

BITS, PILANI – DUBAI CAMPUS

FIRST SEMESTER 2013 – 2014

SECOND YEAR (Chemical)

Course Code: CHE F211 **COMPREHENSIVE EXAMINATION**

Date : 29.12.2013

Course Title: Chemical Process Calculations

Max Marks: 80

Duration: 3hr

(Closed Book)

Weightage: 40%

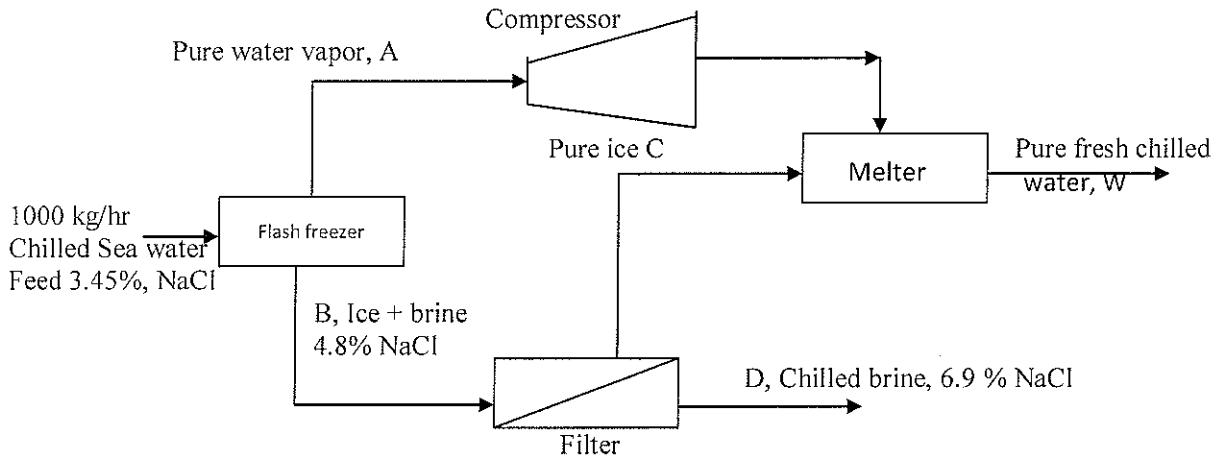
Note : Attempt ALL questions. Mention appropriate units in your answers. Without units, the answer will not be deemed as correct, even if the numerical value is correct. Clearly show all calculation steps.

- 1.(a) It is desired to produce a mixed acid containing 40% sulphuric acid, 35% nitric acid, and 25% water from waste acid containing 37% sulphuric acid, 23% nitric acid and 40% water, using 80% concentrated sulphuric acid and 70% concentrated nitric acid. Calculate the weight of waste acid, concentrated sulphuric acid, and concentrated nitric acid required to make 4000 kg of the desired acid. (6 m)
- 1.(b) A thickener in a waste disposal unit of a plant removes water from wet sewage sludge. If dehydrated sludge is 70 wt %, how many kilograms of water leave the thickener per 100 kg of wet sludge that enter the thickener? The process is in the steady state. (2 m)
- 1.(c) A vacuum gauge connected to a tank reads 31.5 kPa. What is the corresponding absolute pressure if the barometer reads 98.2 kPa? (2 m)
- 2.(a) 300 kg of nitrogen and 75 kg of hydrogen are brought together and allowed to react at 823 K and 300 atm. It is found that there are 38 kmol of gases present at equilibrium. Which is the limiting reactant? What is the percentage excess? How many kmoles of N₂, H₂ and NH₃ are present at equilibrium? What is the degree of completion?
$$\text{N}_2 + 3 \text{H}_2 \leftrightarrow 2 \text{NH}_3$$
 (10 m)
- 2.(b) Thirty pounds of coal (analysis 80% C and 20% H ignoring the ash) are burned with 600 lb of air, yielding a gas having an orsat analysis in which the ratio of CO₂ to CO is 3 to 2. What is the percent excess air? (6 m)
- 3.(a) Figure shows a schematic for making fresh water from sea water by freezing. The pre-chilled sea water is sprayed into a vacuum at a low pressure. The cooling required to freeze some of the feed sea water comes from evaporation of a fraction of the water entering the chamber. The concentration of the brine stream, B, is 4.8% salt. The pure salt-free water vapor is compressed and fed to a melter at a higher pressure where the heat of condensation of the vapor is removed through the heat of fusion of the ice which

contains no salt. As a result, pure cold water and concentrated brine (6.9%) leaves the process as products. (8 m)

(i) Determine the flow rates of streams W and D if the feed is 1000 kg per hour?

