* U F - 8 0 4 3 *

UF-8043

B. E. - II (Sem. III) (Chemical) Examination

May / June – 2012

Process Calculation

(New Syllabus)

Time : **3** Hours] [Total Marks : **100**

Instructions :

નીચે દર્શાવેલ ☛ નિશાનીવાળી વિગતો ઉત્તરવહી પર અવશ્ય લખવી.
Fillup strictly the details of ☛ signs on your answer book.

Name of the Examination :

☛ B. E. - 2 (SEM. 3) (CHEMICAL)

Name of the Subject :

☛ PROCESS CALCULATION (NEW)

☛ Subject Code No. : 8 0 4 3 ☛ Section No. (1, 2,.....) : NIL

Seat No. :

Student's Signature

(2) Attempt all questions.
(3) Figures to the right indicate full marks.
(4) Assume suitable data whenever necessary.

1 (a) Attempt the following : **10**

(i) Give SI unit of power.

(ii) Absolute pressure = _____

Vacuum

(iii) What is NTP ?

(iv) Define excess reactant.

(v) Define Recycle Ratio.

(vi) What is derived unit ?

(vii) Define Normality.

(viii) Convert 2 atm into mm Hg

(ix) Write two values of universal gas constant with units.

(x) Write Dalton's law of partial pressure.

(b) (i) Calculate available nitrogen content of solution having 30% urea ($NH_2\ CONH_2$), 20% ammonium sulphate and 20% ammonium nitrate. **5**

(ii) An evaporator is fed with 15000 kg/h of a solution containing 10% NaCl, 15% NaOH and rest water. In operation water is evaporated and NaCl is precipitated as crystals. The thick liquor leaving the evaporator consists 45% NaOH, 2% NaCl and rest water. **5**

Calculate :

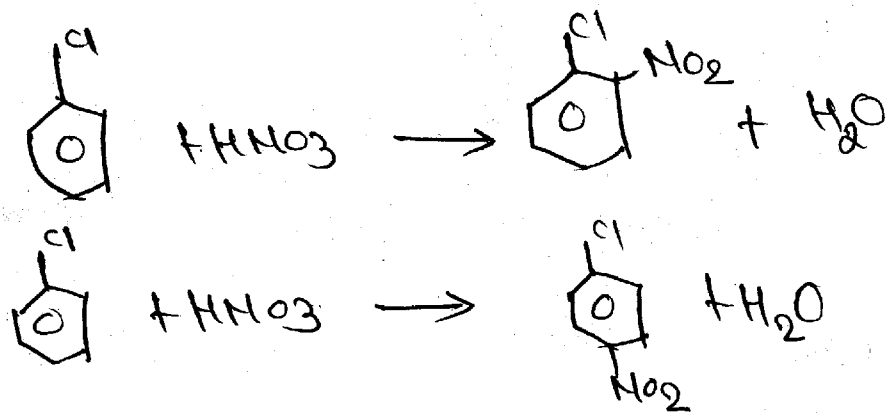
(a) Kg/h water evaporated

(b) Kg/h salt precipitated

(c) Kg/h thick liquor

2 Attempt the following : **7×2=14**

(a) Chlorobenzene is nitrated using a mixture of nitric acid and sulphuric acid. During the pilot plant studies, its charge consists of 100 kg chlorobenzene, 106.5 kg (65.5% by cot) HNO_3, 108 kg (93.6% by weight)H_2SO_4. After two hours of operation, the final mixture was analyzed. It was found that the final product contains 2% unreacted choro benzene. Product distribution shows 66% peranitro benzene and 34% ortho nitro benzene. The chemical reactions involved are :



Calculate :

(i) analysis of charge

(ii) Composition of product mixture.

(b) The spent acid from a nitrating process contains 33% H_2SO_4, 36% HNO_3 and 31% water, by weight. The acid is to be strengthened by addition of concentrated H_2SO_4 containing 96% H_2SO_4 and concentrated HNO_3 containing 78% HNO_3. The concentrated mixed acid is to contain 40% H_2SO_4 and 43% HNO_3. Calculate the quantities of spent acid and concentrated acids that should be mixed to yield 1500 kg of desired mixed acid.

(c) A combustion reactor is fed with 50 kMol/h of butane and 2000 k mol/h of air. Calculate the % excess of air used and composition of the gases leaving the combustion reactor assuming complete combustion of butane.

3 Attempt the following : (any two) **8×2=16**

(a) Ethyl alcohol is industrially produced by fermentation of molasses the molasses sample contains 45% by weight fermentable sugar in the form of sucrose. the reactions taking place in the fermenter are :

$$C_{12}H_{22}O_{11} + H_2O \xrightarrow{Invertase} C_6H_{12}O_6 + C_6H_{12}O_6$$

Sucrose

d-glucose

d-fructose

$$C_6H_{12}O_6 \xrightarrow{Zymaze} 2C_2H_5OH + 2CO_2$$

Monosaccharide

Alcohol

Calculate the theoretical production of rectified spirit having density of 0.785 kg/l in litres per tonne of molasses.

(b) (i) A natural gas has following composition by volume : CH_4 = 82%, C_2H_6 = 12% and N_2 = 6%
Calculate the density of gases at 288 K and 101.325 KPa and composition in weight present.

