Name : .....

Roll No. : .....

Invigilator's Signature : .....

CS/M.Tech(BT)/SEM-1/MBT-102/2011-12

2011

ENGINEERING PRINCIPLES

Time Allotted : 3 Hours *Full Marks* : 70

The figures in the margin indicate full marks.

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

GROUP – A

(Multiple Choice Type Questions)

1. Choose the correct alternatives for any *ten* of the following : 10 × 1 = 10

   i) Liquid which does not flow at all until a threshold stress is attained is

      a) Pseudoplastic b) Bingham plastic

      c) Dilatants d) none of these.

   ii) Primary objective of using a bypass stream for a process is to

      a) improve overall conversion

      b) increase product yield

      c) ensure better control over the process

      d) none of these.

iii) Rate of a chemical reaction is independent of the concentration of the reactants for a reaction of

a) zero order b) third order

c) consecutive d) none of these.

iv) The momentum correction factor for the velocity distribution in laminar flow is

a) 1.3 b) 1.66

c) 2.5 d) none of these.

v) Viscosity of a liquid varies with temperture

a) exponentailly b) linearly

c) logarithmically d) none of these.

vi) Chemical kinetics can predict the ..... of a chemical reaction.

a) rate b) feasibility

c) both (a) and (b) d) neither (a) nor (b).

vii) For an endothermic reaction, the minimum value of energy of activation will be

a) ΔH b) $> \Delta H$

c) $< \Delta H$ d) 0.

viii) According to Chilton-Colburn analogy for mass transfer, N_{st} , $N_{sc}{}^{2/3}$ is equal to

a) f b) $f/2$

c) $2f$ d) $1/f$.

ix) Kopp's rule is used to calculate the heat capacity of

a) gases b) liquids

c) solids d) all of these.

x) The value of a Lewis number for air-water system is

a) 0.1 b) 1.0

c) 10 d) 100.

xi) The dispersion number of a CSTR is

a) zero b) 1

c) 2 d) infinite.

GROUP – B

(Short Answer Type Questions)

Answer any *three* of the following. 3 × 5 = 15

2. Explain the following terms :

a) Differential balance and integral balance 3

b) Degree of freedom and process variables. 2

3. Derive an equation for Shell Momentum balance.

4. Explain velocity profile development in a laminar flow between two parallel plates with respect to Coquette model.

5. Derive Hagen-Poiseuille law for laminar flow in pipes.

6. A pipeline of 300 mm diameter and 3200 m long is used to pump 50 litres/sec of an oil whose specific gravity is 0·95 and kinematic viscosity is 2.1 stokes. The centre of the pipeline at the upper end is 40 m above that at the lower end. Find the difference of pressure at the ends.

GROUP – C

(Long Answer Type Questions)

Answer any *three* of the following. 3 × 15 = 45

7. Prepare a material balance flow sheet for a plant producing 1200 kg 5-chloro 7-iodo 8-hydroxy quinoline (Quiniodochlor) starting from phenol as a raw material as per the reactions given below :

   a) Chlorination

      i) Phenol + Chlorine ∅ Mixed Chlorophenol
      (PCP 60%. OCP 35%, DCP 2.5%, pH 2.5%)
      (Conversion 99%, Loss 0.3%)

      ii) Hydrochloric acid gas + Water ∅ HCl – 30%.

   b) Fractionation Mixed Chlorophenol ∅ PCP 60%, OCP 35%, DCP 2.5%, Phenol 2.5% (Conversion 98%, Loss 2%)

   c) Nitration PCP +Nitric Acid (30%) ∅ Para chloro *o*-nitrophenol + Water (Conversion 95%, Loss 2%)

   d) Reduction *p*-chloro *o*-nitrophenol ∅ *p*-Chloro *o*-aminophenol + iron sludge + 1.6 mol iron and water (HCl as catalyst) (iron dust unreacted) (conversion 90% + loss 2%).

   e) Skraups condensation

      PCOAP + PCONP + Acrolein (Glycerol + Sulphuric Acid) ∅ Chloroxy quinoline + water

      (conversion 85% + loss 2%)

f) Chloroxyquinoline + Iodine monochloride (conversion 99·5% + loss 0·5%) ∅ Iodichloro oxyquinoline + HCl.

g) Iodine + Chlorine (Conversion 99.6% + –(HCl-) ∅ Iodine monochloride.

M.Wt. ∅ (Phenol-94, MCP-128.5, PCONP-173.5, PCOAP-143.5, CHLQ-180, ICHOLQ-306.)

8. In a spray drier, a liquid solution of the material to be dried is sprayed into a stream of hot gas inlet air 3000 cubic metre per hour (measured at N.T.P.) at 300 degree Centigrade, 780 mm of mercury, moisture 0.005 kg of water / kg of air inlet solution : 150 kg per hour, 15% solid, at 20 degree Centigrade outlet air at 90 degree Centigrade. Moisture 0.035 kg water/kg dry air, 760 mm of Hg. Calculate

a) the composition of the outlet solids

b) radiation loss

Assume the specific heat of dry gas to be 0.24 cal/gm degree centigrade and that of dry solids to be 0.2 cal/gm degree Centigrade, Outlet temp. of solids is 40° Centigrade.

9. The ethanol dehydrogenation reaction is carried out with the feed entering at 300°C. The feed contains 90% (mole%) ethanol and balance acetaldehyde. To keep the temperatue from dropping too early and hence quenching the reaction at a low conversion heat is added to the reactor.

It is observed that when the heat addition bring here rate is 5300kJ per 100 moles of the feed gas, the outlet temperature is 265°C.

Calculate

a) the heat balance of the feed and product

b) fractional conversion of ethanol in the reactor.

The reaction is

$C_2H_5OH(g) \varnothing CH_3CHO(g) + H_2(g)$

$\Delta H^0 r = 68.95$ kJ/mol;

$C_2H_5OH(g) \varnothing C_p = 26.3$ cal/mole°C

$CH_3CHO(g) \varnothing C_p = 19.1$ cal/mole°C

H_2 gas $\varnothing C_p = 6.93$ cal/gm mole °C (assume values of C_p to be constant with temperature) 8 + 7

10. With the help of momentum balance, derive expressions for the following in case of a steady laminar flow of incompressible fluid in a pipe : 3 ∞ 5

a) Velocity profile

b) Average velocity

c) Volumetric flow.

11. a) Using Buckingham's Π theorem show that the velocity through a circular orifice is given by $V = (2gh)^{1/2} \phi$ [D/H* μ/ρ *VH*]

where H = head causing flow ;

D = diameter of the orifice;

μ = coefficient of viscosity;

ρ = mass density; 7

b) Dry methane is urned with dry air and both are initially at 25°C. The flame temperature is 1297°C. If complete combustion is assumed, how much excess air is to be used ?

Data : Heat for reaction, $H_r = 0{\cdot}2 \infty 10^6$ cal

C_p for CO_2 = 12.37 cal/mol °C

C_p for H_2O = 9.60 cal/mol °C

C_p for N_2 = 7.68 cal/mol °C, C_p for air = 7.74 cal/mol °C

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