(v) 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) 244 (c) 381 (d) 202.

(vi) The temperature at which the first drop of liquid is formed is known as

(a) Bubble point (b) Dew point
(c) Critical point (d) Supercritical point.

(vii) Which of the following statements is NOT true?

(a) 4gmol of O_2 is equal to 4 available electrons.
(b) Vapour-liquid mixture has a range of boiling points.
(c) Gauge pressure = Absolute pressure – Atmospheric pressure
(d) Change in internal energy is equal to the heat added at constant pressure.

(viii) When temperature of the vapour liquid mixture is less than its bubble point, then it is a

(a) subcooled liquid mixture
(b) saturated liquid mixture
(c) equilibrium vapour liquid mixture
(d) saturated vapour mixture.

(ix) Calculate the heat gained by one kmol of a gas whose heat capacity is given by C_p = a+ bT KJ/(kmol.K) where a= 5 and b= 0.2, when it is heated from 500K to 700K

(a) 25000KJ (b) 25000KW
(c) 2500KW (d) None of the above.

(x) 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) CpdT= dE+PdV, E is internal energy.
(d) CvdT =dE+ PdV, E is the internal energy.

Group - B

2. The following table gives the atomic heat capacity (Cp) of graphite at constant pressure for temperature ranging from 296-600K. From the data given, determine the heat absorved (Q) when one gram atom of graphite is heated from 296-500K, by graphical integration method.

Group - E

8. Citric acid is manufactured using submerged culture of *Aspergillus niger* in a batch reactor operated at 30°C. Over a period of two days, 2500kg glucose and 860kg oxygen are consumed to produce 1500kg citric acid, 500kg biomass and other products. Ammonia is used as nitrogen source. Power input to the system by mechanical agitation of the broth is about 15kW; approximately 100kg water is evaporated over the culture period. Estimate the cooling requirements.
Latent heat of vapourization of water at 30°C is 2430.7kJ/kg.

12

9 *Saccharomyces cerevisiae* is grown anaerobically in continuous culture at 30°C. Glucose is used as carbon source; ammonia is the nitrogen source. A mixture of ethanol and glycerol is produced. At steady state, mass flows to and from the reactor are as follows:
Glucose in: 36kg/h
NH_3 in: 0.4kg/h
Cell out: 2.81k/h
Glycerol out: 7.94kg/h
Ethanol out:11.9kg/h
CO_2 out:13.6kg/h
H_2O out: 0.15kg/h
Estimate the cooling requirements.
Heat of combustion of glucose= -2805kJ/mol
Heat of combustion of NH_3= -382.6kJ/mol
Heat of combustion of glycerol= -1655.4kJ/mol
Heat of combustion of ethanol= -1366.8kJ/mol
Molecular weight of glycerol is 92.

12

B.TECH/BT/3RD SEM/BIOT 2102/2016

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) Validity of the relationship, inputs = outputs, holds good for the system at steady state
   (a) Without chemical reaction
   (b) Without chemical reaction and losses
   (c) With chemical reaction
   (d) None of these.

   (ii) Which of the following ratios defines the recycle ratio in a chemical process?
   (a) Gross feed stream/recycle feed stream
   (b) Recycle stream/fresh feed stream
   (c) Recycle stream/gross feed stream
   (d) None of these.

   (iii) If the pressure of a gas is reduced to half & its absolute temperature is doubled, then the volume of the gas will
   (a) increase two times.
   (b) increase four times.
   (c) be reduced to l/4th.
   (d) none of these.

   (iv) A bypass stream in a chemical process is useful, because it
   (a) facilitates better control of the process.
   (b) increases the yield of products.
   (c) improves the conversion.
   (d) none of these.

Q= $\int_{296}^{500} CpdT$.

Temperature (T) (°K)	296	400	500	600
Cp (Joule/gatom.°K)	2.066	2.851	3.496	4.03

12

3 The following data has been gathered from an experiment to determine the relationship which exist between the diameter of a ring and its period of oscillation.
$T=Ad^n$

Ring dia (d), cm	3.51	7.26	13.7	28.5	38.7
Time period (T), min	0.376	0.532	0.768	1.08	1.32

Find out the value of A and n using log- log graph paper.

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 bottom product from the column carries 8% of benzene in the feed. All % are given in terms of weight %. Find out:
(i) Mass flow rate of the distillate and the bottom product.
(ii) Composition of the bottom product.

(b) The effluent from a coal gasifier contains 52 mol% CO, 39 mol% H_2, 9 mol% CO_2. The stream is mixed with steam before it enters a water shieft reactor where the additional hydrogen is formed. You require a molar feed of steam that is 10% larger than the CO flow rate. Determine the composition of the water shieft reactor feed in terms of mole fraction of constituents.

(4 + 4) + 4 = 12

5. A mixture of acetone vapour and N_2 gas at 101.32 KPa and 295K contains acetone vapour to an extent that it exerts a partial pressure of 15 KPa. The vapour pressure of acetone at 295K is 26.36 KPa. Determine the following:
(i) Mole fraction of acetone in the mixture
(ii) Weight fraction of acetone in the mixture
(iii) The molal humidity
(iv) The absolute humidity
(v) The molal saturation humidity
(vi) The absolute saturation humidity.

2 × 6 = 12

B.TECH/BT/3RD SEM/BIOT 2102/2016

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BIOT 2102 3

Group - D

6. (a) Combustion of solid wastes produces a flue gas of the following composition: CO_2 = 9%, CO = 2%, O_2 = 7% and N_2 = 82%. Find the difference in enthalpies for this gas between the bottom and the top of the stack if the temperature of the gas at the bottom is 600K and that at the top is 375K. The heat capacities of the gas are:

CO: $C_p = 26.586 + 7.582 \times 10^{-3}T - 1.12 \times 10^{-6}T^2$

CO_2: $C_p = 26.540 + 42.454 \times 10^{-3}T - 14.298 \times 10^{-6}T^2$

O_2: $C_p = 25.74 + 12.987 \times 10^{-3}T - 3.864 \times 10^{-6}T^2$

N_2: $C_p = 27.03 + 5.815x10^{-3}T - 0.289 \times 10^{-6}T^2$ where C_p is in KJ/(Kmol.K) and T is in K.

(b) Explain vapour-liquid equilibrium of a binary mixture of n-pentane and n-hexane.

9 + 3 = 12

7. (a) Calculate the energy required to dissociate a kilogram of sodium bicarbonate into sodium carbonate, carbon-di-oxide and water at 298K.

Heat of formation of sodium bicarbonate, kJ/mol	Heat of formation of sodium carbonate, kJ/mol	Heat of formation of carbon di oxide, kJ/mol	Heat of formation of water, kJ/mol
-950.81	1130.68	-393.51	-241.82

(b) A thermic fluid is used as a heating medium in a particular process. A pump sucks the thermic fluid at atmospheric pressure and 473 K. The circulation rate is 10,000 lph. The fluid discharged from the pump, passes through a heater where it receives the heat from product gases of combustion. The heat transfer rate is 232.6 kW. The motor of the pump consumes 1.1 kW. The overall mechanical efficiency of the pump and motor is 50%. The pressure of the fluid at the outlet of the heater is 100 kPag. Assume negligible kinetic energy and potential energy changes, negligible frictional losses and no heat loss to the surrounding. If the mean specific gravity and the mean heat capacity of the fluid are 0.75 and 2.68 kJ/(kg.K) respectively at the operating conditions, calculate the outlet temperature of the fluid.

4 + 8 = 12

B.TECH/BT/3RD SEM/BIOT 2102/2016

Group - D

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4 + 8 = 12

BIOT 2102 4