(ii) The groundnut seeds containing 45% oil and 45% solids are fed to expeller. The cake coming out of expeller is found to contain 80% solids and 5% oil. Find the percentage recovery of oil.

(c) Pure S is burnt in a burner with dry air. O_2 is used 20% excess above that required for the complete combustion of S to SO_3. The efficiency of burner is such that only 30% of the sulphur burns to SO_3 and remainder goes to SO_2. Calculate :

(i) the analysis of resulting mixture into mole % and

(ii) the weight of gas per kg of burnt S.

4 (a) Define the following : 4

(i) GCV = NCV + _____

(ii) Hess law

(iii) Heat of formation

(iv) Specific heat of substance.

(b) A mixture of isomeric diphenyl - diphenyloxides (piphyl DT) is used as a thermic fluid in a liquid heating system. The thermic fluid enters an indirect fired heater at 180°C and leares it at 260°C. The heat capacity of the fluid is given by 4

C_1 = 1.436 + 0.00218 T (kJ/kg.k) where T is in K.

(i) Calculate the supply of heat in the heater per kg of the liquid heated.

(ii) If the heat capacity of Diphul DT at 180°C and 260°C are 2.03 and 2.206 kJ/kg k resp. How much error will be involved in the computation of heat load using the mean heat capacity value ?

(c) The purge gas obtained from ammonia synthesis 100 p has the composition H_2 = 69.0%, N_2 = 23%, Ar = 2.7% and CH4 = 5.3% (mole basis). It is burnt with 20% excess air. Calculate 8

(i) the Gev of mev at 25°C of the purge gas

(ii) theoretical air required and

(iii) the molar composition of the dry flue gases.

5 Attempt any two : **8×2=16**

(a) Calculate the theoretical number of moles of oxygen that must be supplied for combustion of one mol of a gas and the heating value in kg/mol of the gas having the following composition by volume. CO_2 = 5.4%, H_2 = 39.9%, CO = 32.9%, N_2 = 2.6%, O_2 = 0.7%, $C_{2.73}H_{4.22}$ (unsaturates) = 8.4% and $C_{1.14}H_{4.28}$ = 10.1% paratins

Data :

Heating value of H_2 = 285.83 kJ/mol

Heating value of CO = 283.18 kJ mol

Heating value of unsaturates :

411.14 A + 118.06 B + 120.6 when A is No of carbon atoms and 13 is no. of H_2 atoms. Heating value of paraffins = 661.93N + 229 where N is the no. of carbon atoms.

(b) Air containing 21 mole % O_2 and 79 mole % H_2 is to be heated from 303 K to 423 K. Calculate the heat required to be added if the air flow rate is $3m^3$ (NTP) per minute using data given below

$Cp = a+bT + cT^2 + dT^3$, kJ/(k mol k)

Gas	*a*	$b\times10^3$	$c\times10^6$	$d\times10^9$
O_2	26.0257	11.7551	–2.3426	–0.5623
H_2	29.5909	–5.141	13.1829	–4.968

(c) Calculate heat of formation of phenol crystal at 298.15 k from its elements using the following data.

Data :

Standard heat of formation of $CO_{(g)}$ = -393.51 kJ/mol

Standard Heat of formation of H_2O (l) - 285.83 kJ/mol

Heat of combustion of phenol crystals at

298.15 K = -3053.25 kJ/mol

6 Attempt any two : **9×2=18**

(a) A natural gas has the following composition on mole basis.

CH_4 = 84% C_2H_6 = 13% and N_2 = 3%

Calculate

(i) Heat added to heat 2 kmol of gas mixture from 311 K to 533 K

(ii) The heat to be added to heat 200 kg of natural gas from 311 K to 533 K.

Data C^opm values in kJ/kmol k

Gas	$C^o pm(311-298k)$	$C^o pm\ (533-298K)$
CH_4	36.0483	41.7800
C_2H_6	53.5240	67.4954
N_2	29.1317	29.3578

(b) (i) Calculate vapour pressure of (a) n-Hrxane at 32°C and (b) water at 122°C using antonie constants.

Data :

	A	*B*	*C*
n – Hexane	4.00266	1171.53	–48.784
Water	3.55959	643.748	–198.043

(ii) Calculate the heat of formation of ethane gas at 298.15 K from its elements using Hess's law.

Data

Heat of formation of $CO_{2(g)}$ = -393.51 kJ/mol

Heat of formation of $H_2O_{(l)}$ = - 285.83 kJ/mol

Heat of combustion of ethane gas = -1560.69 kJ/mol

at 298.15 k

(c) Methane is oxidised with air to produce formaldehyde as per the following equation :

$CH_{4(g)} + O_{2(g)} \rightarrow HcHO_{(g)} + H_2O_{(g)}$ DHR = -283.094 kJ mol

100 mol of methane are fed to reactor at 311 K, air is used 50% excess and it supplied at 373 K if % conversion is 60, calculate the heat must be removed for the product stream to emerge at 478 K.

Data

Component	$C^{\circ}pm(311.298k)$	$C^{0}pm(478.298k)$
CH_4	36.044	40.193
N_2	–	29.2866
O_2	–	30.0821
$HcHO$	–	41.2902
H_2O	–	34.2396