B.TECH/BT/3RD SEM/BIOT 2102/2018
INDUSTRIAL STOICHIOMETRY
(BIOT 2102)

Time Allotted : 3 hrs **Full Marks : 70**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 5 (five) from Group B to E, taking at least one from each group.

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

Group – A
(Multiple Choice Type Questions)

1. Choose the correct alternative for the following: **10 × 1 = 10**

(i) Consider the following balanced equation:
$4NH_3 + 5O_2 = 4NO + 6H_2O$
How many grams of O_2 (formula wt = 32.0) are required for the complete reaction of 162 g of NH_3 (formula wt = 17.0)?
(a) 108 (b) 381 (c) 244 (d) None of these.

(ii) For a gaseous mixture, composition of the components in volume percent is equal to their composition
(a) in weight % (b) in mole % (c) both (d) none.

(iii) When temperature of the vapour liquid mixture is more than its bubble point but less than its dew point, then it is a
(a) subcooled liquid mixture (b) saturated liquid mixture
(c) Equilibrium vapour liquid mixture (d) Saturated vapour mixture.

(iv) How much heat must be added in order to raise the temperature of a 20%(w/w) caustic soda solution from 280K to 360K. (Mean heat capacity of the solution is 3.635KJ/(Kg.K)).
(a) 291KJ (b)291KJ/kg (c) 58.2KJ (d)58.2KJ/kg.

(v) A vapor whose partial pressure is less than its equilibrium vapor pressure is called a _____ vapor.
(a) Saturated (b) Unsaturated
(c) Supersaturated (d) subcooled.

(vi) 2 litres of nitrogen at N.T.P. weighs _____ gms.
(a) 2.5 (b) 1.25 (c) 28 (d) 14.

(vii) A flue gas mixture has the following molar composition of CO_2= 10%, H_2O= 25%, O_2= 20% and N_2= 45%. What will be the molar composition of O_2 in the dry flue gas?
(a)26.67% (b)20% (c)13.33% (d) Cannot be determined.

(viii) Which of the following statement is false?

(a) Change in internal energy equals the heat added in a constant volume process.
(b) In constant pressure process heat transferred is equal to the enthalpy of the body.
(c) $C_pdT = dE+PdV$, E is internal energy.
(d) $C_vdT = dE+ PdV$, E is the internal energy.

(ix) When the temperature of a binary mixture is less than its bubble point then it is a
(a) Saturated liquid mixture
(b) Equilibrium vapour liquid mixture
(c) Saturated vapour mixture
(d) Subcooled liquid mixture.

(x) Degree of reduction of $C_3H_7O_2N$
(a) 3.33 (b) 10 (c) 4.33 (d)13.

Group – B

2. (a) Use the following data to predict the equation of best fit straight line by Least Square Analysis.

x	0	1	2	3	4
y	1	5	10	22	38

(b) Define (i) absolute error (ii) relative error

9 + 3 = 12

3. (a) The heat capacity equation of CO_2 is as follows:
$C_p = 6.339 + 10.14 \times 10^{-3}Tk - 3.415 \times 10^{-6}Tk^2$
Where C_p = heat capacity as gcal/(gmol.^oK)
T_k = absolute temperature in Kelvin
Transform the equation in a new form where Cp′ is the heat capacity in Btu/(lb.^oF) and temperature (T_f) is in Fahrenheit Scale.

(b) Stainless steel (type 304) has a thermal conductivity K of 16.2 Btu/(hr.ft.^oF). Convert this value of thermal conductivity into gcal/(sec.cm. ^oC)

8 + 4 = 12

Group – C

4. (a) 2000 lit/hr of solution of benzene and toluene (Sp. Gr. 0.872), containing 0.45kg of benzene/kg of mixture is continuously distilled in a column. Distillate is found to contain 0.95 kg of benzene/kg of mixture and waste solution from the column carries 8% benzene in the feed. All % are given in terms of weight %. Find out:
(i) Mass flow rate of the distillate and the waste stream.
(ii) Composition of the waste stream.

(b) A fuel cell can run with methanol or ethanol. Two methanol-ethanol mixtures are contained in separate flasks. The first mixture contains 75 wt% methanol and second mixture contains 50wt% methanol. If 8 gm of first mixture is mixed with 5 gm of second mixture, what is the mass composition of the final mixture?

8 + 4 = 12

5. Production of single cell protein from hexadecane is described by the following reaction equation:

$C_{12}H_{34} + a\,O_2 + bNH_3 \rightarrow cCH_{1.66}O_{0.27}N_{0.20} + dCO_2 + eH_2O$

Where $CH_{1.66}O_{0.27}N_{0.20}$ represents the biomass. If RQ= 0.43, determine the stoichiometric coefficients.

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Group – D

6 Pyrites fines are roasted in a chamber plant for making sulphuric acid. The gases leaving the roaster are at 775K and have molar composition SO_2= 7.09%, O_2= 10.55%, SO_3= 0.45% and N_2= 81.91%. Calculate the heat content of 1 kmol gas mixture over 298K, using the following heat capacity data. $C_p=a+bT+cT^2+dT^3$kJ/kmol.K

Compounds	a	b × 10^3	c × 10^6	d×10^9	e×10^{12}
SO_2	2.346	-5.67	6.345	-234.1	-
O_2	5.243	6.997	-4.234	7.865	-
SO_3	9.876	-432.98	79.567	-4568	-
N_2	12.765	789.765	-567.98	9.766	-

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7. (a) Calculate the heat of formation of liquid 1,3-butadiene, where the heats of combustion of 1,3-butadiene, carbon and hydrogen are -2522.1KJ/mol, -393.51KJ/mol and -241.82KJ/mol respectively.

(b) Water from a tank at a height Z_1m from the ground is pumped with a velocity U_1m/s into a reactor containing $CaCO_3$ resulting in an exothermic reaction. The product is transferred into a reservoir at a height Z_2m from the ground at a velocity of U_2m/s. Balance the energy components considering a steady flow process.

6 + 6 =12

Group – E

8. *Azetobacter vinelandii* is used to produce alginate in a continuous reactor from sucrose at room temperature. The yield of alginate was 4g/gof O_2 consumed. The required rate of alginate production was 5kg/h. The mechanical energy requirement to run the reactor could not be neglected and power requirement was estimated to be 1.5kW. Estimate the cooling requirements. (energy released per gmole of electron transferred = -115kJ)

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9. Steam is used to heat nutrient medium in a continuous flow process. Saturated steam at 150˚C enters a coil on the outside of the heating vessel and is completely condensed. Medium enters the vessel at 15˚C and leaves at 44˚C. Heat losses from the jacket to the surroundings are estimated as 0.22KW. If the flow rate of medium is 3250kg/h and the heat capacity is C_p=0.9Cal/(g.˚C), how much steam is required?

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