2007

CHEMISTRY

PAPER-IV

Full Marks :75

Time : **3 hours**

Answer any five questions taking at least two from each Group

The figures in the right-hand margin indicate marks

Candidates are required to give their answers in their own words as far as practicable

Illustrate the answers wherever necessary

Write the answers Question of each Group in separate books

.GROUP -A

1. (a) **For isothermal streamline, flow of fluid through a pipeline**, show mathematically that the velocity distribution is parabolic and hence **deduce the Poiseuille's equation for pressure** drop in such flow. 9

(b) Calculate the thickness of the boundary layer **at a distance** of 75 mm from **the leading edge** of a surface over which oil of viscosity 50x 10 - 3 Ns/m2 and density 990 kg/m3 flows with a velocity of 0.3 m/sec. 3

(Turn Over)

(c) Show that the velocity **gradient is time rate of** shear. 3

2. (a) Discuss what is meant by suction lift and cavitation. 3

(b) 60% H_2SO_4 is to be pumped at the rate of 4000 cm^3/sec through a lead pipe 25 mm diameter and raised to a height of 25 meter. The pipe is 30 meter long and includes two right angled bends. Calculate the theoretical power required.

Given : Specific gravity of the acid is 1-531, kinematic viscosity is 0.425 cm^2/sec, the density of water 1000 kg/m^3, friction factor f = 0.0094, loss through each bend is 0.8 times the velocity head. 6

(c) A centrifugal pump is to be used to circulate liquid of specific gravity 0.80. and viscosity $0.5 \times 10^{-3} Ns/m^2$ from the reboiler of a distillation column through a vaporiser at the rate of 400 cm^3/sec and to introduce superheated liquid above the vapour space in the reboiler which contains liquid to a depth of 0.7 meter,

how far above the pump must the liquid level in the reboiler be maintained to give a NPSH of 3 meter of liquid. The diamer of the pipe is 2 5 mm and the length of the pipe between the reboiler and the pump is 10 meter and friction factor f=0.0056. 6

3. (a) How **moisture**, **volatile** matter, ash and fixed carbon **are determined** in a sample of coal ? 4

(b) Explain the **significance** of mineral matter and, ash in coal. 4

(c) Give examples of neutral and insulating refractories. Discuss the following properties of

refractories :	2+(21x2) 2
(i) Porosity and slag permeability *(ii)* Refractoriness.	

4. (a) Write down the expression for, and unit of 'Resistance' while flow of heat takes place by conduction and convection, respectively.

(b) Calculate the steady-state heat flux across a copper block of 10 cm length, one side is maintained at 25°C and the other at 95°C .

Heat flow is in axial direction only. as the other **sides are** -properly insulated. The thermal conductivity of copper may be assumed constant at 380 Wm-'K-' . 2

(c) A hot plate made of Aluminium having physical properties :

density = 3000 kg/m=', heat capacity = 0.2 kcal/ (kg)(°C) and thermal conductivity 300 W / (m) (K) is used in laboratory. Find its thermal diffusivity. 2

(d) Why is the counter-current flow heat exchanger more efficient than co-current flow heat exchanger ? When do these exchangers become equally efficient ? 3

(e) Compare the equivalent **diameters** of the shell in a Shell and Tube heat exchanger when tubes are arranged in a (i) square pitch and *(K)* triangular pitch, respectively. The pitch may be assumed to be 1.5 times outer diameter of tube. Outer and inner diameters of a tube are 20 mm and 16 mm, respectively. 3

(f). *Why* are the baffles used in Shell and Tube heat exchanger? 2

a), Derive the expression for log-mean radius of a hollow cylinder through which heat transfer **occurs** by conduction in radial direction only. 5

(b") **Develop the expression** for. LMTD in a **counter-current flow heat exchanger.**

(c) A heavy hydrocarbon **oil is being** cooled in a heat exchanger from 3 72°K to 3 50°K, and flows inside the tube **at a rate** of 3650kg/hr. A flow of 1470 kg water per hour enters at 290 °K for **cooling**. The mean heat capacities . of hydrocarbon **oil and water** are 2.30kJ/ (kg) (K) and 4.2 kJ/ (kg) (K), respectively. Calculate the **water outlet temperature and heat transfer area** if the overall **heat transfer** coefficient, U= 340 W / (m2) (K), and the **streams are counter–current.** **6**

