CHEMICAL ENGINEERING

Paper – I

*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. (a) State Fourier's law of heat conduction and derive the dimension of thermal conductivity from the equation. *5*

(b) Define a Black Body. State Stefan-Boltzmann's law and Kirchhoff's law of radiation. *5*

(c) Give the importance of relative volatility for distillation purpose and derive its relationship with equilibrium composition (x, y) in a mixture. *5*

(d) Write and explain the dimensionless group in mass transfer that is equivalent to Prandtl number in heat transfer. *5*

(e) Define the following terms : *5*

(i) Moisture content

(ii) Equilibrium moisture

(iii) Bound moisture

(iv) Free moisture

(v) Humidity

(f) Determine the equivalent diameter for heat transfer for a fluid flowing through an annulus of inner dia. 0·8 m and outer dia. 1·0 m. *5*

(g) Write the limitations of venturimeter over orifice meter and discuss the principle of orifice meter. *5*

(h) State Rittinger's law, Kick's law and Bond's law of Crushing. *5*

Q2. (a) Explain the working of a ball mill giving the expression for the critical speed of ball mill. *20*

(b) A simple U-tube manometer is installed across an orifice meter. The manometer is filled with mercury (sp. gr. = 13·6) and the liquid above the mercury is water. The manometer reads 200 mm. What is the pressure difference over the manometer in N/m^2 ? *10*

(c) Water is flowing through a steel pipe of 0·0525 m ID with an average linear velocity of 1·524 m/sec. The average bulk temperature of water is 37·8°C.

(i) Determine whether the flow is turbulent or laminar.

(ii) Calculate the water-film coefficient. *10*

Data : [μ of water at 37·8°C = 0·684 cP

k of water at 37·8°C = 0·628 J/s-m^2 (°K/m)

c_p of water at 37·8°C = 4187 J/kg-°K

Q3. (a) Clearly distinguish between particulate fluidization and aggregative fluidization. *10*

(b) Explain about optimum reflux ratio in distillation column. *10*

(c) Fuel oil in a tank is to be heated from 15·5°C to 43°C by means of a steam coil. The steam temperature is 100°C. The film heat transfer coefficient for fuel oil is 15·7 kcal/hr m^2 °C and heat transfer coefficient for steam is 3500 kcal/hr m^2 °C. The fouling factors are 4 kcal/hr m^2 °C and 7 kcal/hr m^2 °C for oily steam and for fuel oil respectively. The coil is required to heat 2250 kg/hr of fuel oil of specific heat 0·8 kcal/kg °C. The inside diameter of pipe is 4·1 cm and outside diameter is 4·83 cm. Calculate the

(i) overall coefficient of heat transfer, and

(ii) heat transfer surface area. *20*

Q4. (a) It is desired to absorb acetone from a dilute solution of acetone in air containing 1 mole % acetone by contacting it countercurrently with pure water in an absorber consisting of two theoretical stages. The total inlet gas flow rate is 30 kmol/hr and that of water is 90 kmol/hr. Under the operating conditions; the equilibrium relationship for acetone in gas-liquid is y = 2x. Estimate the mole fraction of acetone in the water stream leaving the absorber. *20*

(b) Explain the working of a centrifugal pump and a positive-displacement pump. *10*

(c) List the characteristics of a good solvent for absorption column explaining the reasons. *10*

SECTION B

Q1 **Q5.** (a) Mention the advantages of membrane separation processes over the conventional processes. *5*

(b) Define Molecular Weight Cut-Off (MWCO) method for characterization of ultrafiltration membranes. *5*

(c) Discuss the different types of heads used as end closures of cylindrical vessels. *5*

(d) Mention the different types of steel and non-ferrous materials along with their basic characteristics, used in construction of process vessels. *5*

(e) Define the 'Time-Constant' and discuss its effect on response of the system. *5*

(f) Distinguish clearly between 'non-interacting' and 'interacting' systems in control theory. *5*

(g) What are the desired characteristics of a measuring instrument used in industry ? *5*

(h) Define the term 'Stability' of a control system. Also write the merits and demerits of the Routh-Hurwitz criteria. *5*

Q6. (a) Discuss the different types of storage tanks used for storing volatile liquids. Elaborate the steps and procedure for the design of storage tanks. *15*

Q2 (b) The characteristic equation of a closed loop system using a proportional controller with gain K_c is

$$12S^3 + 19S^2 + 8S + 1 + K_c = 0.$$

Find the value of controller's gain K_c at the onset of stability. *15*

(c) Describe the membrane distillation process carried out for deionization of water in the semiconductor industry. *10*

Q7. (a) A P-I-D controller output p(t) is given by

$$p(t) = 30 + 5e(t) + 1{\cdot}25 \int_0^t e(t)\,dt + 15\frac{de(t)}{dt}$$, where e(t) is error at time t.

Determine the transfer function of the controller. *15*

(b) A cylindrical pressure vessel of volume 6π m^3 has to be designed to withstand a maximum internal pressure of 10 atm. The allowable design stress of the material is 125 N/mm^2 and corrosion allowance is 2 mm. Determine the thickness of the vessel for a length/diameter ratio of 3·0. *15*

(c) Explain the electrodialysis process used in desalination and conservation of sea and brackish water and industrial waters. *10*

Q8. (a) Develop the transfer function for a second order system and discuss the characteristics of an underdamped system. *15*

(b) Explain the basic principle of Ultrafiltration giving its advantages. *15*

(c) Discuss in detail, the design of bracket supports. *10*