M.Sc. 2nd Semester Examination, 2011

CHEMISTRY

(Industrial)

PAPER—CEM-204

Full Marks : 40

Time : 2 hours

Answer any **four** questions

The figures in the right-hand margin indicate marks

1. (*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*) Explain why gross calorific value (GCV) of a fuel is higher than that of its net calorific value (NCV). 2

2. The analysis of coal used in a boiler trial is as follows :

82% C, 6% hydrogen, 4% oxygen, 2% moisture and 8% ash.

Determine the theoritical minimum air required for complete combustion of 1 kg of coal. If the actual air supplied is 18 kg/kg of coal, hydrogen is completely burned and 80% of carbon is burned to CO_2, the remainder to CO, determine the volumetric analysis of the dry products of combustion. 10

3. (*a*) Define refractories. Classify refractories on the basis of their chemical nature giving suitable examples. 1 + 2

(*b*) Discuss the following properties of refractories : 2 + 2

(*i*) Porosity and slag permeability

(*ii*) Refractoriness.

(*c*) Mention the desirable properties of a good refractory. 3

4. (*a*) State and explain Fick's law of diffusion. Compare it with Fourier's law for heat conduction and Newton's law of viscosity. 4

(*b*) The ratio of momentum diffusivity to heat diffusivity, and the ratio of momentum diffusivity to mass diffusivity form two dimensionless groups. Discuss the meaning of these ratios. 4

(*c*) Define molecular diffusion and eddy diffusion. 2

5. Alcohol vapour is diffusing through a layer of water-vapour under equimolar counter diffusion at 35 °C and 1 atm pressure. The molar concentration of alcohol on the two sides of the gas film (water vapour) 0·3 mm thick are 80% and 10% respectively. Assuming the diffusivity of alcohol-water vapour to be 0·18 cm^2/s, (*i*) calculate the rate of diffusion of alcohol and water vapour in kg/hr through an area of 100 cm^2, (*ii*) if the water vapour layer is stagnent, estimate the rate of diffusion of alcohol vapour.

Given:

$$D_{\text{alcohol-water}} = 0{\cdot}18 \times 10^{-4}\ m^2/s.$$ 10

6. Briefly describe the manufacturing process of a common refractory. 10

7. (*a*) For an elementary reaction $A + B \rightarrow$ products, the reaction rate at 500 K is ten times that at 400 K. Calculate the activation energy for this reaction. 5

(*b*) The rate of the liquid phase reaction of the type

$$A + B \rightarrow \text{products}$$

is found to be independent of concentration A and B, and equal to 1 kmole/m^3 min at 300 K. Find the conversion in mixed flow reactor having volume equal to 2 m^3 with feed concentration of A and B equal to 5 kmole/m^3, feed flow rate equal to 1 m^3/min, and the reactor temperature equal to 300 K. 5

8. (*a*) Write the function of binder used in the refractory manufacturing process. Name few binder used industrially. 3

(*b*) Discuss the advantages and disadvantages of plug flow reactor over the CSTR. 4

(*c*) The conversion for a 1st order liquid phase reaction $A \rightarrow B$ in a CSTR is 50%. If another CSTR of the same volume is connected in series, then calculate the % conversion at the exit of the 2nd reactor. 3