

Name : .....

Roll No. : .....

Invigilator's Signature : .....

**CS/B.Tech (CT)/SEM-4/CT-404/2010**

**2010**

**PROCESS CALCULATIONS**

Time Allotted : 3 Hours

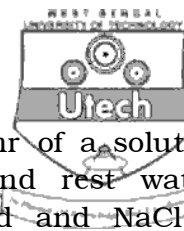
Full Marks : 70

*The figures in the margin indicate full marks.*

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

Answer any five questions.  $5 \times 14 = 70$

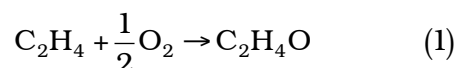
1. A pure hydrocarbon gas is burnt in a furnace giving a flue gas containing 10.8%  $\text{CO}_2$ , 3.8%  $\text{O}_2$  and rest  $\text{N}_2$  and inerts. Calculate
  - a) The atomic ratio of H/C, and from this ratio, the formula of the fuel.
  - b) If the combustion gases leave the furnace at normal pressure and  $430^\circ \text{C}$ , 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  $\text{m}^3/\text{min}$ . 14
2.
  - a) A furnace using a high grade petroleum fuel oil containing 5.4% sulphur. The flue gas is analysed without prior removal of  $\text{SO}_2$  which is therefore reported along with  $\text{CO}_2$ , showing 13.9% ( $\text{CO}_2 + \text{SO}_2$ ), 0.4% CO, 0.1%  $\text{H}_2$ , 2.4%  $\text{O}_2$  and 83.2%  $\text{N}_2$ . What is the composition of the flue gas ?
  - b) A hydrocarbon gas on combustion gives out a flue gas of composition,  $\text{CO}_2$ –11.6%, CO – 2.0%,  $\text{H}_2$  – 1.6%,  $\text{O}_2$  – 4.2% and rest  $\text{N}_2$ . Calculate the percentage of excess air used. 8 + 6



3. a) An evaporator is fed with 14,000 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 bearing 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.

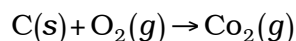
- b) Ethylene oxide is produced by oxidation of  $C_2H_4$  100 kg moles of  $C_2H_4$  are fed to a reactor and the product formed contains 80 kg mole ethylene oxide and 10 kg mole  $CO_2$ . The reactions are as under :



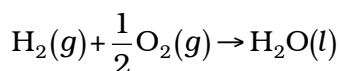
Calculate : a) Conversion of  $C_2H_4$  in percentage

b) Yield of oxide in percentage. 9 + 5

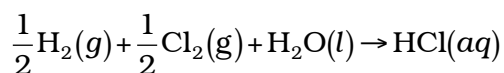
4. a) Calculate standard heat of formation of chloroform  $\{CHCl_3(g)\}$  from its element using Hess's law. Given



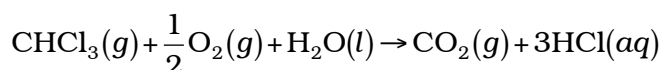
$$\Delta H_1 = -94051 \text{ cal} \quad (1)$$



$$\Delta H_2 = -68317 \text{ cal} \quad (2)$$



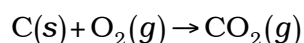
$$\Delta H_3 = -40023 \text{ cal} \quad (3)$$



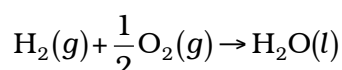
$$\Delta H_C = -121800 \text{ cal} \quad (4)$$



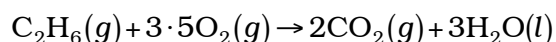
- b) Calculate the heat of formation of ethane gas from the following reactions :



$$\Delta H_1 = -94051 \text{ cal} \quad (1)$$



$$\Delta H_2 = -68317 \text{ cal} \quad (2)$$



$$\Delta H_C = -372820 \text{ cal} \quad (3) \quad 8 + 6$$

5. The gases entering a sulphur converter contains 2.1%  $\text{SO}_3$ , 8.5%  $\text{SO}_2$ , 9.6%  $\text{O}_2$  and 79.8%  $\text{N}_2$ . Only the reaction  $\text{SO}_2 + \frac{1}{2}\text{O}_2 \rightarrow \text{SO}_3$  takes place. No materials are added or removed except the single process stream coming in and going out. The outlet gases contain 82.46%  $\text{N}_2$ . How much heat is evolved per 100 mole of entering gas, if the reaction takes place isothermally at 720 K ?

Data : Heat of formation of  $\text{SO}_3$  at 290 K = - 98.18 kJ

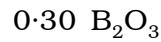
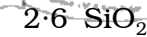
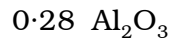
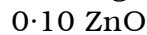
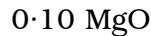
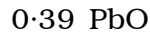
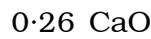
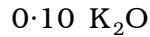
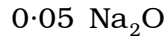
Mean specific heat of  $\text{SO}_3$  = 51.58 J/mole-K

Mean specific heat of  $\text{SO}_2$  = 45.67 J/mole-K

Mean specific heat of  $\frac{1}{2}\text{O}_2$  = 30.98 J/mole-K 14



6. A fritted glaze of following formula :



Calculate the batch composition of the frit and the mill batch using feldspar, borax, red lead, calcined ZnO, precipitated  $\text{MgCO}_3$ , whiting flint. 14

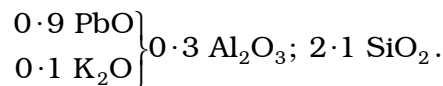
7. Determine the batch composition to yield a glass of the following composition :

$\text{SiO}_2$  - 67%,  $\text{Al}_2\text{O}_3$  - 3%,  $\text{CaO}$  - 12%,  $\text{Na}_2\text{O}$  - 12% &  $\text{K}_2\text{O}$  - 6%

using cullet with composition of  $\text{SiO}_2$  - 70%,  $\text{Na}_2\text{O}$  - 15%,  $\text{CaO}$  - 13%,  $\text{Al}_2\text{O}_3$  - 2%. The raw materials used are glass sand, lime stone, feldspar, anhydrous soda ash, potassium carbonate, cullet used to the extent of 20%. 14

8. a) The per cent composition of a glaze is found by analysis  $\text{PbO}$  - 22.80%,  $\text{Na}_2\text{O}$  - 6.96%,  $\text{K}_2\text{O}$  - 11.54%,  $\text{Al}_2\text{O}_3$  - 9.7%,  $\text{SiO}_2$  - 41.0% &  $\text{B}_2\text{O}_3$  - 8.00%. Report these results as a glaze formula & also calculate the formula wt.

b) From the following lead frit formula, calculate the leather composition using red lead, feldspar, china clay & flint.



7 + 7