



Name : .....

Roll No. : .....

Invigilator's Signature : .....

**CS/B.Tech(BT)/SEM-3/BT-304/2009-10  
2009**

**INDUSTRIAL STOICHIOMETRY**

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.*

*Log-log graph paper(s) will be provided by the institution.*

**GROUP – A**

**( Multiple Choice Type Questions )**

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

$$10 \times 1 = 10$$

- i) Volume percent for gases is equal to
  - a) weight per cent
  - b) mole per cent
  - c) mole per cent only for ideal gas
  - d) none of these.
- ii) Average molecular weight of air is about
  - a) 21
  - b) 29
  - c) 23
  - d) 79.
- iii) A gas mixture contains 14 kg of  $N_2$ , 16 kg of  $O_2$  and 17 kg of  $NH_3$ . The mole fraction of  $O_2$  is
  - a) 0.16
  - b) 0.33
  - c) 0.66
  - d) 0.25.



- iv) For a constant pressure of a gas, heat added is equal to
- enthalpy change
  - entropy change
  - potential energy change
  - internal energy change.
- v) Combustion is an/a
- anaerobic process
  - aerobic process
  - slow process
  - none of these.
- vi) Dimension of force is
- $ML^{-1} T^{-3}$
  - $ML^{-3}$
  - $L^{-2} T^{-1}$
  - $MLT^2$  .
- vii) Steady flow process is the one where
- variables are changing with time
  - variables are independent of time
  - no continuous stream of material enter of leave the system
  - none of these.
- viii) For any component mixture, mole fraction and volume fraction are
- equal
  - mole fraction is less than volume fraction
  - mole fraction is more than volume fraction
  - none of these.
- ix) Choose the incorrect relationship :
- $C_p - C_v = R$
  - $C_p - C_v = P ( dV / dT )$
  - $dE = C_v dT$
  - $C_p - C_v = V ( dV / dT )$ .



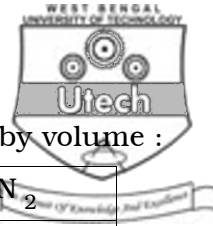
- x) Weight fraction of any component expressed as
- ratio of the moles of the components to the total mass of the mixture
  - ratio of the mass of the component to the total moles of the mixture
  - ratio of the mass of the component to the total mass of the mixture
  - none of these.
- xi) Significance of Reynolds number is
- inertia force / viscous force
  - pressure force by gravity force
  - molecular diffusivity of momentum / molecular diffusivity of heat
  - wall heat transfer rate / heat transfer by conduction.
- xii) Identify the odd one :
- 760 mm of Hg
  - 101.325 kPa
  - 10 bar
  - 14.7 psi.

**GROUP – B**

**( Short Answer Type Questions )**

Answer any *three* of the following.  $3 \times 5 = 15$

2. Oxygen is prepared according to the equation  $2 \text{KClO}_3 = 2 \text{KCl} + 3 \text{O}_2$ . What is the yield of oxygen when 9.12 grams of potassium chlorate are decomposed? How many grams of potassium chlorate must be decomposed to liberate 2.5 grams of oxygen?

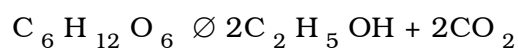


3. A chimney gas has the following composition by volume :

| CO <sub>2</sub> | CO   | O <sub>2</sub> | N <sub>2</sub> |
|-----------------|------|----------------|----------------|
| 9.5%            | 0.2% | 9.6%           | 80.7%          |

Using ideal-gas law, calculate

- its composition by weight
  - volume occupied by 1.0 lb of the gas at 80°F and 29.5 in Hg pressure
  - partial pressure of the components.
4. Dilute sulphuric acid has to be added to dry charged batteries at service stations to activate a battery. You are asked to prepare a batch on new 18.63% acid as follows. A tank of old weak battery acid (H<sub>2</sub>SO<sub>4</sub>) solution contains 12.43% H<sub>2</sub>SO<sub>4</sub> (the remainder is pure water). If 200 kg of 77.7% H<sub>2</sub>SO<sub>4</sub> is added to the tank and the final solution is to be 18.63% H<sub>2</sub>SO<sub>4</sub>, how many kilograms of battery acid have been made?
5. Derive energy balance equation for steady flow process and for a non-flow process at constant volume.
6. Estimate the theoretical growth and product yield coefficients for ethanol fermentation by *S. cerevisiae* as described by the following overall reaction :





