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Chemical Process Calculations

Subject Code: BTCH-302A

Paper ID:

Time allowed: 3 Hrs

Max Marks: 60

Important Instructions:

- All questions are compulsory
- Assume any missing data
- Additional instructions, if any

PART A (10x 2marks)

Q. 1. Short-Answer Questions:

- What is orsat analysis?
- Explain Intensive property and Extensive property with an example.
- State three reasons for using a recycle stream in a chemical process.
- Along with a example explain the concept of 'Limiting Reactant' and Excess reactant?
- What are Reduced properties? What is their significance?
- Define the term 'Degree of Superheat'.
- What do you mean by 'Standard Integral heat of formation ΔH_f° '?
- Define theoretical flame temperature.
- Define the term 'Absolute humidity' & give its mathematical expression.
- Explain Bubble point and dew point with a diagram

PART B (5x8marks)

Q. 2. Stainless steel, type 304 (18% Cr, 8% Ni, 0.08% C max.) has a thermal conductivity k of 16.2 Btu/(hr) (ft) ($^\circ$ F). Convert this value of thermal conductivity into g-cal/(sec) (cm) ($^\circ$ C). COa

OR

- In the Caustic soda plant, in multiple effect evaporator, the second effect is maintained under vacuum of 410 torr. Find the absolute pressure in kgf/cm^2 , kPa, atm, N/m^2 , bar, psi and mm Hg. COa
- An aqueous solution of K_2CO_3 is prepared by dissolving 86 kg K_2CO_3 in 200 kg water at 293 K. Find molarity, normality and molality of the solution. Take sp. gravity of solution as 1.3.

Q. 3. If 10 kg of PbS and 3 kg of oxygen react to yield 6 kg Pb. And 1 kg of PbO_2 and the only other product of the reaction is SO_2 . What is COb

- the amount of PbS that does not react?
- the amount of SO_2 formed?
- the percent conversion of PbS to Pb?

OR

The average molecular mass of a flue gas sample is calculated by two different engineers. One engineer uses the correct molecular mass of 28 for N_2 and determines the average molecular mass to be 30.08, the other engineers, using an incorrect value of 14, calculates the average molecular mass to be 18.74. (a) Calculate the volume% of N_2 in the flue gases. If the remaining components of the flue gases are CO_2 and O_2 , calculate the volume % of each of them. COb

- Q. 4. The coal having the ultimate analysis (Carbon = 50.22%, Hydrogen = 2.79%, COc Sulphur = 0.37%, Nitrogen = 2.05%, Ash = 19.53%, Oxygen = 18.04% and Moisture = 7.00% all are weight %) is burnt with 100% excess air. Calculate:
- Theoretical oxygen requirement per unit weight of coal
 - The theoretical dry air requirement per unit weight of coal and
 - The wet and orsat analyses of flue gases when the coal is burnt with 100% excess dry air.

OR

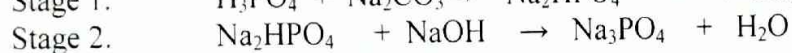
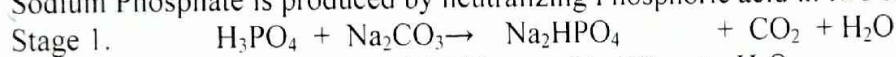
A furnace is fired with coke containing 90% carbon and 10% ash. The ash pit residue COc after being washed with water analyzes 10% carbon; 40% ash and rest water. The flue gas analysis shows CO₂- 14%; CO- 1%; O₂- 6.4% and rest N₂. Calculate the following:

- Volume of flue gas produced at 750 mm Hg and 250°C per ton of coke charged
- % Excess air used
- % of carbon charged which is lost in the ash

- Q. 5. Air at 60°C and 745 mm Hg having a percent humidity of 10 is supplied to a drier at Cod the rate of 1000m³/hour. Water is evaporated in the drier at a rate of 20 kg/hr. The air leaves the drier at 35°C and 742 mm Hg. Calculate (a) Percent humidity of air while leaving the drier (b) Vol. flow rate of wet air leaving the drier.
- Given: Vapor pressure of water at 60°C = 150 mm Hg and at 35°C = 42 mm Hg.

OR

Sodium Phosphate is produced by neutralizing Phosphoric acid in two stages: COD



The process is carried out as follows:

Soda Ash (Na₂CO₃) is dissolved in water & the solution is reacted with commercial Phosphoric acid containing 85% H₃PO₄ (rest water) to complete the first stage of reaction. The second stage of reaction is carried out by reacting the disodium phosphate solution containing 50% caustic lye (NaOH) resulting in a trisodium phosphate solution having a concentration of 20%. To produce 1 tonne (1000 kg) of trisodium phosphate, calculate:

- The concentration of soda Ash solution fed;
- The ratio in which Phosphoric acid (85%) & the soda ash solution to be mixed;
- The weight of caustic lye needed;
- If Na₂CO₃ be added 10% in excess in the first stage, how much caustic lye should be added in the second stage.

Atomic weights P=31, Na=23, C=12, O=16, H=1.

- Q. 6. A gas containing 20% CO and 80% N₂ is burnt with 100% excess air, both air and COe gas initially being at 25°C. A flame temperature of 942°C is attained during combustion. Calculate the enthalpy of the products. Given mean molar heat capacities between 25°C and 942°C as: CO₂—11.74, O₂—7.90 and N₂—7.45 cal/gm mol K.

OR

Calculate the theoretical flame temperature of a gaseous fuel containing 20% CO, and COe 80% N₂ when burnt with 100% excess air, both air and gas initially being at 25°C.

Heat of combustion of carbon monoxide = 67636 kcal/kmol.

Data: Specific heats of products of combustion in kcal/(kmol.°K)

Carbon dioxide: $C_p = 6.339 + 10.14 \times 10^{-3}T$

Oxygen: $C_p = 6.117 + 3.167 \times 10^{-3}T$

Nitrogen: $C_p = 6.457 + 1.389 \times 10^{-3}T$

where T = temperature in Kelvin