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42

2011

CHEMICAL ENGINEERING

FIRST PAPER

Full Marks : 200

Time : 3 hours

*The figures in the margin indicate full marks
for the questions*

Answer any **five** questions

1. (a) Explain the experimental method followed by Joule to prove the equivalence of heat and work. How are these two entities related in SI units, used in our day-to-day calculations? 8
- (b) What are the differences between heat capacity and specific heat? For an ideal gas, show that $C_p - C_v = R$. 8
- (c) How do you define 'compressibility factor'? Explain the significance and applications of 'compressibility chart' with a suitable example. 8
- (d) What are the thermodynamic functions directly derived from the second law of thermodynamics? Define each function very briefly. 8

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(Turn Over)

(e) Prove that

$$\left(\frac{\partial E}{\partial V}\right)_T = T \cdot \left(\frac{\partial P}{\partial T}\right)_V - p$$

8

2. (a) Describe in brief the steps involved in hydrogenation of oils. Why this process holds a great importance in a country like India? 10
- (b) What are the different sources of 'cellulose' used for manufacture of paper in India? Describe in brief the bleaching process widely adopted in the paper mills of our region. 10
- (c) Starting from molasses, extensively produced as a by-product of sugar industry, how would you manufacture ethanol? What is the type of fermentation involved in this process? 10
- (d) What do you mean by LDPE? Describe the manufacturing process of LDPE with respect to—
- (i) the raw materials used;
 - (ii) the chemical reactions involved;
 - (iii) the operating conditions necessary. 10

3. (a) What do you mean by an autocatalytic reaction? Show that

$$\ln \frac{M + X_A}{M(1 - X_A)} = C_{AO} \cdot (M + 1)k \cdot t = (C_{AO} + C_{RO})k \cdot t$$

where $M = C_{RO} / C_{AO}$

C_{AO} = initial concentration of reactant (A)

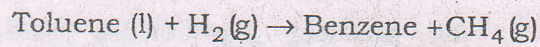
C_{RO} = initial concentration of product (R)

k = autocatalytic reaction rate constant

5+10=15

- (b) Derive an expression for the performance of a batch reactor. List out the advantages and disadvantages of a batch reactor. 10

- (c) A reaction is given as follows :



Propose a suitable mechanism for this reaction and derive the rate law.

Consider the surface reaction to be the rate limiting step. 15

4. (a) What do you mean by terminal velocity? Derive an expression for terminal velocity of a spherical particle falling through a fluid under gravity. 15

(b) If you are given a sample mixture of various particles, how would you determine the total surface area and the number of particles in the sample by adopting experimental methods? 15

(c) What is fluidization? Explain the basic principle of this process and mention the major applications of it in industry. 10

5. What are the essential differences between—

(a) free settling and hindered settling;

(b) light distillates and medium distillates of petroleum;

(c) thermosets and thermoplastics;

(d) phenol-formaldehyde and urea-formaldehyde resins;

(e) physical equilibrium and chemical equilibrium? 8×5=40

6. (a) Why do we go for vacuum distillation of petroleum after atmospheric distillation; as found in many refineries? How is the vacuum created in the distillation column? 10

(b) What are the different feed stocks used for production of petrochemicals? Discuss the refining and petrochemicals scenario of Assam vis-à-vis India. 10

(5)

- (c) Why do we use pipe still heater? Mention the different steps in designing a pipe still heater and explain briefly. 10
- (d) What is cracking? How many types of cracking do you know about, being used in refineries and petrochemical complexes? Give examples of each type. 10

7. Write short notes on any *five* of the following : 8×5=40

- (a) Working principle of a cyclone separator
- (b) Relationship between Cetane Number and Diesel Index
- (c) By-products of sugar industry
- (d) Definition of soaps and detergents, with the differences between both
- (e) Characteristics of a plug flow reactor
- (f) Virial equations of state
- (g) Rittinger's law and its application
- (h) Uses of polyvinyl chloride
