

CHUKA



UNIVERSITY

UNIVERSITY EXAMINATIONS

**THIRD YEAR EXAMINATION FOR THE AWARD OF
BACHELOR OF SCIENCE IN INDUSTRIAL CHEMISTRY**

CHIN 313: MATERIAL AND ENERGY BALANCES

STREAMS: BSC. INDUSTRIAL CHEMISTRY

TIME: 2 HOURS

DAY/DATE: TUESDAY 6 /07/ 2021

5.00 PM – 700 PM

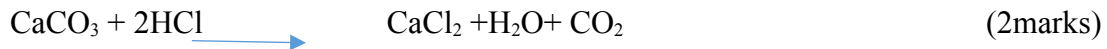
INSTRUCTIONS:

- Answer question **One** (Compulsory) and any other **Two** questions.
- Do not write anything on the question paper

QUESTION ONE (30 MARKS)

- a) Differentiate between a unit operation and a unit process (2marks)
- b) Briefly discuss the following unit operations
- i) Fluid flow operations (2marks)
 - ii) Mass transfer operations (2marks)
 - iii) Mechanical separations (2marks)
- c) The flow rate of water through a pipe is reported as 15 cubic feet per minute. Taking density of water as 1 g/cm^3 , calculate the mass flow rate in Kg/s. (1 ft= 0.3048 m, 1 min= 60 seconds) (4 marks)

- d) Find the equivalent weight of CaCO_3



- e) Define the following terms (4 marks)

- i) Parts per million
- ii) Molarity
- iii) Molality
- iv) Normality

- f) Using an equation briefly discuss Material Balance Principle (3marks)

- g) Differentiate between:

- i) Steady state and unsteady state processes (2marks)
- ii) Batch and continuous processes (2marks)

- h) Coal contains 85% carbon and 15% ash. The cinder formed in the combustion of coal contain 80% ash and 20% carbon. Determine the weight of cinder formed by the combustion of 100 kg of coal and the percent of fuel value that is lost (5marks)

QUESTION TWO (20 MARKS)

- a) 1000 pounds per minute of gas (average molecular weight =30.24) is being sent to an absorption column. What is the molar flow rate of the gas in Kmol/h ? (1 pound (Lb)= 0.4536 kg, 1 h= 60 minutes) (3 marks)

- b) 10 kg of liquid A of specific gravity 1.17 is mixed with 5 kg of liquid B of specific gravity 0.83. Assuming that there is no volume change on mixing, what is the specific gravity of the mixture (Density of water= 1000 kg/cm^3) (4 marks)

- c) Pure water and alcohol are mixed to get 60% (weight) alcohol solution. The densities(Kg/m^3) of water, alcohol and the solution may be taken to be 998,798 and 895 respectively at 293 K. Calculate the following (6marks)

- a) The volume percent of ethanol in the solution at 293 K
- b) The molarity
- c) The molality

- d) Explain a tie element briefly (2marks)

e) 1000 kg of mixed acid composition 40% H₂SO₄, 45 % HNO₃ and 15% H₂O is produced by strengthening waste acid of composition 30% H₂SO₄, 36 % HNO₃ and 34% H₂O in weight. Concentrated sulphuric acid of strength 95% and concentrated nitric acid containing 80% acid are available for this purpose. How many kilograms of spent acid and concentrated acids are to be mixed together (5marks)

QUESTION THREE (20 MARKS)

a) Sulphur trioxide gas is obtained by the combustion of iron pyrites (FeS₂) according to the following reaction (5marks). (S= 32.06 Fe= 55.85 O=16)



i) How many kilograms of pyrites are burned to obtain 100 kg of sulphur trioxide?

[3 Marks]

ii) How many kilograms of oxygen are consumed in the production of 50 Kg of SO₃?

[2 Marks]

b) A wet ammonium sulphate containing 20% water is sent to a dryer. The material leaving the dryer contains 2.44% moisture (4marks).

i) Determine how many kg of water is removed per kg of wet material charged.

ii) Find the percent of original water in the feed that is removed by drying

c) A crystallizer is charged with 100 kg of a solution containing 25% Ba(NO₃)₂ in water. On cooling 10% of the original water evaporates. Calculate the yield of crystals when the solution is cooled to 283 K. (The solubility at 283 K is 7.0 kg Ba(NO₃)₂/100 Kg total water) (5 marks)

d) Isopropyl alcohol and water can be separated by extraction with ethylene tetrachloride (CCl₄). 100 kg of a solution containing 30 %(weight) isopropyl alcohol and the rest water is mixed with the ethylene tetrachloride. After extraction, the raffinate phase analyzed 71% water, 28.1 % isopropyl alcohol and 0.9 % ethylene tetrachloride. The extract phase analyzed 94% ethylene tetrachloride, 5.2% isopropyl alcohol and the rest water. Calculate the following:

i)The amount of solvent (2marks)

ii) The qualities of raffinate and extract phases (2marks)

iii)The percent extraction of isopropyl alcohol (2marks)

QUESTION FOUR (20 MARKS)

- a) The solubility of sodium chloride in water at 290 K is 35.8/100 kg of water. Express the solubility of the following:
- Mass fraction and mass percent of NaCl (2 marks)
 - Mole fraction and mole percent of NaCl (2marks)
 - Kmol NaCl per 1000 kg of water (1 mark)
- b) A drier is fed with wet solid to reduce the moisture content from 80% to 15%. The product leaving the drier is admitted into an oven which further brings down the moisture to 2%. If the drier can handle 1000 kg of wet solid per day. Calculate:
- The weight of products leaving the drier and oven per day (3marks)
 - The percentage of the original water that is removed in the drier and the oven (2marks)
- c) i) Define combustion (1 mark)
- ii) Define the following terms in relation to combustion (4marks)
- Theoretical oxygen
 - Excess oxygen
 - Net oxygen
 - Heat of reaction
- d) Pure CO_2 may be prepared by treating limestone with aqueous H_2SO_4 . The limestone used contained CaCO_3 and MgCO_3 , the remainder being inert insoluble materials. The acid used contained 12% H_2SO_4 by weight. The residue from the process had the following composition-9.00 % CaSO_4 ; 5.00 % MgSO_4 , 1.2% H_2SO_4 ; 0.5% Inerts; 0.2% CO_2 and 84.10 % H_2O . During the process, the mass was warmed and CO_2 and H_2O vapours were removed.
- Calculate the following:
- The analysis of limestone used (2marks)
 - The percentage excess of acid used (2marks)
 - The mass of water vapour vaporized and removed per 100 kg of limestone (1 mark)

