

mfs

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ATi

2007

CHEMICAL ENGINEERING (Optional)

000064

रासायनिक अभियांत्रिकी (वैकल्पिक)

Time : 3 hours

Maximum Marks : 200

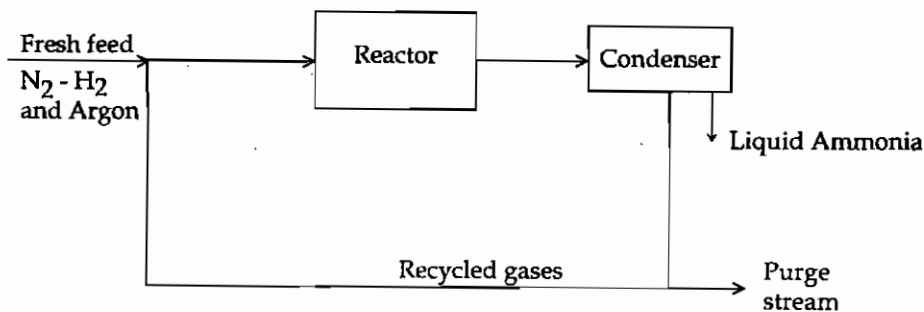
- Note :
- In all attempt Five questions.
 - Question No. 1 is compulsory.
 - Of the remaining Questions. Attempt Any four by selecting One Question from each section.
 - Numbers of optional questions upto the prescribed number in the order in which questions have been solved, will only be assessed and excess answers of the question/s will not be assessed.
 - Additional data is provided at the end of the question paper.
 - Candidate should not write roll number, any names (including their own), signature, address or any indication of their identity anywhere inside the answer book otherwise he will be penalised.

- Describe Ergun equation for flow through packed beds and explain the significance of the terms in the equation. 8
 - Describe how the concentration - time data obtained from a batch homogeneous reactor can be analysed and employed to design a plug flow reactor and a continuous stirred tank reactor. 8
 - A product stream 1000 kg/hr is cooled from 110°C to 40°C by cooling water available at 30° C. The temperature rise in the cooling water is 6°C. Which flow pattern will you recommend and why ? (co-current or counter-current) 8
 - Explain the statement : "Sulfuric acid plants above 1000 MTPD capacity are deemed as power plants". 8
 - A certain liquid of specific gravity 0.8, viscosity 0.6 mPa.s is flowing through a smooth pipe of 5.0 cm inner diameter at a linear velocity of 1.8 m/s. The ratio of the wall shear stress to the average kinetic energy per unit volume of the fluid is known to be inversely proportional to the fourth root of the Reynolds number of the flow and the proportionality constant is 0.078. The pipe has two 90° bends in a total length of 50 m and discharges the liquid at a height of 18 m. If a pump of 50% efficiency is used for the purpose, estimate the power required to operate the pump. 8

P.T.O.

Section - A

2. (a) Describe different types of non-Newtonian flow behaviour giving an example of each type. 10
- (b) Gases comprising of 10 mol % SO_2 , 11% O_2 and rest nitrogen are supplied to a catalytic converter at 430°C . Some of the SO_2 is oxidised to SO_3 in the converter. The outlet temperature of the gases is 600°C . Estimate the composition of gases leaving the converter. 20
- (c) Describe in brief, the various methods of separating solids from a mixture of solids and liquids. 10
3. (a) Two spherical particles of same size are dropped through a column of a fluid. The particles are made from different materials whose specific gravities are 3.0 and 8.0. The fall of the particles is in the Stoke's law regime. Estimate the ratio of their terminal settling velocities if the specific gravity of the fluid is 1.0. 10
- (b) In the operation of a synthetic ammonia plant, a nitrogen-hydrogen mixture (1 : 3 mol ratio) is fed to the reactor resulting in a 23% conversion to ammonia.