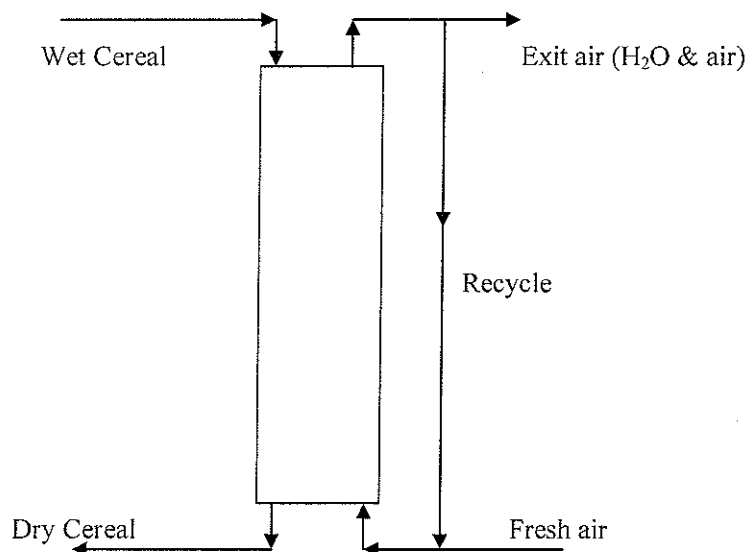
(ii) Determine the flow rates of streams C, B and A per hour?



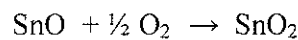
3.(b) Cereal is being dried in a vertical drier by air flowing countercurrent to the cereal. To prevent breakage of the cereal flakes, exit air from the drier is recycled. For each 1000 kg/hr of wet cereal fed to the drier, calculate the input of moist fresh air in kg/hr and the recycle rate in kg/hr. (8 m)

Data on stream compositions (note some are mass and others mol fraction)

	Fresh air F	Wet cereal W	Exit air E	Dried cereal D	Air entering drier G
H ₂ O mol fraction	0.0132	0.2	0.263	0.05	0.066



- 4.(a) A gas used to extinguish fires is composed of 80% CO₂ and 20% N₂. It is stored in a 2 m³ tank at 200 kPa and 25°C. What is the partial pressure of the CO₂ in the tank in kPa? (2 m)
- 4.(b) Liquid oxygen is used in the steel industry, in the chemical industry, in hospitals, as a rocket fuel oxidant and for waste water treatment as well as many other applications. A hospital tank of 0.0284 m³ volume is filled with 3.5 kg of liquid O₂ that will vaporize at -25°C. Will the pressure in the tank exceed the safety limit of the tank specified as 10⁴ KPa? (6 m)
- 5.(a) 66.26 m³ of carbon di oxide gas at 2 atm pressure and 323 K has to be heated to 523 K. Compute the heat duty in the following modes (i) by integrating the expression for Cp (ii) using direct Cp values (6 m)
- 5.(b) Calculate the change in enthalpy for 5 kg mol of CO which is cooled from 927°C to 327°C. (4 m)
- 6.(a) In a new process for the recovery of tin from low-grade ores, it is desired to oxidize stannous oxide, SnO, to stannic oxide, SnO₂, which is then soluble in a caustic solution. What is the heat of reaction at 90°C and 1 atm for the reaction? (6 m)



	ΔH_f^0 (KJ/ g mol)	Cp (J / g mol K), T in K
SnO	-283.3	$39.33 + 15.15 \times 10^{-3} T$
SnO ₂	-577.8	$73.89 + 10.04 \times 10^{-3} T - (2.16 \times 10^4 / T^2)$

- 6.(b) A gaseous fuel of 50% CH₄ and 50% N₂ at 38 °C and 1atm burns with 20% excess air supplied at 15°C and 1atm. Suggest 3 different ways to increase adiabatic reaction temperature of the process. No numerical calculations are needed, but explain (justify) your recommendations in detail. (6 m)
7. What are the dry bulb temperature, wet bulb temperature, relative humidity, and humid volume of air that has an absolute humidity of 0.02 kg/kg dry air and an enthalpy at saturation of 85.1 KJ/Kg dry air. Sketch and show the above results. (8 m)

