Name : .....

Roll No. : .....

Invigilator's Signature : .....

CS/B.TECH(CT-OLD)/SEM-4/CT-404/2012

2012
PROCESS CALCULATION

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.

Attempt any *five* questions. 5 × 14 = 70

1. A pure hydrocarbon gas is burnt in a furnace giving a flue gas containing 10·8% CO_2, 3·8% O_2 and rest N_2 and inerts. Calculate :

   a) The atomic ratio of H/C, and from this ratio, the formula of the fuel.

   b) If the combustion gases leave the furnace at normal pressure and 430°C, calculate the volumetric ratio of flue gas/fuel gas.

   c) If the furnace burns 90 kg of fuel/hr, calculate the volume of combustion gas in m^3/min. 14

2. a) A furnace using a high grade petroleum fuel oil containing 5·4% sulphur. The flue gas is analyzed without prior removal of SO_2 which is therefore reported along with CO_2, showing 13·9 % ($CO_2 + SO_2$), 0·4% CO, 0·1% H_2 , 2·4% $O_2$and 83·2% N_2. What is the composition of the flue gas ?

b) A hydrocarbon gas on combustion gives out a flue gas of composition CO_2—11·6%, CO—2·0%, H_2—1·6%, O_2— 4·2% and rest N_2. Calculate the % of excess air used. 8 + 6

3. a) An evaporator is fed with 14000 kg/hr of a solution containing 10% NaCl, 15% NaOH and rest water. During operation water is evaporated and NaCl is precipitated as crystals. The thick liquor leaving the evaporator contains 45% NaOH, 2% NaCl and rest water. Calculate :

(i) kg/hr water evaporated.

(ii) kg/hr salt precipitated.

(iii) kg/hr thick liquor produced.

b) Ethylene oxide is produced by oxidation of C_2H_4. 100 kg moles of C_2H_4 are fed to a reactor and the product formed contains 80 kg mole ethylene oxide and 10 kg mole CO_2. The reactions are as under :

$$C_2H_4 \rightarrow \frac{1}{2}O_2 \rightarrow C_2H_4O \text{ ..... (1)}$$

$$C_2H_4 + 3O_2 \rightarrow 2CO_2 + 2H_2O \text{ ..... (2)}$$

Calculate :

(i) Conversion of C_2H_4 in percentage.

(ii) Yield of oxide in percentage. 9 + 5

4. a) Calculate standard heat of formation of chloroform $\{CHCl_3(g)\}$ from its elements using Hess's law, given

$C(s) + O_2(g) \rightarrow CO_2(g)$ ..... $\Delta H_1 = -94051$ cals

$H_2(g) + \frac{1}{2}O_2 \rightarrow H_2O(l)$ ..... $\Delta H_2 = -68317$ cals

$\frac{1}{2}H_2(g) + \frac{1}{2}Cl_2(g) \rightarrow HCl\ (aq)$ ..... $\Delta H_3 = -40023$ cals

$CHCl_3(g) + \frac{1}{2}O_2(g) + H_2O(l) \rightarrow$

$CO_2(g) + 3HCl\ (aq)$ ..... $\Delta H_C = -121800$ cals

b) Calculate the heat of formation of ethane gas from the following reactions :

$C(s) + O_2(g) \rightarrow CO_2(g)$ ..... $\Delta H_1 = -94051$ cals

$H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(l)$ ..... $\Delta H_2 = -68317$ cals

$C_2H_6(g) + 3 \cdot 5O_2(g) \rightarrow 2CO_2(g) + 3H_2O(l)$ .....

..... $\Delta H_C = -372820$ cals

8 + 6

5. a) The feed containing 60 mole % *A*, 30 mol % *B*, and 10 mole % inerts enter a reactor. The product stream leaving the reactor is found to contain 2 mole % *A*. The reaction taking place is $2A + B \rightarrow C$. Find the % of original *A* getting converted to *C*.

b) A combustion reactor is fed with 50 kg mole of butane per hour and 2100 kg mole of air per hour. Calculate the % excess air.

The reaction is : $C_4H_{10} + \frac{13}{2}O_2 \rightarrow 4CO_2 + 5H_2O$.

7 + 7

6. Calculate a glass batch to yield a glass of following composition :

SiO_2 – 68%, Al_2O_3 – 2%, CaO – 13%, Na_2O – 11% and K_2O – 6%

Using the following raw materials :

Sand (SiO_2 – 99%), Feldspar (SiO_2 – 65%, Al_2O_3 – 19%, K_2O – 16%); Limestone 98% pure and 2% SiO_2, K_2CO_3 (K_2O – 68%) and soda ash – 98% pure. 14

7. Calculate the batch composition of a glass with the oxide composition of SiO_2 – 71%, Na_2O – 15%, CaO – 10%, Al_2O_3 – 4% using the following raw materials :

Sand, feldspar, anhydrous soda ash and cullet (20%)

The cullet composition is SiO_2 – 75%, Na_2O – 15%, CaO – 9·5% and Al_2O_3 – 0·5%. 14

8. The batch composition of a glaze is as follows in parts by weight :

Mill batch		Lead frit	Borax frit	
Lead frit	137·2 parts	PbO. $2SiO_2$	Borax	76·4 parts
Borax frit	131·2 parts		Whiting	20·0 parts
Whiting	10·0 parts		Feldspar	55·6 parts
China clay	51·6 parts		Flint	2·0 parts
Flint	36·0 parts			

Calculate the glaze formula. 14