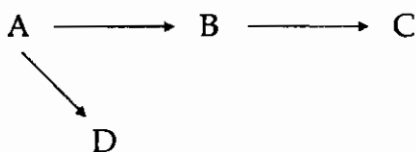
All of the ammonia formed is separated by condensation and the unconverted gases are recycled to the reactor. The fresh feed of $\text{N}_2 - \text{H}_2$ mixture contains 0.17 mol Argon per 100 mol $\text{N}_2 - \text{H}_2$ mixture. The concentration of Argon in the gases entering the reactor is to be kept below 6 mol Argon per 100 mol $\text{N}_2 - \text{H}_2$ mixture. Estimate the minimum fraction of the recycle that must be purged. 20

- (c) Describe in brief, the difference between the behaviour of a compressible and a non-compressible filter cake. 10

Section - B

4. (a) Describe the relationship between adiabatic saturation temperature and the humidity of air. How is it related to wet bulb temperature ? 20
- (b) Describe the use of different models for non ideal flow in an industrial reactor. How are the parameters of these models obtained ? 10
- (c) Based on the general definition of entropy change in a process in a closed system, show that Gibbs free energy minimum is the criteria for equilibrium in a system at constant pressure and temperature. 10

5. (a) Describe the significant differences in the penetration and film theories of mass transfer. In the case of binary simple distillation. Derive a simplified relationship between the mols of the liquid distilled and composition of the liquid in the still based on a constant average relative volatility. 20
- (b) Develop the expressions for rates of change in concentration of the species A, B, C and D for the following scheme of reactions assuming each reaction to be first order.



How do you expect the concentrations to change with time ? 10

- (c) Derive the relationship between standard Gibbs free energy change in a chemical reaction and the composition of the mixture at equilibrium in a chemical reaction. Simplify the equation for a low pressure, homogeneous gas-phase reaction. 10

Section - C

6. (a) Write a short note on pool boiling. 10
- (b) Discuss the various instruments used for the measurement of flow with their salient features. Represent a system of two interacting tanks in series. What will be the response of this system to a step change in input flow rate to the first tank. 20
- (c) Why are different materials of construction required in chemical industry? Give examples. 10
7. (a) What are the different types of heat exchanges employed in the chemical industry. Give one example each of applications of these exchanges. 10
- (b) What are the differences in the responses of a proportional and a PID controller? Give examples of use of each of these controllers. 20
- (c) Why do metals corrode? What are the different alternative materials of construction used in the chemical process industry? 10

Section - D

8. (a) State elements of 'Project Cost Schedule'. What is working capital? How is it estimated? How will you make provision for the same? 10
- (b) What is Bio-diesel? Is it possible to produce it from renewable source? Discuss whether India should go flat-out in Bio-diesel program. 20
- (c) What are the pollutants possible in the stack gases from a steam boiler depending on the fuels used? Briefly outline the possible treatment. 10
9. (a) What is discounted profit flow (cash flow) analysis? "Internal rate of return is more realistic barometer of project viability than payback period". Do you agree? Why? 10

- (b) Describe the integration of the various plants in a fertiliser complex including an ammonia plant. What are the various raw materials used in a fertiliser complex? 20
- (c) Discuss the possible options available for solid waste treatment depending on the nature of waste. 10

Physico - Chemical Data

Name	$\Delta H_f^\circ, 298.16 \text{ K}$ Kcal/mol	$C_{p_{avg}} 25 - 430^\circ\text{C}$ cal/mol.K	$C_{p_{avg}} 25 - 600^\circ\text{C}$ cal/mol.K
SO ₂	-70.96	11.00	11.45
SO ₃	-94.45	15.30	16.33
O ₂	0.00	7.42	7.62
N ₂	0.00	7.11	7.23

$$L_n (\text{Vap Pr. H}_2\text{O, mm Hg}) = 18.3036 - \frac{3816.44}{T_k - 46.13}$$

$\lambda_{\text{vaporisation, water, } 100^\circ\text{C}} = 9.72 \text{ Kcal/mol.}$