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TEST 2

Date: 06.11.13

Course Title: Chemical Process Calculations

Max Marks: 20

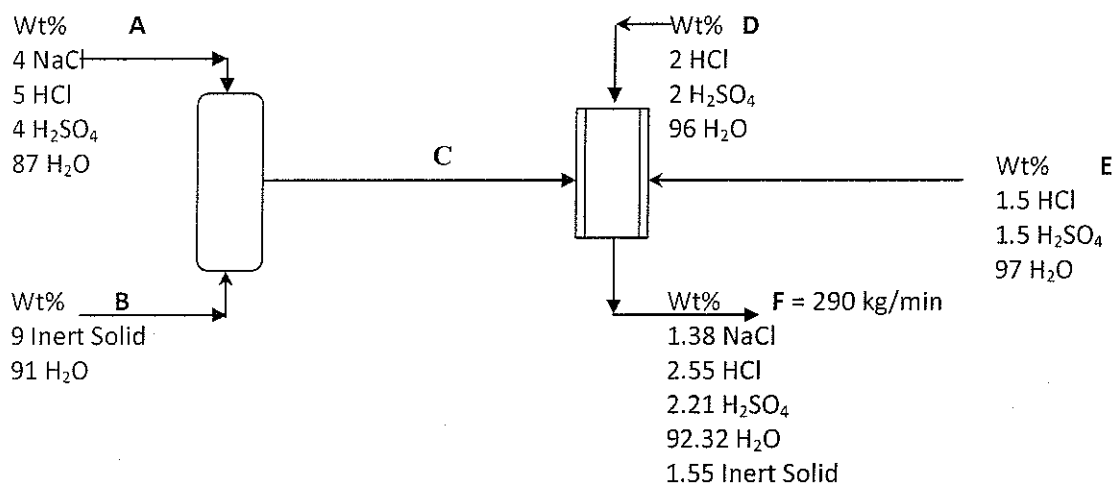
Duration : 50 minutes

(Open Book)

Weightage: 20%

Note : only prescribed text book and own handwritten notes are allowed, physical and chemical property tables are allowed

1. Several streams are mixed as shown in figure. Calculate the flows of each stream in kg/min. (8 m)



2. Pure A in gas enters a reactor. 50% of this A is converted to B through the reaction $A \rightarrow 3 B$.
What is the mole fraction of A in the exit stream? What is the extent of reaction? (2 m)

3. A gas with the following composition (mol %) is burned with 50% excess air in a furnace. What is the composition of the flue gas by percent? (7 m)
 CH_4 60 %; C_2H_4 = 20%; CO = 5%; O_2 = 5%; N_2 = 10 %
 $CH_4 + 2 O_2 \rightarrow CO_2 + 2 H_2O$
 $C_2H_4 + 3.5 O_2 \rightarrow 2 CO_2 + 3 H_2O$
 $CO + (1/2) O_2 \rightarrow CO_2$

4. Calculate the specific volume (m^3/kg) of propane at a pressure of 6000 kPa and a temperature of 230°C. (1 atm = 101.325 kpa; $R = 0.18855 \text{ kPa } m^3 / \text{Kg K}$) (3 m)

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SECOND YEAR (Chemical)

Course Code: CHE F211

Course Title: Chemical Process Calculations

Duration : 50 minutes

TEST 1

(Closed Book)

