Name : .....

Roll No. : .....

Invigilator's Signature : .....

CS/B.TECH (CT)/SEM-4/CT-404/2011

2011
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

1. a) A producer gas has the following composition by volume :
$CO - 24\%$, $CO_2 - 4 \cdot 2\%$, $O_2 - 1 \cdot 8\%$, $N_2 - 70\%$. Calculate the volume of gas in m^3 at $25^\circ C$ and 740 mm Hg pressure/kg of carbon present.

   b) A hydrocarbon fuel is burnt and the analysis of flue gas shows $CO_2 - 11\%$, $CO - 1 \cdot 3\%$, $O_2 - 7 \cdot 5\%$ and $N_2 - 80 \cdot 2\%$. What is the atomic ratio of H/C in fuel ?

7 + 7

2. On combustion of a hydrocarbon fuel oil dry stack gas analysis shows $CO_2 - 10 \cdot 8\%$, $O_2 - 7 \cdot 9\%$ and $N_2 - 81 \cdot 3\%$.
Calculate
   a) the % of C and H in the fuel
   b) The % excess air used.
   c) Cubic metre of air used at standard temperature and pressure/kg of fuel. 14

3. a) Calculate the standard heat of reaction of the following, using Hess's law

$C_5H_{12}(l) + 8O_2(g) \rightarrow 5CO_2(g) + 6H_2O(l)$

Given,

component	ΔH°_f cal/gm.mole
$C_5H_{12}(l)$	– 41370
$CO_2(g)$	– 94051
$H_2O(l)$	– 68315

b) Calculate the heat of formation of glycerol from the following reactions

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

$H_2(g) + {}^1/_2\ O_2(g) \rightarrow H_2O(l)$: $\Delta H_2 = -68371$ cals

$C_2H_8O_3(l) + 3{\cdot}5O_2(g) \rightarrow 3CO_2 + 4H_2O(l)$:

$\Delta H_2 = -396270$ cals

c) A combustion reactor is fed with 50 kg mole of butane per hour and 2100 kg mole of air per hour. Calculate the percent excess air. 4 + 5 + 5

4. Methane is burnt with stoichiometric proportion of air. The reaction is not complete. All the methane that burns is converted to carbon dioxide. If methane and air enter the combustor at 300 K and the total products including unburned methane and unused oxygen leave at 680 K, what percentage of methane is burnt ? The water thus formed leaves the reactor in vapor state.

Date : $\Delta H_r = -0{\cdot}82028 \times 10^6$ J/mole for water in vapour form

C_p for $O_2 = 30{\cdot}98$ J/mol-K

C_p for $N_2 = 29{\cdot}68$ J/mol-K

C_p for $CH_4 = 45{\cdot}55$ J/mol-K

C_p for $CO_2 = 43{\cdot}87$ J/mol-K

C_p for water vapour = $34{\cdot}94$ J/mol-K 14

5. a) A dryer is used to dry 100 kg/hr wet solids from 20% to 1% moisture by weight by air. Fresh air containing $0 \cdot 025$ kg water vapour per kg dry air is available at a temp. of 30°C and 760 mm Hg. Air leaving the dryer is found to contain $0 \cdot 1$ kg water vapour per kg dry air. If recycle ratio (recycle air/fresh air) is maintained at 3 kg dry air in recycle air per kg dry air in fresh air, Calculate the volumetric flow rate of fresh air assuming mol. wt. of fresh air is $28 \cdot 8$.
(Gas constant R = $0 \cdot 082$ m^3-atm/kmol-K)

b) An evaporator is fed with 12000 kg/hr of weak solution of caustic soda (18% by weight) and is concentrated to get thick liquor containing 40% caustic soda.
Calculate
a) water evaporated in kg/hr
b) thick liquor in kg/hr. 9 + 5

6 a) Calculate the per cent oxide composition of the glass using the following batch composition :
Sand – 1000 parts
Soda ash – 350 parts
Salt cake – 6 parts
Burnt dolomite – 100 parts
Borax – 35 parts
K-feldspar – 55 parts.

b) Determine the batch composition to yield a glass of composition $SiO_2 - 67\%$; $Al_2O_3 - 3 \cdot 0\%$; $CaO - 13\%$; $Na_2O - 11\%$; $K_2O - 6\%$. Using sand (99% pure); feldspar ($SiO_2 - 65\%, Al_2O_3 - 19\%$ & $K_2O - 16\%$); limestone 98% pure; K_2CO_3 ($K_2O - 65\%$) and soda ash (97% pure) as raw materials. 5 + 9

7. a) Calculate the formula of a glaze with a batch of :

lead bisilicate	171·5
whiting	23·0
stone	120·4
china clay	32·2
flint	30·0

the formula of the stone is

$0 \cdot 28\,CaO$

$0 \cdot 62\,K_2O$ $\quad Al_2O_3.7SiO_2$

$0 \cdot 10\,Na_2O$

b) Calculate the batch composition for the frit with formula

$0 \cdot 30\,Na_2O$ $\qquad\qquad$ $2 \cdot 00\,SiO_2$

$0 \cdot 10\,K_2O$ $\quad 0 \cdot 18 Al_2O_3$ $\quad 0 \cdot 60\,B_2O_3$

$0 \cdot 60\,CaO$

using borax, whiting, feldspar, china clay and flint as raw materials. 10 + 4

8. Fritted glaze has the following formula :

$0 \cdot 10\,K_2O$ $\qquad\qquad$ $2 \cdot 65\,SiO_2$

$0 \cdot 20\,Na_2O$ $\quad 0 \cdot 27 Al_2O_3$ $\quad 0 \cdot 40\,B_2O_3$

$0 \cdot 44\,CaO$

$0 \cdot 26\,PbO$

Calculate the batch compostion of borax frit and the mill batch using feldspar, borax, whiting, red lead, china clay and flint as raw material. 14