Name : .....

Roll No. : .....

Invigilator's Signature : .....

CS/B.Tech(FT-(O))/SEM-3/FT-303/2011-12

2011

PROCESS CALCULATIONS, THERMODYNAMICS & FOOD SCIENCE

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.

Semi-log graph sheet will be provided by the institution on demand.

GROUP – A

(Multiple Choice Type Questions)

1. Choose the correct alternatives for the following : $10 \times 1 = 10$

i) Carbohydrate content of cereals is

a) 50% b) 20%

c) 80% d) none of these.

ii) The dimensionless ratio fugacity coefficient is represented by

a) $\frac{f_i}{P}$ b) $\frac{f_i}{T}$

c) f_i d) $f_i P$.

iii) A correlation is represented by $Y = 0{\cdot}687\,X$. The type of graph paper fitted for this equation will be

a) semi-log b) log-log

c) rectangular d) none of these.

iv) Recycle ratio of process can be given by

a) input/output

b) output/input

c) (output – input) / input

d) none of these.

v) Lactose is a

a) monosaccharide b) disaccharide

c) polysaccharide d) oligosaccharide.

vi) Dry bulb temperature is higher than wet bulb temperature.

a) True b) False.

vii) For real gas $dH = C_p\ dT$.

a) True b) False.

viii) Work done in isothermal process is less than that in adiabatic process.

a) True b) False.

ix) The accuracy of graphical integration using Simpson's rule is greater than that using trapezoidal rule.

a) True b) False.

x) Heat of neutralization for all acid-base is same.

a) True b) False.

GROUP – B

(Short Answer Type Questions)

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

2. Prove that $dH = C_p \, dT + [V - T (\delta V / \delta T)_p] \, dP$.

3. Write in brief the essential steps to be followed to solve material balance problems.

4. Define coefficient of performance of a refrigeration cycle. Derive an expression for the amount of heat absorbed by the regenerator.

5. Describe the nutritional importance of fat and oil in the diet.

6. What is residual property ? Derive Maxwell relation

$$\left(\frac{\delta T}{\delta P}\right)_s = \left(\frac{\delta V}{\delta S}\right)_p .$$

7. Write the effect of temperature on enthalpy.

GROUP – C

(Long Answer Type Questions)

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

8. a) What is the basic material balance equation ? Define Limiting reactant and Excess reactant in a chemical process. 5

b) Estimate the consumption of 96% NaCl and 93% H_2SO_4 for the production of 600 kg HCl if the conversion is 95%. Also calculate the amount of Na_2SO_4 produced during the process. HCl is produced according to the reaction :

$2NaCl + H_2SO_4 = Na_2SO_4 + 2HCl.$

Molecular weights of NaCl, H_2SO_4, Na_2SO_4 and HCl are 58·5, 98, 142 and 36·5 respectively. 10

9. a) Calculate the reversible work done in compressing of 0·0283 m^3 of mercury at a constant temperature of 273·15 K from 1 atm to 3000 atm. The isothermal compressibility of mercury at 273·15 K is

$$k = 3{\cdot}9 \propto 10^{-6} - 0{\cdot}1 \propto 10^{-9} P$$

where P is in atm and k is in atm^{-1}. 7

b) A nuclear power plant generates 750 MW, the reactor temperature is 588·15 K and a river with water temperature of 193·15 K is available. What is the maximum possible thermal efficiency of the plant and what is the minimum rate at which heat must be discarded to the river ? If the actual thermal efficiency of the plant is 60% of maximum, at what rate must heat be discarded to the river and what is the temperature rise of the river if it has a flow rate of 165 $m^3 s^{-1}$?

8

10. The Arrhenius equation which relates the rate of reaction with temperature is as follows :

$K = Ae^{-E/RT}$

where K = Specific reaction rate (sec^{-1})

A = Frequency factor (sec^{-1})

E = Base of natural logarithms

R = Gas constant, g-cal/g mole (0 K)

T = Absolute temperature (0 K)

By investigating a certain chemical reaction, the following data were obtained :

Temperature (T)

°C	K	1/T	K
100	273·16	$3{\cdot}661 \propto 10^{-3}$	$1{\cdot}055 \propto 10^{-16}$
110	283·16	$3{\cdot}532 \propto 10^{-3}$	$1{\cdot}070 \propto 10^{-15}$
120	293·16	$3{\cdot}411 \propto 10^{-3}$	$9{\cdot}25 \propto 10^{-15}$
130	303·16	$3{\cdot}299 \propto 10^{-3}$	$6{\cdot}94 \propto 10^{-14}$
140	313·16	$3{\cdot}193 \propto 10^{-3}$	$4{\cdot}58 \propto 10^{-12}$
150	323·16	$3{\cdot}085 \propto 10^{-3}$	$3{\cdot}19 \propto 10^{-12}$

Using the data in the table evaluate E and A of the Arrhenius equation with the help of semi-log graph paper.

11. a) In a continuous fermentation process for ethanol from a sugar substrate, the sugar is converted to ethanol and part of it is converted to a yeast cell mass. Consider a 1000 L continuous fermenter operating in a steady state. Cell free substrate containing 12% glucose enters the fermenter. The yeast has a generation time of 1·5 hr and the concentration of the yeast cells within the fermenter is $1 \propto 10^7$ / ml. Under this condition a dilution rate (F/V where *F* is the rate of feeding of cell free substrate and *V* is the volume of fermenter) which causes the cell mass to stabilize at a steady state results in a residual sugar content in the overflow of 1·2% the stoichiometric sugar : dry cell mass ratio is 1 : 0·5 on a weight basis, and the sugar : ethanol ratio is based on 2 moles of ethanol produced per mole of glucose. A dry cell mass of 4·5 gm/L is equivalent to a cell count of 1·6 $\propto 10^7$ /ml. Calculate the ethanol productivity of the fermenter in gm ethanol/L-h. 10

b) Calculate the specific heat of orange juice concentrate having a solid content of 45%. 5

12. Describe the subjective methods of evaluation of food flavour. What are the limitations of sensory evaluation of food ? Describe the triangle test. How can you formulate Hedonic scale for flavour assessment ? 5 + 2 + 3 + 5

13. Write short notes on any *three* of the following : 3 × 5

i) Linde liquefaction process

ii) Choice of refrigerant

iii) Effect of recycle on the fractional yield of a process

iv) Role of crude fibre in food

v) Food colour measurement instruments.