Date: 02.10.13

Max Marks: 25

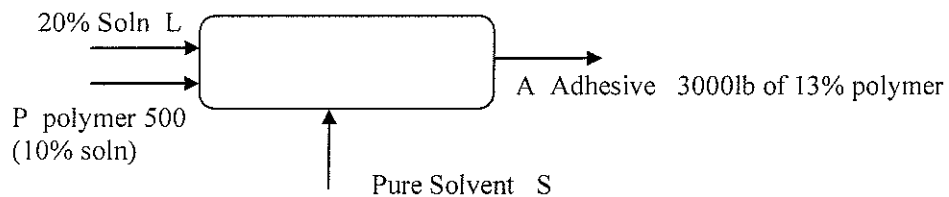
Weightage: 25%

1. A common method used in manufacturing sodium hypochlorite bleach is by the reaction

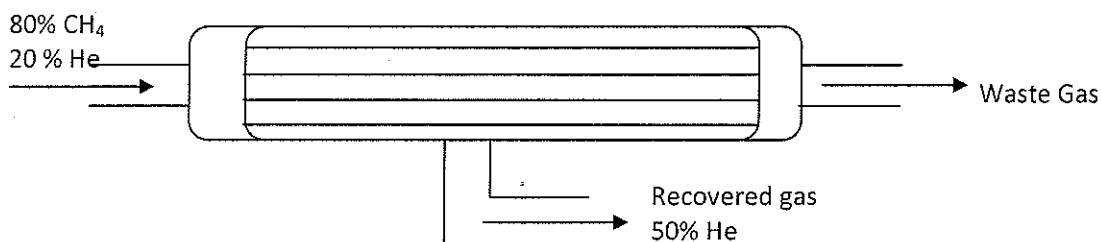


Chlorine gas is bubbled through an aqueous solution of sodium hydroxide, after which the desired product is separated from the sodium chloride (a by-product of the reaction). A water-NaOH solution that contains 1145 lb of pure NaOH is reacted with 851 lb of gaseous chlorine. The NaOCl formed weighs 618 lb. (MW: Cl 35.5, Na 23)

- What was the limiting reactant?
 - What was the percentage excess reactant used?
 - What is the degree of completion of the reaction, expressed as the moles of NaOCl formed to the moles of NaOCl that would have formed if the reaction had gone to completion?
 - What is the yield of NaOCl per amount of chlorine used (on a weight basis)?
 - What was the extent of reaction? (2 + 4 + 2 + 2 + 2 = 12 m)
2. A liquid adhesive of a polymer dissolved in a solvent. The amount of polymer in the solution is important to the application. An adhesive dealer receives an order for 3000 pounds of an adhesive solution containing 13 % polymer by weight. On hand is 500 pounds of 10% solution, very large quantities of 20% solution and pure solvent. Calculate the weight of each that must be blended together to fill this order. Use all of the 10 % solution. (4 m)



3. A gas containing 20 mole % He (mw: 4) and 80 mole % CH₄ (mw: 16.03) is sent through quartz diffusion tube to recover the helium. Twenty percent by weight of the original gas is recovered, and its composition is 50 mole% He. Calculate the composition (mole %) of the waste gas if 100 k moles of gas are processed per minute. (9 m)



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QUIZ 2

(Closed Book)

Date: 04.12.13

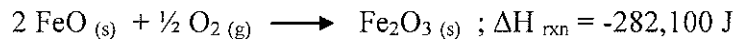
Max Marks: 07

Weightage: 7%

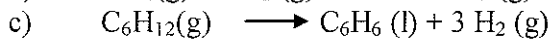
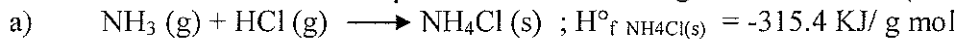
Name: ID No: Prog:

Note : Physical and chemical property tables are allowed

1. Determine the heat of formation for FeO (s) for the following reaction at 25°C and 1 atm, and the same compare from physical property data. (2.5 m)



2. Calculate the std heat of reaction (25°C and 1 atm) per g mol of the first reactant on the left-hand side of the reaction equation for the following reactions: (1.5 × 3 = 4.5 m)



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Duration : 20 minutes

QUIZ 1

(Closed Book)

Date: 25.09.13

Max Marks: 08

Weightage: 8%

Name: ID No: Prog:

1. A technical publication describes a new model 20 hp Stirling (air cycle) engine that drives a 68 kW generator. Is this possible? (1 m)

2. You have a request that the speed of the company Boeing 737 is to be cut from 525 miles/hr to 475 miles/hr to “conserve fuel”, thus cutting consumption from 2200 gal/hr to 2000 gal/hr. How many gallons are saved in a 1000 mile trip? (2 m)

3. You are asked to make up a laboratory solution of 0.10 molar H_2SO_4 (0.1 mol $\text{H}_2\text{SO}_4/\text{L}$) from concentrated (96%) H_2SO_4 . You look up the sp. gravity of 96% H_2SO_4 and find it is 1.858. Calculate (1.5+1.5+2 = 5 m)
 - a. the weight of 96% acid needed per L solution
 - b. the volume of 96% acid used per L of solution
 - c. the density of the 0.1 molar solution