**GROUP – C**

( Long Answer Type Questions )

Answer any *three* of the following.  $3 \times 15 = 45$

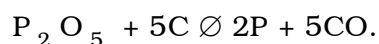
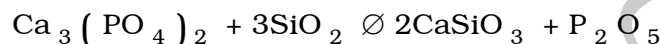
7. The following data have been gathered from an experiment meant to determine the relationship which exists between the diameter of a ring and its period of oscillation as a pendulum. Each diameter was measured and each period was determined by measuring the number of cycles per unit of time.

|                             |       |       |       |      |      |
|-----------------------------|-------|-------|-------|------|------|
| <b>Ring Diameter ( cm )</b> | 3.51  | 7.26  | 13.7  | 28.5 | 38.7 |
| <b>Time period ( sec.)</b>  | 0.374 | 0.532 | 0.768 | 1.08 | 1.32 |

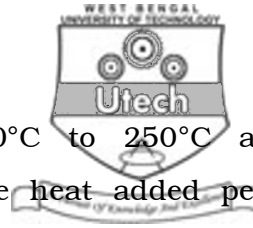
These data follow a relationship of the form  $T = Ad^n$  where  $T$  is the period of oscillation,  $A$  is the constant of proportionality,  $d$  is the diameter of the ring and  $n$  is a constant. Find out the values of  $A$  and  $n$  using log-log graph paper. 15

8. Phosphorus is prepared by heating in the electric furnace a thoroughly mixed mass of calcium phosphate, sand and charcoal. In a certain charge, silica used is 10% in excess of that theoretically required to combine with all the Ca to form the silicate and charcoal used is 40% in excess of that required to combine as carbon monoxide, with the oxygen that would accompany all the phosphorus as the pentoxide.

- Calculate the composition of the original charge.
- If the decomposition of the phosphate is 90% complete and reduction of the pentoxide is 70% complete, calculate the amount of phosphorus produced per 100 kg of charge.



8 + 7



9. a) Pure methane is heated from 30°C to 250°C at atmospheric pressure. Calculate the heat added per Kmol methane.

$$C_p = a + bT + cT^2 + dT^3 \text{ kJ / ( kmol.K )}$$

$$a = 19.2494$$

$$b = 52.1135 \times 10^{-3}$$

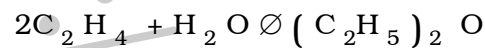
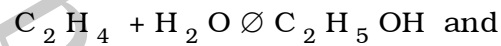
$$c = 11.973 \times 10^{-6}$$

$$d = - 11.3173 \times 10^{-9}$$

- b) Justify that change in internal energy of a gas equals the heat added at constant volume process. 12 + 3
10. An aqueous solution of  $\text{Na}_2\text{CO}_3$  contains 15% carbonate by weight. 80% of the carbonate is recovered as  $\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$  by evaporation of water and subsequent cooling to 278 K. The solubility of  $\text{Na}_2\text{CO}_3$  at 278 K is 9% ( weight ). On the basis of 100 kg solution treated, determine the following :
- a) The quantity of crystal formed
- b) The amount of water evaporated. 15
11. a) Define per cent conversion, per cent yield, per cent excess and limiting reactant.



b) In the vapour phase hydration of ethylene to ethanol, diethyl ether is obtained as a byproduct as per the following reactions :



A feed mixture consisting of 60% ethylene, 3% inerts and 37% water is sent to the reactor. The products analyzed 53.89% ethylene, 14.37% ethanol, 1.80% ether, 26.35% water and 3.59% inerts. Calculate the conversion of ethylene, yield of ethanol and ether based on ethylene.

4 + 11