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RM-6427

B. E. - II (Sem. IV) (Chem.) Examination

May / June – 2010

CH-402 : Process Calculation

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

Instructions :

(1)

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. 4) (Chem.)**

Name of the Subject :

☛ **CH-402 : Process Calculation**

☛ Subject Code No. : **6 4 2 7** ☛ Section No. (1, 2,.....) : **1&2**

Seat No. :

Student's Signature

(2) Answer to each section must be written in **separate** answer books.
(3) Figures to the right indicate full marks.
(4) Assume suitable data if necessary.
(5) Atomic weight : H=1, C=12, O=16, K=39, S=32, Na=23, Cl = 35.5
(6) Use of scientific calculator casio fx 82, 83 or fx 100 or equivalent of other companies are allowed.

SECTION - I

1 (a) Attempt the following : **6×2=12**

(i) $-15^{o}F$ = _____ ^{o}C

(ii) (a) 1 torr is equal to _____ mmHg

(b) 1 kg/dm^3 = _____ Kg/L

(iii) Define conversion and yield

(iv) Convert 5000 ppm into weight %.

(v) Convert 3m K_2SO_4 to G/L

(vi) Define molarity.

(b) A force equal to 19.635 kgf is applied on a piston with a diameter of 5 cm. Find the pressure exerted on the piston in KPa, bar and PSI.

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

(a) A saturated solution of salicylic acid in methanol contains 64 kg salicylic acid per 100 kg methanol at 298.15 K. Find (i) the mass % and (ii) mole % composition of the solution.

(b) A producer gas has the following composition by volume.
$CO = 21\%$, $CO_2 = 5\%$, $O_2 = 3\%$ and balance being N_2. Calculate the volume of gas in m^3 at 298 k and 99.325 KPa per kg of carbon present.

(c) Estimate the density of chlorine gas at temperature of 503 k and 15.2 MPa pressure by using
(i) Ideal gas law
(ii) Vander waals equation
$a = 0.6354\ (m^3)^2\ MPa/(Kmol)^2$
$b = 0.0543\ m^3/kmol$

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

(a) a 100 kg mixture of 27.8% of acetone (A) and 72.2% of chloroform (B) by mass is to be batch-extracted with a mixed solvent at 298 K. The mixed solvent of an unknown composition is known to contain water (S_1) and acetic acid (S_2). The mixture of the original mixture and the mixed solvent is shaken well, allowed to attain equilibrium and separated into two layers. The compositions of the two layers are given below :

	Composition, mass %			
Layer	A	B	S1	S2
Upper Layer	7.5	3.5	57.4	3.16
Lower layer	20.3	67.5	2.8	9.6

Find
(i) the quantities of the two layers
(ii) the mass ratio of the mixed solvent to the original mixture
(iii) The composition of the mixed solvent (mass basis).

(b) The waste acid from a nitrating process containing 20% HNO_3, 55% H_2SO_4 and 25% H_2O by weight is to be concentrated by addition of concentrated sulphuric acid containing 95% H_2SO_4 and concentrated nitric acid containing 90% HNO_3 to get desired mixed acid containing 26% HNO_3 and 60% H_2SO_4. Calculate the quantities of waste and concentrated acids required for 1000 kg of desired mixed acid.

(c) A mixture of NaCl and Kcl treated with H_2SO_4 and 1.175 kg of mixed sulphate (Na_2SO_4 and K_2SO_4) was obtained. If the original sample is 1 kg, estimate the percentage of Cl_2 in the sample.
Chem Rxn :

$$2NaCl + H_2SO_4 \rightarrow Na_2SO_4 + 2HCl$$

$$2KCl + H_2SO_4 \rightarrow K_2SO_4 + 2HCl$$

SECTION - II

4 (a) Attempt all : 4

(i) Potential Energy (ii) Limiting Reactant

(iii) Heat capacity (iv) Humidification.