GROUP -B

6. (a) Give a neat sketch of differential manometer and show how pressure difference can be measured by this manometer. 4

(b) Explain the principles of measurement of fluid flow by an orificemeter and discuss the theoretical principles involved. What are the advantages and disadvantages of orificemeter over venturi meter. 4+2

(c) 'Water. flowing at 1500 cm3/sec in a 50 mm diameter pipe is metered by means of a simple orifice of diameter 25 mm. If the co-efficient of discharge of the meter is 0.62, what will be the reading on a mercury under water manometer connected to the orificemeter ? What is the Reynolds number for the flow in the pipe ?

Given : Density of water = 1000 kg/m3 ,

Viscosity of water= 1 x 10-3 Ns/m2 . 5

7. (a) What are the advantages of continuous nitration over the batch nitration process. 3

(**b) Discuss** briefly the **kinetics and mechanism of the nitration of aromatic compounds.** **4**

(c.) Explain the term D. V. S and Nitric **Ratio. How** is D. V. **S calculated** ? What **is the significance and importance** of D. V. **S in technical nitrations?** **2+2+4**

(a) The gases from a sulfur burner in a sulphuric acid plant has the following composition : SO2 = 5.0 %, SO3 = 2.5 %, 02=12**.5%andN2=80%.**

(I) Calculate **the percentage excess oxygen** supplied **for complete** oxidation to SO3 , and the composition of the gas leaving the converter at a temperature of 75°C and a pressure of 740 mmHg. 6

(ii) Also, calculate the volume of gas leaving the converter per 1000 kg of pure sulfur burnt. 2

(b) It is required to absorb 90% ammonia in a gas containing 4 moll ammonia in air in a counter-current tray tower. The total inlet gas flow to the tower is 100 kmol/hr, and the total inlet pure water used to absorb ammonia is 300 kmol/hr. The process is to operate isothermally at 303° K and a total pressure of 101 -3 kPa. Determine graphically, the number of theoretical stages required for the separation. The equilibrium data for NH3 - H20 system at 30°C are as follows : .7

x, kmo1NH3/kmol•H20	0	0.02	0.04	0.074	0.14	0.21	0.30
y,k1nolNH3/km01 air	0	0025	0.053	0.105	0235	0.46	0.95

(a) The vapor **pressure data are given** below for **n -hexane / n -octane** system :

T, °C	Vapor pressure, mm Hg	
	n-Hexane	**n-Octane**
68.7	760	121
79.4	10.25	173
93.3	1480	278
107.2	2130	434
125.7	3420	760

(i) Using Raoult's law, calculate and plot the x - y data at a total pressure of 101.3 kPa (760 mm Hg).

(*ii)* **Plot the boiling-point (TBP) diagram.** 4

(iii) **Find the boiling point and equilibrium composition of the mixture containing 55% n-hexane.**

(b) Explain `Relative Volatility'..

10. Continuous fractionating column operating at a pressure of 1 bar, is used to separate 1000kg/hr. of a solution containing 10% Acetone and 90% water at 35°C, into an overhead product containing 99% Acetone at 25°C and a bottom product containing less than 100 ppm Acetone at 100°C. All compositions are by weight. A reflux ratio of 10 is used in the operation.

(a) Calculate the amount of top and bottom products. 2

(b) Calculate the Reboiler and Condenser duties, **assuming** the rise in temperature of cooling water used in the condenser is limited to 30°C. The boiling point of the solution containing 99% Acetone is 56.5°C. The latent heats of Acetone and Water at 56.5°C are' 620 kJ/kg and 2500 kJ/kg, . respectively. The mean heat **capacities** of Acetone and Water are assumed to be 2.2kJ/(kg) (K) and 4.2kJ/(kg) (K), respectively. 10

(c) Estimate the rates of steam and cooling water required in the reboiler and condenser, respectively for the separation. Dry saturated steam is available at 25 psig, with the latent heat of 2730kJ/kg. 3