वियोज्य *DETACHABLE*

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 sequential 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.(a) Differentiate between promoter, inhibitor and accelerator for a chemical reaction. 8

1.(b) Derive Maxwell's relation and state their importance. 8

1.(c) Explain Henry's law and show that Raoult's law is a special case of Henry's law. 8

1.(d) What is the effect of pressure on equilibrium conversion of a gas-phase chemical reaction ? 8

1.(e) State 'yield' and 'selectivity' of a process. 8

2.(a) Discuss the following with suitable examples : 20

(i) Limiting and excess reactant

(ii) Recycle and bypass ratio

(iii) Bypass and purge streams

(iv) Trouton's rule and Kistiakowsky equation

2.(b) An ideal gas ($C_P = 5$ kcal/kmol-°C, $C_V = 3$ kcal/kmol-°C) is changed from 1 atm and 22·4 m^3 to 10 atm and 2·24 m^3 by the following reversible processes :

(i) isothermal compression

(ii) adiabatic compression followed by cooling at constant volume

(iii) heating at constant volume followed by cooling at constant pressure

Calculate the heat interaction, work-done, change in internal energy and change in enthalpy of the overall process in each case. 20

3.(a) A mixture of 1 mol of sulphur dioxide gas, 0·5 mol of oxygen gas and 2 moles of argon gas are fed into a reactor at 30 bar and 900 K to produce sulphur trioxide gas. The equilibrium constant for the reaction is 6. Calculate the degree of conversion and equilibrium composition of the reaction mixture assuming that the mixture behaves like an ideal gas. 15

3.(b) Derive an expression for the design equation of a CSTR. 15

3.(c) Bring out the criteria for vapour-liquid equilibria. 10

4.(a) The gas phase reaction $A + B \rightarrow C + D + E$ is carried out in a CSTR by introducing a feed stream containing 5 kmol/m^3 of B. The reactor volume is 25 m^3 and the rate constant is 0·0001 m^3/kmol.s at the condition of temperature and pressure in the reactor. Calculate the volumetric flow rate, space time and reaction holding time for 60% conversion of the reactants. 15

4.(b) Discuss and bring out the significance of the terms – Fugacity, Activity and Chemical Potential. 15

4.(c) A binary liquid mixture consists of 60 mol per cent ethylene and 40 mol per cent propylene. At 423 K, the vapour pressure of ethylene and propylene are 15·2 atm and 9·8 atm respectively. Calculate the total pressure and equilibrium composition of the vapour phase. Assume that the mixture behaves like an ideal solution. 10

SECTION 'B'

5.(a) Justify – 'Creation and destruction of ozone are well-balanced in nature, but still ozone layer is being depleted'. 8

5.(b) Write an informatory note on 'Break-even point analysis'. 8

5.(c) What is adiabatic lapse rate ? How does it affect the dispersion of pollutants ? 8

5.(d) Enumerate the factors that influence the location and economy of a commercial plant. 8

5.(e) Compare and contrast between enzymatic and microbial fermentation. 8

6.(a) Elucidate the methodology of biodiesel production employing heterogeneous transesterification of a second generation non-edible oil. 15

6.(b) Explain with neat sketch the working principle of an electrostatic precipitator. 15

6.(c) A piece of equipment having negligible salvage and scrap value is estimated to have a service life of 10 years. The original cost of the equipment was Rs. 50,000. Determine the following :

(i) the depreciation charge for the 5th year if sum-of-the-years-digits depreciation is used.

(ii) the depreciation charge for the 5th year if straight line method is used.

(iii) the % of the original investment paid off in the first half of the service life using the sum-of-the-years-digits method. 10

7.(a) Explain with flow diagram the manufacturing of Portland cement by wet process and discuss the chemical reactions associated with the process. 15

7.(b) Illustrate the terms 'discounted cash flow' and 'project scheduling' with suitable example. 15

7.(c) Emphasize with logical diagram on the term 'HAZOP' that provides a balance between operability problems and hazards identified. 10

8.(a) Elucidate the safety measures to be taken into account in the ammonia manufacturing plant. 15

8.(b) Discuss the different processes of dispersion of starch into LDPE for enhancing the mechanical properties of produced polymer film. 15

8.(c) Give an account of various mathematical methods for profitability evaluation considering the advantages and disadvantages concerned with them. 10