Haldia Institute of Technology

Department of Food Technology

COURSE INFORMATION

**Course Code: FT-301**

**Course Name: Thermodynamics and Kinetics**

**Contacts: 4 h (3L + 1T)**

**Credits: 4**

COURSE OUTCOME **At the end of this course, the incumbent will be able to:**

FT301.1 Ability to understand the **basics and meanings** of thermodynamics and kinetics.

FT301.2 Ability to **understand and introduce the laws of thermodynamics**, their implications, and become familiar with their use and applications.

FT301.3 Ability to **predict intermolecular potential and excess property behavior** of multi component systems and ability to determine rate constant of different reactions.

FT301.4 Ability to **understand physical transformations** in pure materials as well as the properties of pure mixtures.

EI 501.5Ability to **design and develop solutions** for practical engineering problems related to different cycles, refrigeration systems and system components.

FT301.6 Ability to **apply the knowledge of thermodynamics** for coming semester subjects (eg. Food Process Engineering etc.) **and kinetics** (eg. Enzyme technology etc.), so that it can help to understand those subjects very effectively.

PREREQUISITES

**To understand this course, the incumbentmust have idea of:**

* Elementary chemistry, physics, thermodynamics.
* Basic calculus.

SYLLABI

**Module I: 10L**

Basic Concepts of Thermodynamics: The Ideal Gas, Review of first and second laws of thermodynamics, PVTbehaviour of Pure Substances, Virial Equation of State,, Application of the Virial Equations, Cubic Equations ofState, Generalized Correlations for Gases and Liquids. The Nature of Equilibrium, the Phase Rule, Duhem’sTheorem.

**Module II: 10L**

Simple model’s for vapour/liquid Equilibrium, Raoult’s Law, Henry’s law, Modified Raoult’s Law,

Vapour Liquid Equilibrium, K-value correlations; VLE from Cubic Equations of State; Equilibrium and Stability; Liquid/liquid equilibrium; Solid/liquid equilibrium, Solid/vapour equilibrium.

**Module III: 10L**

Thermodynamics and its Applications: The Chemical Potential and Phase Equilibria Fugacity and

FugacityCoefficient: for pure species and solution; generalised correlations for Fugacity, the Ideal

Solution, PropertyChanges and Heat Effects of Mixing Processes. The Vapour-Compression Cycle, the Choice of Refrigerant, Absorption, Refrigeration and liquefaction: Low temperature cycle: Linde and Claude.

**Module IV: 10L**

Kinetics: Rate of chemical reaction; Effect of Temperature on Rate Constant, Arrehnius equation,

Collision Theory,Transition State Theory, Order and Molecularity of a Chemical reaction,

Elementary Reactions, First, Second andthird order reactions, Non Elementary Reactions, Pseudo-

first order reaction, Determination of rate constant andorder of reaction, Half-life method, Fractional order reactions.

