Indian Forest Service Examinat: 2013

A-JGPT-M-DIFOM-B

CHEMICAL ENGINEERING

PAPER—II

(CONVENTIONAL)

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 Question-cum-Answer Booklet 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

1. Write on/Answer the following briefly :   5×8=40

   (a) Principle of corresponding states, and its use   5

   (b) van der Waals' equation of state, and its application   5

   (c) What are basic and derived units?   5

   (d) Reversible and irreversible expansion of a gas   5

   (e) Write Maxwell's relations.   5

   (f) What is a limiting reactant and an excess reactant?   5

   (g) A gas mixture contains 20% CO by volume. If the total pressure is 1·6 atm,
        determine the partial pressure of CO.   5

   (h) State Henry's law and indicate its application.   5

2. (a) Waste acid from a nitrating process contains 25% HNO_3, 55% H_2SO_4 and
        20% H_2O by weight. This is to be concentrated to get fortified acid containing
        27% HNO_3, 60% H_2SO_4 and 13% H_2O. This is done by adding concentrated
        H_2SO_4 of 93% strength and concentrated HNO_3 of 90% strength in suitable
        quantities to the waste acid. If 1000 kg of fortified acid is to be produced,
        calculate the amount of various solutions mixed.   15

   (b) A gaseous mixture contains ethylene = 30·6%, benzene = 24·5%, ethane = 25%,
        methane = 15·5%, N_2 = 3·1% and O_2 = 1·3% by volume basis. Estimate the
        composition in weight % and mole %.   15

   (c) Hydrogen is formed by steam cracking of methane according to the reaction

        $$CH_4(g) + 2H_2O(g) \rightarrow CO_2(g) + 4H_2(g)$$

        A reaction mixture containing stoichiometric quantities of pure reactants is
        fed to the reactor. The reaction occurs at 600 °C and 101·32 kPa, where
        equilibrium constant is found to be 6·0. Find the percentage conversion of
        methane to hydrogen.   10

3. (a) What is the second law of thermodynamics? Discuss its significance.   10

   (b) Prove the following :   10

        (i) $C_p - C_v = R$ for an ideal gas

        (ii) $\left(\dfrac{\partial H}{\partial P} \right)_T = 0$ for an ideal gas

(c) Discuss the following :   5×4=20

    (i) Thermodynamic properties and their estimation   5

    (ii) Fugacity and fugacity coefficient   5

    (iii) Carnot heat engine cycle and its application   5

    (iv) Multistage compression and its significance   5

4. (a) Explain the integral method of analysis for finding the rate of reaction.   10

    (b) Describe various types of flow reactors.   10

    (c) For the series reaction $A \to R \to S$ taking place in a batch reactor with rate constants k_1 and k_2 for the two reactions, determine the time at which the concentration of R is maximum and also determine the maximum concentration of R that can be attained at this time.   20

SECTION—B

5. Answer **all** the following briefly :   5×8=40

    (a) Differentiate the present worth of an equipment from its market value.   5

    (b) Explain sinking fund method.   5

    (c) Explain photochemical smog.   5

    (d) Explain greenhouse effect.   5

    (e) Explain toxicity and its role in determining the limits of pollutants.   5

    (f) Explain deaeration. Where is it applied?   5

    (g) Explain ozone depletion.   5

    (h) Explain how fermentation is useful in production of antibiotics.   5

6. (a) Explain how paper is manufactured from bamboo wood. Discuss the key parameters like by-products and pollutants generated during the manufacturing process.   20

    (b) Describe the manufacture of Portland cement highlighting the salient points.   20

7. (a) Explain the necessity of analysis of pollutants. Classify the pollutants in industrial wastewater streams. Highlight the limits of pollutants in treated wastewater before its disposal.   20

    (b) Explain Bhopal gas disaster. What were its ill effects? How can disaster management be useful in such cases?   20

8. *(a)* How are fixed and working capital requirements estimated? Explain various methods of calculating depreciation. 20

   (b) The total capital for a chemical plant is estimated as ₹ 12·5 crore, which produces one crore kg of the product annually, selling at an average price of ₹ 11,000 (eleven thousand) per 1000 kg. The annual fixed charges are estimated to be ₹ 2·0 crore, distribution cost to be 4% of total cost of manufacturing. Input costs per 1000 kg of product are estimated to be— raw materials : ₹ 3,000; labour : ₹ 1,500; utilities : ₹ 750; packaging : ₹ 250.

   Estimate the total cost of manufacturing per year and gross profit per kg of product. 20

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