

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-m² (°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 m² °C and heat transfer coefficient for steam is 3500 kcal/hr m² °C. The fouling factors are 4 kcal/hr m² °C and 7 kcal/hr m² °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

$$p(t) = 30 + 5e(t) + 1.25 \int_0^t e(t) dt + 15 \frac{de(t)}{dt}, \text{ where } e(t) \text{ is error at time } t.$$

Determine the transfer function of the controller. 15

(b) A cylindrical pressure vessel of volume $6\pi \text{ m}^3$ 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 electro dialysis 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

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