I.F.S. EXAM-(M) 2018

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 all of the following questions :** *8×5=40*

(a) A liquid has 40 (wt%) CH_3OH and 60 (wt%) C_2H_5OH. Calculate the average molecular weight of the liquid. *8*

(b) Discuss 'Autocatalytic' reactions with the help of typical rate concentration curve. *8*

(c) How is the COP of a heat pump related to the COP of a refrigerator ? *8*

(d) Calculate the entropy change if 1 kg of water at 303 K is heated to 353 K at 1 bar pressure. The heat capacity of water may be taken as 4·2 kJ/kg K. *8*

(e) What is the standard Gibb's free energy change of a chemical reaction ? How is it related to equilibrium constant ? *8*

Q2. (a) A batch adiabatic reactor at an initial temperature of 373 K is being used for the reaction : $A \rightarrow B$. Assume that the heat of reaction is – 1 kJ/mol at 373 K and the heat capacity of both A and B to be constant and equal to 50 J/mol K. Calculate the temperature rise for 1 mole of feed and after a conversion of 0·5. *15*

(b) A wet paper pulp contains 75% water. After 100 kg of water is removed in a dryer, it is found that the pulp now is containing 30% water. Calculate the weight of the original pulp. *15*

(c) One mole of methane undergoes complete combustion in a stoichiometric amount of air. Both the reactants and products are in the gas phase. Estimate the mole fraction of water vapour in the product gas. *10*

Q3. (a) The homogeneous gas phase decomposition of phosphine

$$4PH_3\,(g) \rightarrow P_4\,(g) + 6H_2$$

proceeds at 922 K with first order rate

$$-r_{PH_3} = (10/hr)\ C_{PH_3}$$

What size of plug flow reactor operating at 922 K and 460 kPa can produce 80% conversion of a feed consisting of 40 moles of pure phosphine per hour ? *15*

(b) The rate constant for a second-order reaction at 300 K is 2·5 and the activation energy is 20000 J/mol. What are the units of the rate constant ? At what temperature would the rate be triple of the rate at 300 K for this reaction ? *10*

(c) A first-order, irreversible liquid-phase reaction is taking place in a CSTR and 50% conversion is obtained. If two more CSTRs of the same size are placed downstream, what is the final conversion ? *15*

Q4. (a) A rigid and insulated tank of volume 2 m^3 is divided into two equal compartments by a very thin partition. One compartment contains an ideal gas at 400 K and 3 MPa while the second compartment contains the same gas at 600 K and 1 MPa. The partition is punctured and the gases are allowed to mix. Determine the entropy change of the gas. The isobaric molar heat capacity of the gas is equal to (5/2)R. The value of R may be taken as 8·314 J/mol.K. *15*

(b) Estimate the standard Gibbs free energy of formation of CH_3OH (g) from the known value of standard Gibbs free energy of CH_3OH (l) which is given as $\Delta G^{\circ}_{f298} = -\ 166{\cdot}215$ kJ. The saturation pressure of CH_3OH at 298 K is 0·16716 bar. *10*

(c) A saturated liquid at 1500 kPa and 500 K, with an enthalpy of 750 kJ/kg is throttled to a liquid-vapour mixture at 150 kPa and 300 K. At the exit conditions, the enthalpy of the standard liquid is 500 kJ/kg and the enthalpy of the saturated vapour is 2500 kJ/kg. Find the percentage of the original liquid which vaporises. *15*

SECTION B

Q5. Answer all of the following questions : *8×5=40*

(a) What is black liquor ? What are the chemicals present in it ? *8*

(b) What is plant layout ? How is it prepared ? *8*

(c) What are the legal aspects of safety in plant design ? *8*

(d) Explain primary and secondary air pollutants. *8*

(e) How is present worth determined ? What is discrete payment present worth factor ? *8*

Q6. (a) Explain the production of sugar with flow diagram. Also give major engineering problems associated with the production. *15*

(b) Why is hydrogenation of edible oil required ? Explain hydrogenation of vegetable oil with suitable diagram. *15*

(c) Explain the relative advantages and disadvantages of updraft and downdraft biomass gasifier. *10*

Q7. (a) Discuss various methods for the extinction of fire. Differentiate between Hazard and Risk. *15*

(b) Discuss the various plume patterns for the different environmental prevailing lapse rate. *10*

(c) What are biodegradable and non-biodegradable organics ? Explain in short, various methods used to treat biodegradable organics present in the waste water. *15*

Q8. (a) An equipment has an initial cost of ₹ 12,000. The depreciation will be charged as by making equal charges each year and first payment being made at the end of the first year. Determine the yearly cost due to depreciation. Useful life period of equipment is seven years. Salvage value is ₹ 1000 and depreciation fund will be accumulated at an annual interest rate of 4·5%. *15*

(b) The purchase cost of a heat exchanger of 20 m^2 area was ₹ 5,00,000 in 2007. What will be the estimated cost of a similar heat exchanger of 50 m^2 area in the year 2014 ? Assume the six-tenth factor rule for scaling and the cost index for 2007 as 430·2. The projected cost index for the year 2014 is 512·6. *10*

(c) The total capital investment for a chemical plant is ₹ 20,00,000 and its working capital is ₹ 2,00,000. If the plant produces an average of 10,000 kg final products per day during 365 days/year, what selling price in ₹ per kg of product would be necessary to give a turnover ratio of 1 ? *15*