UPSC - INDIAN FOREST SERVICE - 2014

C–HENT–N–BNDOB

CHEMICAL ENGINEERING

Paper—II

Time Allowed : Three Hours | *Maximum Marks : 200*

QUESTION PAPER SPECIFIC INSTRUCTIONS

Please read each of the following instructions carefully before attempting questions :

There are **EIGHT** questions in all, out of which **FIVE** are to be attempted.

Question nos. **1** and **5** are compulsory. Out of the remaining **SIX** questions, **THREE** are to be attempted selecting at least **ONE** question from each of the two Sections A and B.

Attempts of questions shall be counted in chronological order. Unless struck off, attempt of a question shall be counted even if attempted partly. Any page or portion of the page left blank in the Answer Book must be clearly struck off.

All questions carry equal marks. The number of marks carried by a question/part is indicated against it.

Answers must be written in **ENGLISH** only.

Unless otherwise mentioned, symbols and notations have their usual standard meanings.

Assume suitable data, if necessary and indicate the same clearly.

Neat sketches may be drawn, wherever required.

SECTION—A

Q. 1. **Answer the following in about 150 words each :** **5×8=40**

Q. 1(a) Distinguish clearly between batch reactor, plug flow reactor and continuous flow stirred tank reactor. 5

Q. 1(b) Distinguish between ideal and non-ideal flow reactors. 5

Q. 1(c) Compare and contrast between State functions and Path functions. 5

Q. 1(d) Write a note on — First and Second law of thermodynamics. 5

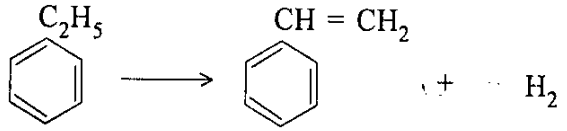
Q. 1(e) State Henry's law and outline its significance. 5

Q. 1(f) Write briefly about — Concept of Reduced Equation of State and its significance. 5

Q. 1(g) Explain about micrometeorology and dispersion of pollutants in environment. 5

Q. 1(h) Distinguish between Space time, Holding time and Mean residence time. 5

Q. 2(a) The free energy change under standard conditions for reaction cited below :



Ethyl Benzene Styrene Hydrogen

is given by following equation :

$\Delta G^\circ = 29{,}720 - 31.10\ [T]$ where T is in °K, and ΔG° is in cal/g.mole. For the calculation equilibrium constant for chemical reaction equilibria (K), the std. equation $\Delta G^\circ = -RT\ ln\ K$ can be utilised.

Calculate the value of equilibrium conversion (x_e) for the above reaction where styrene is being formed under conditions of T = 800°K and P = 1 atm. 20

Q. 2(b) Draw P-x-y diagram for an ideal binary system. Explain stepwise procedure for calculation of x-y data for an ideal binary system. 20

Q. 3(a) Acetic anhydride is hydrolysed in a CSTR wherein water is used in excess and reaction follows pseudo first-order kinetics. The concentration of acetic anhydride at the start is 0.4 g.mole/litre. Feed rate to reactor is 28 litres/min and can be assumed as constant. The reaction rate constant is 0.4 min^{-1} at the temperature at which reactor operates. Calculate the volume of CSTR to achieve 65% conversion. 20

Q. 3(b) For the reaction $A \xrightarrow{k_1} R \xrightarrow{k_2} S$ taking place in a batch reactor with rate constants k_1 and k_2 for the two reactions obeying first-order kinetics, derive an expression for time (θ) at which the concentration of R is maximum and also determine the maximum concentration of R that can be attained at this time (θ). 20

Q. 4(a) Explain the following terms with appropriate illustrations :

(i) Limiting reactant

(ii) Excess reactant

(iii) Recycle and by pass. 10

Q. 4(b) Two streams of effluent are mixed before disposal. One stream contains 8.05% of a soluble salt while other stream contains no salt. The combined stream is found to contain 0.45% of the soluble salt. In what ratio, the two streams are mixed ? 15

Q. 4(c) Natural gas containing 95% Methane and 5% Hydrogen by volume is burnt in a furnace with 15% excess air. How much air at 298°K and 101.3 KPa is required if the fuel consumption is 10 M^3/s measured at 298°K and 101.3 KPa ? 15

SECTION—B

Q. 5. **Answer the following in about 150 words each :** **5×8=40**

Q. 5(a) Write a brief note on "Ozone Layer Depletion". 5

Q. 5(b) Elaborate on "Sources of Pollutants in Water". 5

Q. 5(c) Write briefly about "Solid Waste Disposal Techniques". 5

Q. 5(d) Discuss about — Project Scheduling — PERT and CPM approach. 5

Q. 5(e) Write a short note on Net present value by discounted cash flow. 5

Q. 5(f) Outline use of Unit Process — Fermentation in production of antibiotics. 5

Q. 5(g) Distinguish between Catalytic Cracking and Thermal Cracking of Petroleum fractions. 5

Q. 5(h) Discuss about wood and wood based chemicals. 5

Q. 6(a) Explain various steps involved in manufacture of sugar with neat flow sheet. 20

Q. 6(b) Discuss manufacturing of various petroleum products obtained by carrying out atmospheric distillation of crude oil. Also give a neat flow sheet diagram for atmospheric distillation tower and various product cuts. 20

Q. 7. **Answer the following :**

Q. 7(a) Give a critical overview of coal based chemicals. Highlight manufacturing of any coal based chemical with a neat flow sheet. 15

Q. 7(b) Describe the manufacturing of power alcohol from renewable sources by fermentation process with a neat flow sheet. 15

Q. 7(c) Discuss briefly the important Environmental legislations enacted in India covering Air, Water and Environment. 10

Q. 8(a) Analyse critically various factors affecting investment and production costs. Discuss briefly about — "Break-even point analysis". 15

Q. 8(b) Write critically on various aspects related to "Plant location and Plant layout". 15

Q. 8(c) Write about HAZOP and HAZAN with appropriate examples. 10