

**II B.Tech I Semester Supplementary Examinations, May 2005**  
**MATERIALS AND ENERGY BALANCE**  
**(Chemical Engineering)**

Time: 3 hours

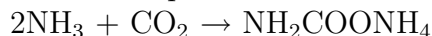
Max Marks: 70

Answer any FIVE Questions  
All Questions carry equal marks

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1. A natural gas has the following composition, all figures being in volumetric percent:  
Methane,  $\text{CH}_4 = 80\%$   
Ethane,  $\text{C}_2\text{H}_6 = 15\%$   
Nitrogen,  $\text{N}_2 = 5\%$   
Calculate:
  - (a) Composition in mole percent.
  - (b) Composition in weight percent.
  - (c) Average molecular weight.
  - (d) Density at standard conditions,  $\text{kg/m}^3$ .
2. (a) State and explain:
  - i. Daltons law
  - ii. Amagat's law.(b) Prove that for an ideal gas mixture, the pure component volume of a component of the gaseous mixture is equal to the product of the total volume and the mole fraction of that component.
3. (a) Define
  - i. Vapour pressure.
  - ii. Normal boiling point.(b) Differentiate a gas and a vapour.
- (c) Write about the effect of change in temperature and pressure on vapour pressure of substances.
4. Air at a temperature of  $20^\circ\text{C}$  and pressure of 750 mm Hg has a relative humidity of 80%. Calculate the following:
  - (a) The molal humidity of the air.
  - (b) The molal humidity of the air if its temperature is reduced to  $10^\circ\text{C}$  and its pressure is increased to 2.4 atm, condensing out some of water.
  - (c) The weight of the water condensed from  $1000 \text{ m}^3$  of the original wet air in cooling and compressing to the conditions of part (b).
  - (d) The final volume of the wet air of part (c).  
Vapour pressure of water:  
 $17.5 \text{ mm Hg}$  at  $20^\circ\text{C}$ .  
 $9.2 \text{ mm Hg}$  at  $10^\circ\text{C}$ .

5. Urea is produced by reacting  $\text{NH}_3$  and  $\text{CO}_2$  to form ammonium carbamate which then decomposes to urea and water as per the following reactions



If only 60% of the ammonia takes part in the desired reaction and 1000kg of urea are to be produced Calculate

- (a) The volume of  $\text{NH}_3$  to be fed at NTP.
  - (b) The quantity of water produced.
6. The dry flue gas from an oil fired furnace has a composition of 11.2%  $\text{CO}_2$ , 5.8%  $\text{O}_2$ , and 83%  $\text{N}_2$  when analysed by an orsat apparatus. Calculate
- (a) % excess air and
  - (b) Weight of combustion air used per Kg of oil fired. Assume fuel to have 82% C, 12% H, 3% S and balance impurities. Molecular weight of dry gas is 30.

7. Flue gases leaving a stack at  $300^\circ\text{C}$  have an overall molar composition of 8.2%  $\text{CO}_2$ , 2.7%  $\text{CO}$ , 2.7%  $\text{H}_2\text{O}$ , 9.4%  $\text{O}_2$  and the rest  $\text{N}_2$ . Calculate the heat lost in 100 kg moles of this gas basing the gas on a datum temperature of  $35^\circ\text{C}$ . Assume water is in the vapor form. The constants for  $C_p$  are as follows:

Gas	a	b x $10^3$	c x $10^6$
$\text{CO}_2$	7.7	5.30	-0.83
$\text{CO}$	6.6	1.20	—
$\text{H}_2\text{O}$ (vapor)	8.2	0.15	1.34
$\text{O}_2$	6.8	0.61	0.13
$\text{N}_2$	6.8	0.61	0.13

Where  $C_p$  is in cal/g mol K and T is in K.

8. (a) State Hess law
- (b) How much heat is absorbed or removed from the following reaction



i. use heat of formation data

ii. use of heat of combustion data

heat of formation in kcal/mol :  $\text{C}_2\text{H}_6 = -20.236$ ,  $\text{C}_2\text{H}_2 = -54.194$

heat of combustion data in kcal/mol :  $\text{C}_2\text{H}_6 = -372.82$

$\text{C}_2\text{H}_2 = -310.615$  ;  $\text{H}_2 = -68.317$

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