Revision: 5L

LECTURE PLAN

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| **LectureNo.** | **Details of coverage** | **Handout, Lecture Notes, Links etc.** |
| 1 | Introduction on thermodynamics. Some basic concepts. | [Lecture Note1](Lecture%20Note.pdf) |
| 2 | Basic Concepts of Thermodynamics, ideal gas law. | Physical Chemistry by K.L.Kapoor |
| 3 | Review of first and second laws of Thermodynamics, few general derivations. | -----Do-----, Physical chemistry by Atkins |
| 4 | Gibbs free energy, Helmholtz free energy. Relation between them. Spontaneity. | -----Do----- |
| 5 | Definition, Derivation, Gibbs-Duhem equations.  | -----Do----- |
| **6** | Chemical potential of two phases. Definitions, Derivations of all.  | -----Do-----,  |
| **7** | Criteria of ideal solution. Derivation of ΔS, ΔG, ΔH and ΔV for mix. Fugacity of ideal gas mixture. | -----Do----- |  |
| **8** | Derivation of ΔH and ΔV for mix. Fugacity of ideal gas mixture. | -----Do-----, Smith & Vanness, Thermodynamics for Chemical Engineers, MGH |
| **9** | Partial molar properties. Some derivations. | -----Do----- |
| 10 | Definition, derivations / expressions. Numerical problems.  | -----Do----- |
| 11 | Describe VLE. For VLE, fugacity and fugacity coefficient.  | Smith & Vanness, Thermodynamics for Chemical Engineers, MGH |
| 12 | Fugacity for pure species.  | -----Do-----, Physical chemistry by Atkins |
| 13 | Simple models for VLE: Modified Raoult’s law. Mathematical expression. Application. | -----Do----- |
| 14 | K-value co-relations: Description, mathematical expression. Derivations.  | -----Do----- |
| 15 | Binary component: boiling condition. Numerical problems. | -----Do----- |
| 16 | VLE from cubic equation of state: | -----Do----- |
| 17 | EOS, cubic EOS (for Vander waals), critical, reduced equation of state for Vander waals equation.  | -----Do----- |
| 18 | Z and V value for both vapour and liquid phases. | -----Do----- |
| 19 | Modification of **a** and **b** value from Vander waals’ equation. | -----Do----- |
| 20 | LLE: Few LL solutions. LLE condition in terms of fugacity, activity and activity coefficient. The application of LLE. Distribution coefficient. | -----Do----- |
| 21 | SLE: Introduction. Relation between μ and T. Stability criteria of SLE.  | -----Do----- |
| 22 | SLE: Relation between entropy, latent heat of fusion and melting / freezing point. The stability criteria. | -----Do----- |
| 23 | SVE: Introduction. Triple point curve. The condition and stability of SVE. | -----Do----- |
| 24 | Refrigeration: Introduction. Capacity of refrigeration. COP. Numerical problem (s). | Engineering Thermodynamics by P.K.Nag |
| 25 | Vapour Compression Cycle: Simple VC cycle. T-S diagram.  | -----Do----- |
| 26 | P-H diagram. Description. Numerical problems on refrigerant flow rate, power requirement. | -----Do----- |
| 27 | Selection criteria of ideal refrigerant. J-T effect. | -----Do----- |
| 28 | Absorption refrigeration system. Schematic diagram. Description.  | -----Do----- |
| 29 | Liquefaction: Definition. Introduction. Linde liquefaction process: diagram, description, fractionation of gas liquefied. | -----Do----- |
| 30 | Liquefaction: Claude liquefaction process: diagram, description, fractionation of gas liquefied. | -----Do----- |
| 31 | Equilibrium and stability criteria. Some derivations. | -----Do----- |
| 32 | Pure substance (s). PVT behaviour. | -----Do----- |
| 33 | Describe, derive and usefulness of Virial equation of state. | Physical chemistry by P.C. Rakshit. |
| 34 | Kinetics: Introduction. Definition, rate. | -----Do----- |
| 35 | Elementary and non-elementary reactions, order, molecularity. Examples. | -----Do----- |
| 36 | First order kinetics. Rate constant, numerical problem (s). | -----Do----- |
| 37 | Second order kinetics. Rate constant, numerical problem (s). | -----Do----- |
| 38 | Third order kinetics. Rate constant, numerical problem (s). | -----Do----- |
| 39 | Numerical problems. | -----Do----- |
| 40 | Pseudo-first order reaction. Definition. Examples.  | -----Do----- |
| 41 | Order of reactions. Numerical problems. | -----Do----- |
| 42 | Determination of half-value method. Numerical problem. | -----Do----- |
| 43 | Differential method.  | -----Do----- |
| 44 | Fractional order of reactions. | -----Do----- |
| 45 | Effect of temperature on the reaction rate constant. Derivation of Arrhenius law and hence equation. | Physical chemistry by Atkins |
| 46 | Calculation of Activation energy and frequency factor from Arrhenius equation. | -----Do----- |
| 47 | Theory of chemical reactions: Transition state theory.  | -----Do----- |
| 48 | Theory of chemical reactions: Collision theory. | -----Do----- |
| 49 | Revision on Thermodynamics. | From previous years Semester Question papers. |
| 50 | Revision on kinetics. | -----Do----- |
| \*Minimum 36 lectures for 3 contact courses and 48 lectures for 4 contact courses |

RECOMMENDED READINGS

**TEXT**

Smith & Vanness, Thermodynamics for Chemical Engineers, MGH

**REFERENCES**

1. Physical Chemistry by K.L.Kapoor

2. Physical chemistry by Atkins

3. Physical chemistry by P.C. Rakshit.

4. Engineering Thermodynamics by P.K.Nag