bar)
 - SUMMER 2025 (q4b-OR) - 04 Marks (Same as above)
 - SUMMER 2023 (q4b) - 04 Marks (Vapour pressure of water)

Other Important Questions:

6. **Draw and explain the mnemonic diagram for thermodynamic property relations.**
 - SUMMER 2024 (q5a-OR) - 03 Marks
7. **Calculate U, H, S, G for a substance assuming ideal gas behavior with $C_p(T)$.**
 - WINTER 2023 (q4c) - 07 Marks (Numerical for N₂)
8. **Discuss different types of thermodynamic diagrams (H-T, H-S, P-H, T-S) and their applications.**
 - WINTER 2023 (q4c-OR) - 07 Marks
 - SUMMER 2023 (q4c-OR) - 07 Marks
 - SUMMER 2025 (q4a-OR) - 03 Marks (T-H diagram)

Chapter 6: THERMODYNAMICS OF FLOW PROCESSES

Repeated Questions:

1. **Derive the relation between area and velocity for isentropic flow in a nozzle. Prove that $da/du = (A/u)(M^2 - 1)$.**
 - WINTER 2023 (q5c) - 07 Marks
 - SUMMER 2025 (q4c-OR) - 07 Marks
2. **Derive the equation of continuity for a control volume.**
 - SUMMER 2023 (q5a) - 03 Marks
3. **For flow through a nozzle, calculate the temperature drop/velocity change.**
 - WINTER 2022 (q5a) - 03 Marks (Calculate temp drop for air in a nozzle)
 - SUMMER 2023 (q5c-OR) - 07 Marks (Theory: Max velocity is sonic velocity)

Other Important Questions:

- **Application of SFEE (Steady Flow Energy Equation) to various plant equipment** like turbines, compressors, pumps, heat exchangers, and nozzles. This is the fundamental concept underlying all flow processes and is implicitly tested in many numerical problems across papers (e.g., work calculations in compressors, enthalpy changes in heaters).
- **Analysis of isentropic efficiencies** for turbines and compressors.
- **Choked flow conditions** in nozzles.

Chapter 7: REFRIGERATION AND LIQUEFACTION

Repeated Questions:

1. Explain with a schematic diagram the working of a vapor compression refrigeration system.
 - WINTER 2022 (q5b) - 04 Marks
 - SUMMER 2023 (q5c) - 07 Marks
 - WINTER 2024 (q4c-OR) - 07 Marks
2. Explain with a schematic diagram the working of an absorption refrigeration system.
 - SUMMER 2024 (q4c-OR) - 07 Marks
 - WINTER 2022 (q5c) - 07 Marks
 - WINTER 2024 (q5c) - 07 Marks
 - SUMMER 2025 (q3b-OR) - 04 Marks (Neat sketch)
3. Explain the working principle of a heat pump.
 - SUMMER 2024 (q3b-OR) - 04 Marks
 - SUMMER 2024 (q5c) - 07 Marks
 - SUMMER 2023 (q5b) - 04 Marks
4. State various liquefaction processes and explain any one (Linde/Claude).
 - SUMMER 2024 (q4b) - 04 Marks
 - WINTER 2022 (q4b-OR) - 04 Marks
 - WINTER 2024 (q5c-OR) - 07 Marks
 - WINTER 2023 (q5a) - 03 Marks (Linde process)
 - WINTER 2023 (q5c-OR) - 07 Marks (Claude process)
5. Show that for multistage compression, minimum work requires that the inter-stage pressure is the geometric mean.
 - SUMMER 2024 (q4c) - 07 Marks (For 2-stage)
 - SUMMER 2024 (q5c-OR) - 07 Marks (For multistage)
 - WINTER 2024 (q5b-OR) - 04 Marks
 - SUMMER 2025 (q5b) - 04 Marks (Short note)
6. What are the desirable properties of a refrigerant? / List properties affecting the choice.
 - SUMMER 2024 (q5b) - 04 Marks
 - WINTER 2023 (q5a-OR) - 03 Marks
 - SUMMER 2023 (q5a-OR) - 03 Marks

Other Important Questions:

7. Explain the throttling process. / What is the Joule-Thomson effect?
 - WINTER 2023 (q5b) - 04 Marks
 - WINTER 2022 (q5a-OR) - 03 Marks
 - SUMMER 2025 (q5a) - 03 Marks
8. Derive the relation between area and velocity for isentropic flow in a nozzle.
 - WINTER 2023 (q5c) - 07 Marks
 - SUMMER 2025 (q4c-OR) - 07 Marks (Prove $da/du = (A/u)(M^2-1)$)
9. For an ideal gas undergoing an adiabatic process, prove that $PV^\gamma = \text{constant}$.
 - SUMMER 2025 (q5c) - 07 Marks
10. Discuss Carnot's principle/refrigerator with a P-V diagram.
 - SUMMER 2025 (q5b) - 04 Marks
 - WINTER 2023 (q5b-OR) - 04 Marks (Carnot refrigeration cycle)
11. Write a short note on ejectors.
 - SUMMER 2024 (q4a-OR) - 03 Marks
 - SUMMER 2023 (q5b) - 04 Marks