

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.

Questions no. 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

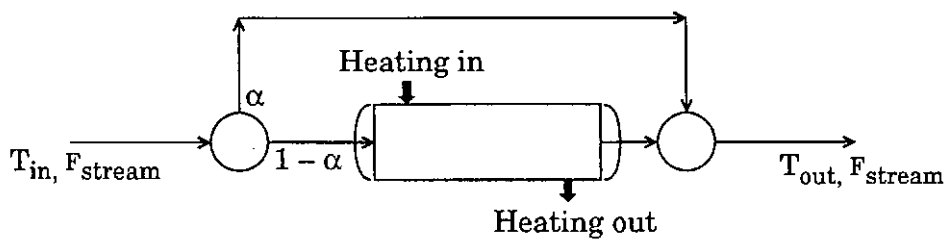
Q1. Answer each of the following questions :

5×8=40

- (a) Explain the merits and demerits of oxycombustion versus regular combustion of fuels. 5
- (b) Give one example each of bypass, recycle and purge in a chemical flow reacting system, and explain their importance. 5
- (c) What is meant by fuel NO_x and thermal NO_x ? How are they minimized ? 5
- (d) Explain the importance of Le Chatelier's principle with an example. 5
- (e) Write the Vapour Liquid equilibrium equation for a system having non-ideality only in the gas phase. 5

- (f) Explain the term Coefficient of Performance (COP) in refrigeration systems. 5
- (g) Explain the main difference between plug flow reactor and continuous stirred tank reactor. 5
- (h) When are semi-batch reactors preferred over batch reactors? 5

Q2. (a) A heat exchanger is used to heat up a process stream. The configuration has a bypass of the process stream as shown below :



The mass flow rate of the process stream is F_{stream} and gets split with a fraction α as bypass. Given that the process stream has a specific heat of C_p and a fixed amount of heat Q is delivered by the heating medium, estimate the outlet temperature of the process stream as a function of α . 20

- (b) What are the desirable properties of a refrigerant that are typically used in a refrigeration cycle? 10
- (c) What is a Horton sphere? What is it used for and why? 10

- Q3.** (a) Using an example, explain what is reactive distillation. What are the requirements for reactive distillation to be feasible? 10
- (b) A spherical coal particle with 40% ash (uniformly distributed) is to be burnt. Describe the phenomena in the following two cases : 20
- (i) Combustion is controlled by diffusion of oxygen in the surrounding air.
- (ii) Combustion is controlled by diffusion of oxygen in the ash layer.
- (c) A binary vapour mixture of benzene and toluene containing x mole fraction of benzene is cooled at constant pressure P . Outline the method to estimate the dew point of the mixture and the liquid phase composition. 10

- Q4. (a) Explain the term chemical potential and its use. 10
- (b) How is power generated in a thermal power plant ? Explain with a neat diagram(s). 15
- (c) Two waste streams, the first containing 100 m^3 per hour of 0.1 N HCl , and the second containing 200 m^3 per hour of 1 N HNO_3 , are charged into a neutralization pit having volume 1000 m^3 . Estimate the flow rate of 1 N base that would be needed to enable acceptable discharge from the neutralization pit. 15

SECTION B

- Q5. Answer each of the following questions :** **5×8=40**
- (a) Explain why and when biomass gasification would be preferred over combustion. 5
 - (b) What are the major solid wastes from forests ? How would you use or dispose them ? 5
 - (c) Explain the molecular level aspects that provide cleansing action in soaps and detergents. 5
 - (d) Explain what is meant by Global Warming Potential (GWP). Arrange the following in increasing order of their GWP :
Steam, Methane, CO₂. 5
 - (e) What is flyash ? What are its sources and what is its environmental impact ? 5
 - (f) Explain the factors that influence optimal design of waste heat recovery systems. 5
 - (g) What are the important sinks of CO₂ ? Explain the role of forests as sources/sinks of CO₂. 5
 - (h) What is steam reforming of methane ? What is it used for ? 5
- Q6.**
- (a) Explain the process of cement production with a neatly labelled diagram. 15
 - (b) Explain what is meant by first generation biofuels. What are the drawbacks of these fuels ? 10
 - (c) Write a brief note on PERT/CPM. 15
- Q7.**
- (a) Explain the process of producing ethylene using a neatly labelled flow diagram. 15
 - (b) Describe the process of production of bio-diesel via trans-esterification of fatty acids/oils. 15
 - (c) Outline the different methods of asset depreciation and analyze their impact on determining the profitability and payback. 10
- Q8.**
- (a) Explain the steps in the production of ammonia from the Haber Process using a neatly labelled flow diagram. 15
 - (b) Describe two methods of air pollution control. Compare the treatment methods. 15
 - (c) Explain the discounted cash flow method for assessing the profitability of a project. 10