MANICALAND STATE UNIVERSITY OF APPLIED SCIENCES

FACULTY OF ENGINEERING

DEPARTMENT: CHEMICAL AND PROCESSING ENGINEERING

MODULE: SEPARATION PROCESSES 1

CODE: CHEP 315

SESSIONAL EXAMINATIONS
DECEMBER 2022

DURATION: 3 HOURS

EXAMINER: MISS N.T. MADZIWA

INSTRUCTIONS

1. *Answer **ALL** questions*
2. *Start a new question on a fresh page*
3. *Total marks 100*
4. *Formulae sheet is given at the end of the paper.*

Additional material(s): *Calculator*

QUESTION 1

a) Explain what is meant by separation processes in relation to chemical engineering operations. [2]

b) Outline any two types of membrane processes and their applications. [4]

c) With the aid of well-labelled diagrams, explain the process of reverse osmosis. [8]

d) With the aid of well-labelled diagrams, explain any two types of membrane modules. [6]

QUESTION 2

a) With the aid of well-labelled diagrams, explain the principle of electrodialysis. [8]

b) Explain the parameters influencing the efficiency of electrodialysis. [6]

c) Explain the meaning of these terms as used in thermodynamics

i. *Flow work*

ii. *Shaft work*

iii. *Isolated system*

iv. *Spontaneous process* [4]

d) Explain entropy and Gibbs energy. [2]

QUESTION 3

a) Explain the process of crystallization and its applications in separation processes. [6]

b) With the aid of diagrams, explain the types of flow patterns as used in process mixing. [6]

c) With the aid of diagrams, explain the gas dispersion levels and their applications. [8]

QUESTION 4

a) What is the yield of sodium acetate crystals ($CH_3COONa.{}_3H_2O$) obtainable from a vacuum crystalliser operating at 1.33 kN/m^2 when it is supplied with 0.56 kg/s of a 40 per cent aqueous solution of the salt at 353 K? The boiling point elevation of the solution is 11.5 deg K. [6]

Data:

Heat of crystallisation, q =144 kJ/kg trihydrate

Heat capacity of the solution, C_p =3.5 kJ/kg deg K

Latent heat of water at 1.33 kN/m^2, λ=2.46 MJ/kg

Boiling point of water at 1.33 kN/m^2 =290.7K

Solubility of sodium acetate at 290.7 K, c_2 =0.539 kg/kg water.

b) Explain the two types of primary nucleation. [4]

c) Explain the mechanisms of blending. [6]

d) Calculate the entropy change of a sample of perfect gas when it expands isothermally from a volume Vi to a volume V_f. Outline the method used and comment your work. [4]

QUESTION 5

a) Calculate the entropy change in the surroundings when 1.00 mol H_2O (l) is formed from its elements under standard conditions at 298 K, we use $\Delta H°$=286 kJ. The energy released as heat is supplied to the surroundings, now regarded as being at constant pressure, so q_{surr} =+286 kJ. Comment on your value [4]

b) What is the theoretical yield of crystals which may be obtained by cooling a solution containing 1000 kg of sodium sulphate (molecular mass =142 kg/kmol) in 5000 kg water to 283 K? The solubility of sodium sulphate at 283 K is 9 kg anhydrous salt/100 kg water and the deposited crystals will consist of the deca-hydrate (molecular mass = 322 kg/kmol). It may be assumed that 2 per cent of the water will be lost by evaporation during cooling. [6]

c) State the driving forces for transport in membranes. [4]

d) State the advantages of using tumbling mixers in solid mixing. [4]

e) What is supersaturation? [2]

END OF EXAMINATION

LIST OF FORMULAE

Crystal yield initial solvent balance: $w_1 = w_2 + y\frac{R-1}{R} + w_1 E$

Crystal yield solute balance: $w_1 c_1 = w_2 c_2 + y/R$

Yield for aqueous solutions: $y = Rw_1 \frac{c_{1-c_2\,(1-E)}}{1-c_2(R-1)}$

Quantity from heat balance: $E = \frac{qR(c_1-c_2)+C_p(T_1-T_2)(1+c_1)[1-c_2(R-1)]}{\lambda[1-c_2(R-1)]-qRc_2}$

Power: $\frac{Power_{gassed}}{Power_{ungassed}} = 0.1(\frac{Q}{NV_L})^{-0.25}(\frac{N^2d^4)}{gBV_L{}^{2/3}})^{-0.20}$