

GUJARAT TECHNOLOGICAL UNIVERSITY
BE-7 SEMESTER – OLD PAPER – S22 TO W25 – QUESTION BANK
Subject Name & Code: Principles of Combustion - 3171924

Chapter 1: Combustion and Thermochemistry

Repeated Questions:

1. Thermodynamics and Thermochemistry Basics:

- **Q.** List the main comparisons between sub and supersonic combustion thermodynamics. **(WINTER 2022, 3 Marks; WINTER 2025, 4 Marks)**
- **Q.** Explain heat of reaction and formation in brief. **(WINTER 2022, 4 Marks; WINTER 2025, 3 Marks – also includes "Stagnation pressure")**

2. Equivalence Ratio and Stoichiometry:

- **Q.** Define Equivalence Ratio. Prove that equivalence ratio is more meaningful than air-fuel ratio when comparing different fuels. **(SUMMER 2022, 7 Marks; WINTER 2024, 4 Marks – as part of a question)**
- **Q.** Explain stoichiometry. / Determine the stoichiometric equation for combustion of (a) Oxygen (b) Air. **(WINTER 2022, 4 Marks; WINTER 2024, 4 Marks; WINTER 2024, 4 Marks; WINTER 2025, 4 Marks)**

3. Adiabatic Flame Temperature:

- **Q.** Discuss the concept of Adiabatic Flame Temperature. / Write a short note on it. **(SUMMER 2022, 4 Marks; WINTER 2022, 4 Marks; WINTER 2024, 3 Marks; WINTER 2025, 4 Marks)**

Other Important Questions:

1. Standard State and Chemical Equilibrium:

- **Q.** What three conditions define the standard reference state? **(SUMMER 2022, 3 Marks)**
- **Q.** Describe the effect of increasing temperature and pressure on the equilibrium composition of combustion products. **(SUMMER 2022, 7 Marks)**
- **Q.** Explain water-gas equilibrium. **(SUMMER 2022, 4 Marks)**
- **Q.** Explain free energy and the equilibrium constants. **(From Syllabus)**

2. Flame Temperature and Thermodynamic Properties:

- **Q.** Explain flame temperature calculations – Analysis & Practical considerations. **(From Syllabus)**
- **Q.** Explain extensive and intensive properties with example. **(WINTER 2025, 4 Marks OR)**

Chapter 2: Chemical Kinetics

Repeated Questions:

1. Reaction Types and Mechanisms:

- **Q.** Discuss Global versus Elementary reactions. / Differentiate between Global and Elementary reaction. **(SUMMER 2022, 4 Marks; WINTER 2022, 7 Marks)**
- **Q.** Explain chain and chain branching reactions with suitable examples. **(SUMMER 2022, 7 Marks; WINTER 2022, 7 Marks)**

2. Reaction Rates and Their Temperature Dependence:

- **Q.** Explain Pseudo-first-order reactions and the “fall-off” range. **(WINTER 2022, 3 Marks; WINTER 2024, 7 Marks; WINTER 2025, 3 Marks; WINTER 2025, 3 Marks OR)**
- **Q.** Write a short note on Arrhenius rate expression. / Explain rates of reactions and their temperature dependence. **(WINTER 2024, 7 Marks; WINTER 2024, 7 Marks)**

Other Important Questions:

1. Collision and Rate Theories:

- **Q.** Explain Collision theory. **(SUMMER 2022, 3 Marks)**
- **Q.** Consider the reaction $\text{CH}_4 + \text{O}_2 \rightarrow \text{CH}_3 + \text{HO}_2 \dots$ List two factors important in determining whether or not a reaction occurs during a collision. **(SUMMER 2022, 7 Marks)**
- **Q.** Explain Transition state and recombination rate theories. **(From Syllabus)**

2. Equilibrium Assumptions and Reaction Systems:

- **Q.** Write a short note on partial equilibrium assumption. **(WINTER 2024, 7 Marks)**
- **Q.** Explain explosion limits for stoichiometric hydrogen-oxygen mixture. **(SUMMER 2022, 3 Marks)**
- **Q.** Explain simultaneous interdependent reactions. **(WINTER 2025, 4 Marks)**
- **Q.** Explain pressure effect in fractional conversion. **(From Syllabus)**

3. Large Reaction Mechanisms:

- **Q.** Explain rate of production analysis. **(WINTER 2025, 4 Marks OR)**
- **Q.** Explain chemical kinetics of large reaction mechanisms – Sensitivity analysis, Rate of production analysis. **(From Syllabus)**

Chapter 3: Chemical and Thermal Systems (Reactors)

Repeated Questions:

1. Reactor Types:

- Q. Explain Well Stirred flow reactor and derive expression for it. (**WINTER 2022, 7 Marks; WINTER 2024, 7 Marks**)
- Q. Explain constant volume reactor. / Explain constant volume-fixed mass reactor. (**SUMMER 2022, 4 Marks; WINTER 2022, 4 Marks**)
- Q. Explain Plug flow reactor. (**SUMMER 2022, 3 Marks; WINTER 2025, 7 Marks**)

2. Homogeneous and Heterogeneous Reactions:

- Q. Explain heterogeneous reactions. (**WINTER 2022, 3 Marks; WINTER 2024, 3 Marks; WINTER 2024, 3 Marks**)
- Q. Differentiate homogeneous and heterogeneous reaction with suitable example. (**SUMMER 2022, 4 Marks; WINTER 2024, 4 Marks**)

3. $\text{H}_2\text{--O}_2$ System:

- Q. Explain the $\text{H}_2\text{--O}_2$ system in details. (**SUMMER 2022, 7 Marks; WINTER 2022, 7 Marks; WINTER 2024, 7 Marks**)

Other Important Questions:

1. Reactor Models and Applications:

- Q. Explain constant pressure fixed mass reactor. (**From Syllabus**)
- Q. Enlist applications of combustion system modelling. (**WINTER 2025, 3 Marks OR**)

Chapter 4: Conservative Equations

Repeated Questions:

1. Conservation Laws:

- **Q.** Explain the fundamental one-dimensional conservation laws in details. (**SUMMER 2022, 7 Marks; WINTER 2022, 7 Marks; WINTER 2024, 7 Marks**)

2. Conserved Scalar and Mixture Fraction:

- **Q.** Explain and derive conserved scalar energy equation. / Define Mixture fraction and derive conserved scalar energy equation. (**SUMMER 2022, 7 Marks; WINTER 2022, 7 Marks**)
- **Q.** Explain Mixture fraction in brief. / Explain conserved scalar concept in short. (**WINTER 2022, 3 Marks; WINTER 2024, 3 Marks; WINTER 2024, 4 Marks; WINTER 2025, 3 Marks OR; WINTER 2025, 4 Marks OR**)

Other Important Questions:

1. Mass, Momentum and Energy Conservation:

- **Q.** Explain species mass conservation. (**WINTER 2022, 4 Marks**)
- **Q.** Derive equation for mass conservation. (**WINTER 2025, 7 Marks OR**)
- **Q.** Explain momentum conservation. (**From Syllabus**)
- **Q.** Explain energy conservation. (**From Syllabus**)

2. Multicomponent Diffusion:

- **Q.** Explain multicomponent diffusion. (**From Syllabus**)

Chapter 5: Laminar Flames

Repeated Questions:

1. Laminar Flame Characteristics:

- **Q.** Explain various factors influencing flame velocity and thickness for laminar flames. **(SUMMER 2022, 7 Marks; WINTER 2022, 7 Marks; WINTER 2025, 7 Marks OR)**
- **Q.** Enlist various factors affecting the flame length. / Define flame length. Enlist various factors affecting it. **(SUMMER 2022, 3 Marks; WINTER 2022, 3 Marks; WINTER 2024, 3 Marks; WINTER 2025, 4 Marks)**
- **Q.** Explain laminar flame structure with figure. / Explain the laminar flame structure – temperature and heat release rate profiles. [Diagram required – refer to the original question paper] **(SUMMER 2022, 4 Marks; WINTER 2024, 7 Marks)**

2. Flame Stabilization and Counter Flow Flames:

- **Q.** Explain flame stabilization. Enlist various methods for flame stabilization. **(SUMMER 2022, 3 Marks; WINTER 2022, 4 Marks; WINTER 2025, 3 Marks)**
- **Q.** Explain counter flow flames in details. **(WINTER 2022, 4 Marks; WINTER 2024, 4 Marks; WINTER 2025, 7 Marks)**

3. Soot Formation:

- **Q.** Explain Soot Formation. **(SUMMER 2022, 3 Marks; WINTER 2022, 3 Marks; WINTER 2024, 3 Marks; WINTER 2025, 7 Marks – includes "and destruction")**

Other Important Questions:

1. Premixed and Diffusion Flames:

- **Q.** Explain Laminar Premixed Flames – Physical Description, Simplified Analysis, Detailed analysis. **(From Syllabus)**
- **Q.** Differentiate between laminar premixed flames and laminar diffusion flames. **(WINTER 2025, 7 Marks OR)**
- **Q.** Explain Laminar Diffusion Flames – non reacting constant density laminar jet. **(From Syllabus)**
- **Q.** Explain non reacting constant density laminar jet with neat sketch. [Diagram required – refer to the original question paper] **(WINTER 2025, 3 Marks)**

2. Pollutant Formation:

- **Q.** Write a short note on oxides of nitrogen formation. **(SUMMER 2022, 4 Marks)**
- **Q.** Explain Soot destruction. **(From Syllabus)**

Chapter 6: Turbulent Flames and Related Topics

Repeated Questions:

1. Turbulent Premixed Flames:

- Q. List any three/four applications of turbulent flames. (WINTER 2022, 3 Marks; WINTER 2024, 4 Marks; WINTER 2025, 3 Marks)
- Q. Explain the structure of Turbulent Premixed Flames. (SUMMER 2022, 3 Marks; WINTER 2022, 4 Marks; WINTER 2025, 7 Marks)
- Q. Explain wrinkled laminar flame regime with neat sketch. [Diagram required – refer to the original question paper] (SUMMER 2022, 4 Marks; WINTER 2022, 7 Marks; WINTER 2024, 4 Marks; WINTER 2024, 7 Marks; WINTER 2025, 7 Marks OR)

2. Jet Flames:

- Q. Explain Jet Flames in brief. / Explain jet flames in short. (WINTER 2022, 3 Marks; WINTER 2024, 3 Marks; WINTER 2025, 7 Marks)

3. Droplet and Spray Evaporation:

- Q. Explain Simple Model of Droplet Evaporation with all assumptions. / Write a short note on droplet and spray evaporation. (SUMMER 2022, 7 Marks; WINTER 2022, 7 Marks)

Other Important Questions:

1. Turbulent Flame Characteristics:

- Q. Define turbulent flame speed. (SUMMER 2022, 3 Marks)
- Q. What are the objectives of turbulent diffusion flame analysis? (WINTER 2024, 4 Marks)

2. Solid Fuel Combustion:

- Q. Explain the burning of carbon with chemical equations. (WINTER 2024, 3 Marks)
