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 alternatives for the following: 10 x 1=10

(i) The limiting reagent in a chemical reaction is one that
- (a) has the largest molar mass (formula weight).
- (b) has the smallest molar mass (formula weight).
- (c) has the smallest coefficient.
- (d) is consumed completely.

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

(iii) The objective of material and energy balance is to assess the
- (a) input-output (b) conversion efficiency
- (c) losses (d) all the above.

(iv) The heat gained by one kmol of a gas when heated from 500K to 700K whose heat capacity is given by $C_p = a + bT$ KJ/(kmol.K) (where a= 5 and b= 0.2) is
- (a) 25000kW (b) 25000kJ
- (c) 2500kW (d) None of the above.

(v) 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.

(vi) In a chemical process A (200 kg)and B (200kg) are used as two reactants. If conversion is 50% and A and B reacts in equal proportion then calculate the weight of the product formed.
(a) 150 kg (b) 200 kg (c) 250 kg (d) 400 kg

(vii) If feed of 100 tonnes per hour at 5% concentration is fed to a crys product obtained at 25%concentration is equal to ___ tonnes per hou
(a) 20 (b) 25 (c) 35

(viii) When temperature of the vapour liquid mixture is less than its dew po is a
(a) subcooled liquid mixture
(b) saturated liquid mixture
(c) Equilibrium vapour liquid mixture
(d) Saturated vapour mixture.

(ix) Degree of freedom of a binary mixture of ethanol and water is
(a) more than one
(b) less than one
(c) one
(d) Indeterminate.

(x) Mass balance equation for unsteady state batch process without chemical
(a) In=out (b) In-out=accumulation
(c) In≠out (d) out-in=accumulation.

Group – B

2.(a) Air is pumped through an orifice immersed in liquid. The size of the bubbles the orifice depends on the properties of the liquid. The equation represen situation is

$g(\rho_L-\rho_G)D_b^3/(\sigma Do)=6$ where
g is gravitational acceleration= 32.174 ft/sec2
ρ_L is liquid density =1 gm/cc
ρ_G is gas density 0.081 lb/ft³
σ is gas liquid surface tension = 70.8 dyne/cm
Do is orifice diameter = 1mm.
Calculate the bubble diameter D_b in mm.

(b) P is the power required to drive the impeller installed in a fermente dependent on the following parameter

P=f (n, Di, g, ρ, μ).

where, n is rotational speed, in rpm; Di is impeller diameter; G is gravit acceleration; ρ is density of fermentation broth; μ is viscosity of fermentation Find out the dimensionless parameters involved in this system with the Buckingham pi theorem.

3. The concentration of drug (C_d) in blood during metabolism is related with t $C_d=K e^{(-mt)}$. From the given data, calculate K and m using semi log graph paper. 6 +

Time (hr)	1	2	3	4	5	6
Conc. Of drug (mg/cc)	2.25	1.143	0.63	0.396	0.279	0.09

8 +

Group – C

Propane is dehydrogenated to form propylene in a catalytic reactor

$C_3H_8 \rightarrow C_3H_6+H_2$

The process is to be designed for a 95% overall conversion of propane. The react ion products are separated into two streams. Stream 1 containing H_2, C_3H_6 and 0.555%of propane that leaves the reactor is taken off as a product. Stream 2 contains the balance of the un-reacted propane and 5% of the propylene in the product stream and this stream 2 is recycled to the reactor. Calculate the composition of the product, recycle ratio and single pass conversion.

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(a) 10,000 kg /hr of solution containing 20% methanol is continuously distilled in a column. The distillate is found to contain 98% methanol and waste solution from the column carries 1 % methanol. All % are by weight. (i)Calculate the mass flow rate of distillate and bottom product. (ii) Calculate the % loss of methanol.

(b) In a process of Cl_2 manufacture, a dry mixture of HCl gas and air is passed over a heated catalyst which promotes oxidation of acid. Air is used in 30% excess of that theoretically required. Calculate (i) The weight of air supplied per kg of acid. (ii) Composition by weight of the gas entering the chamber. (iii) Assuming that 60% of the acid is oxidised in the process, calculate the composition by weight of the gas leaving the chamber.

5 + 7 = 12

Group – D

6. A heat exchanger for cooling a hot hydrocarbon liquid uses 10,000kg/h of cooling water, which enters the exchanger at 294K. The hot oil at the rate of 5000kg/h enters at 423K and leaves at 338K and has an average heat capacity of 2.51kJ/(kg.K). Calculate the outlet temperature of water. C_p of water= a+ bT+ cT² + dT³ kJ/(kmol.K)

a	b x10³	c x 10⁶	d x10⁹
50.845	213.08	-631.398	648.746

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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
the thermic fluid at atmospheric pressure and 473K. The circula
10,000lph. The fluid discharged from the pump, passes through a hea
receives the heat from product gases of combustion. The heat tra
232.6kW. The motor of the pump consumes 1.1kW. The overall
efficiency of the pump and motor is 50%. The pressure of the fluid at
the heater is 100kPag. Assume negligible kinetic energy and pote
changes, negligible frictional loss and no heat loss to the surrounding
specific gravity and the mean heat capacity of the fluid are 0.75 and 2.
respectively at the operating conditions, calculate the outlet tempera
fluid.

Group – E

8. *Saccharomyces cerevisiae* is grown anaerobically in continuous cultur
Glucose is used as carbon source and ammonia as the nitrogen source. A
ethanol and glycerol is produced. At steady state, mass flows to and from t
at steady state 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.

9. Baker's yeast is produced in a 50,000l fermenter under aerobic condit
carbon substrate is sucrose; ammonia is provided as nitrogen source. The
biomass composition is $CH_{1.83}O_{0.55}N_{0.17}$ with 5% ash. Under efficient
conditions, biomass is the only major product; the biomass yield from s
0.5g/g. If the specific growth rate is $0.45h^{-1}$, estimate the rate of heat
required to maintain constant temperature in the fermenter when t
concentration is 10g/l.

Biochemistry
(BIOT 2103)

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

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

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Group – A
(Multiple Choice Type Questions)

Choose the correct alternatives for the following: **10 x 1=10**

i) The net gain of ATP molecule resulting from complete oxidation of 1 molecule of glucose:
(a)2 (b) 4 (c) 32 (d) 38.

ii) Hexokinase
(a) catalyses transfer of phophate group from ATP to any hexose
(b) catalyses transfer of phophate group from ATP to only glucose
(c) tranfers inorganic phosphate to hexose
(d) converts fructose 6 phosphate to fructose-1,6-bisphosphate.

(iii) TCA cycle is
(a) catabolic (b) amphibolic (c) anabolic (d) cyclic.

(iv) Rubisco binds to
(a) CO_2 (b) O_2 (c) both CO_2 and O_2 (d) none.

(v) Alanine is deaminated to produce
(a) pyruvic acid (b) citric acid (c) oxalic acid (d) fumeric acid.

(vi) Three amino acids that donate amino group for purine biosynthesis are
(a) glycine, glutamine and aspartate
(b) glycine, beta-alanine and aspartate
(c) glycine, alanine and aspartate
(d) lysine , glutamine and asparagine.

(vii) One ketogenic amino acid is
(a) leucine (b) arginine (c) alanine (d) glutamine.

(viii) Palmitic acid is an
(a) odd chain saturated fatty acid (b) odd chain unsatured fatty acid
(c) even chain saturated fatty acid (d) even chain unsaturated fatty acid.