(b) Calculate the net calorific value at 298 k at a sample of fuel oil having C/H ratio 9.33 (by weight) and containing sulphur to the extent of 1.3% by weight.
Data : The Gev of the fuel oil at 298 k (25°C) = 41785 kJ/kg
Latent heat of water vapour at 298 k (25°C) = 2442.5 kJ/kg.

(c) Monochloroacetic acid (MCA) is manufactured in a semibatch reactor by the action of glacial acid with chlorine gas at 373 k (100°C) in the presence of PCl_3 catalyst. MCA thus formed will further react with chlorine to form diachloro acetic acid (DCA) to prevent the formation of DCA excess acetic acid is used. A small scale unit which produces 5000 kg/d MCA requires A536 kg/d of chlorine gas. Also 263 kg/d of DCA is separated in the crystalliser to get almost pure MCA product. Find the % conversion, % yield of MCA and selectivity.

(d) Chlorinated diphenyl is heated from 313 k (40°C) to 553 K (280°C) at the rate of 4000 kg/h in an indirectly fired heater. In this particular temperature range the heat capacity of the fluid is given by the equation.
$C_1 = 0.7511 + 1.465 \times 10^{-3}$ T kJ/(kg.k)
where T is in K.
Also heat capacity of diphyl A-30 at 313 K and 553 K are 1.1807 and 1.5198 kJ / (kg.k) respectively.
Calculate the heat to be supplied to the fluid in the heater using the heat capacity equations and calculate the % error involved in using the mean heat capacity data for the heat change calculations.

5 Attempt any **two** : **8×2=16**

(a) Pure sulphur is burnt in a burner at a rate of 0.3 kg/s. Fresh dry air is supplied at 303 K (30°C) and 100 KPa. The gases from the burner contain 16.5% SO_2 3% O_2 and rest H_2 on SO_3 free volume basis. The gases leave the burner at 1073 K and 101.325 KPa. Calculate:

(i) the fraction of sulphur burnt into SO_3.

(ii) the percentage excess air over the amount required to oxidise the sulphur to SO_2.

(iii) The volume of dry air in m^3/S.

(b) Flue gases leaving the boiler stack at 523 K (250°C) have the following composition.
CO_2 = 11.3 H_2O 13.04%, O_2 = 2.17% H_2 = 73.48% (by volume)
Calculate the heat lost in 1 kmol of gas mixture above 298 K (25°C) using the heat capacity data given below :
$Cp = a+bT + Ct^2 + dT^3$, kJ/(Kmol.k)

Gas	a	$b \times 10^3$	$c \times 10^6$	$d \times 10^9$
Co_2	21.3655	64.2841	–41.0506	9.7999
H_2O	32.4921	0.0796	13.2107	–4.5474
O_2	26.0257	11.7551	–2.3426	–0.5623
N_2	29.5909	–5.141	13.1826	–4.968

(c) The ultimate analysis of a residual fuel oil (RFO) sample is as given below :
C – 88.4% 9.4% and 2.2% (by weight)
It is used as a fuel in a power generating boiler with 25% excess air
Calculate :
(i) The theoretical dry air requirement
(ii) the actual dry air supplied and
(iii) the orsat analysis of flue gases

6 Attempt any **two** : **7×2=14**

(a) Define heat capacity and explain relationship between C_p and C_v for ideal gas.

(b) In the BASF oil quench process for manufacture of acetylene, pure oxygen and pure methane are fed to the acetylene burner. The composition of the cracked gas from the burner on dry basis is as follows :
H_2 - 56.5%, CH_2 = 5.2%, C_2H_4 - 0.3%, C_2H_2 = 7.5%, C_3H_6 0.5%, CO - 25.8%, CO_2 - 4% O_2 = 0.2%
Calculate :
(i) Methale required
(ii) Oxygen required
(iii) Water produced for production of 100 kmol, cracked gas. Also calculate the % conversion of methane and yield of acetylene.

(c) A sample of fuel oil has C/H ratio 9.33 (by volume) and contains 1.3% sulphur (wt. basis) the net calorific value of fuel oil is 39685 kJ/kg at 298 k. Calculate the gev. using latent heat of water at .298 K.
Latent heat of water vapours = 2100.55