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Module Code: MANP H4004
CRN:

TECHNOLOGICAL UNIVERSITY DUBLIN
TALLAGHT CAMPUS

TU876

BSc in Pharmaceutical Science

Year 4

SEMESTER 1
EXAMINATIONS 2024/25

Manufacturing Technology and Unit Processes

Internal Examiner:
Dr Adrienne Fleming
Dr Eugene Hickey

External Examiner:
Dr Sandra Lenihan

Exam Duration:
Two hours in duration with an additional 15 minutes of reading time in advance
Instructions:
Answer two questions from Section A.
Answer two questions from Section B.
Please use separate answer books for each section.
Formula Sheet at end of exam paper.

Section A Answer any two questions

Question 1 Answer all parts (100 marks)

SECTION B: [Dr. Eugene Hickey]

You are required to answer TWO complete questions

Question 4 **(100 marks)**

a) 500kg of a 5% slurry of calcium hydroxide in water is to be prepared by diluting a 20% slurry. Calculate the quantities required. (10 marks)

b) 10% excess air is supplied to a furnace burning 100m^3/hr of natural gas (95% methane, 5% ethane by volume). Calculate the air flow of air (21% O2) required. The reactions are:

$$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$$

$$C_2H_6 + 7/2\ O_2 \rightarrow 2CO_2 + 3H_2O$$

(25 marks)

c) In ammonia production from H_2 and N_2, unreacted material is recycled. The feed stream to the process is at 200mols/hr and contains 0.2% argon as an inert. To avoid a build up of the inert there is a purge stream. Calculate the required flow rate in the purge stream to maintain the argon level in the recycle stream below 5%. (25 marks)

d) Coper crystallises in face-centered cubic form with a lattice parameter of a = 0.3615nm. Use this to calculate the ionic radius of copper. (20 marks)

e) Draw rough sketches of cubic unit cells showing the following planes:

(i) (0 0 1) (5 marks)
(ii) (1 0 1) (5 marks)
(iii) (0 2 1) (5 marks)
(iv) (1 1 1) (5 marks)

Question 5 **(100 marks)**

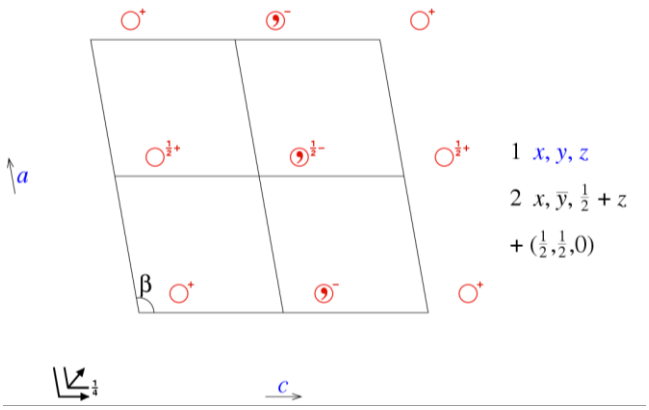
a) An oil stream enters a counter flow heat exchanger at a temperature of 85°C and leaves at 40°C. The cold stream has an input temperature of 25°C and an output temperature of 65°C. The flow of the hot stream is 2.2kg/s. The heat capacity of the hot stream is 1160J/kg/°C, that of the cold stream is 4190J/kg/°C

(i) Show that the flow rate of the cold stream is 0.69kg/s (15 marks)

(ii) Show that the LMTD for this process is 17.4°C. (10 marks)

(iii) Calculate the UA value of the heat exchanger. (15 marks)

b) The diagram below shows the monoclinic space group, Cc



(i) What does monoclinic mean in terms of the length of the three sides, a, b, c, and the angles between them, α, ß, and γ? (5 marks)

(ii) Is this space group Primitive, Face Centred, Body Centred, or Base Centred? (5 marks)

(iii) What does c (lowercase) mean in the space group title? (10 marks)

(iv) Is there a centre of symmetry in the cell? Justify your answer. (10 marks)

(v) What is the multiplicity of the general position, (x, y, z), for the space group? (10 marks)

(vi) Locate a special position in the space group and give its multiplicity. (10 marks)

(vii) Is this space enantiomorphous? Justify your answer. (10 marks)

Question 6 **(100 marks)**

a) Draw Explain how a vle diagram can be constructed from a binary phase diagram (10 marks)

b) Use the diagram below to answer the following questions:

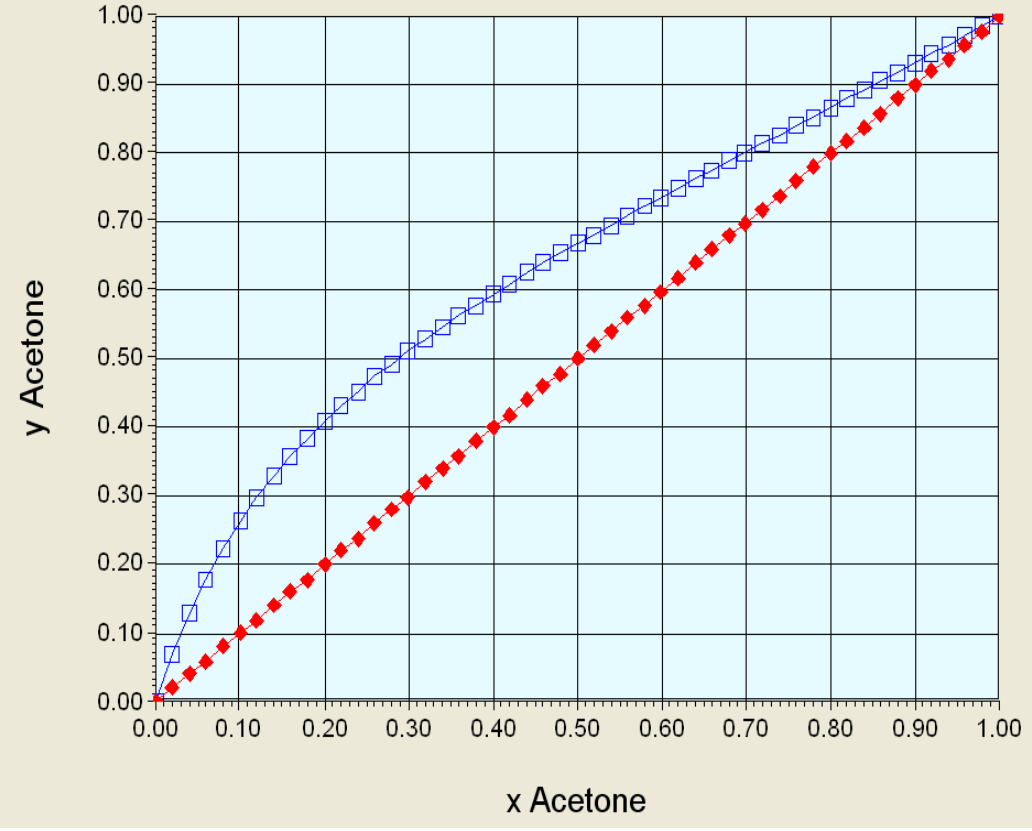
(i) What is the mole fraction in acetone of the vapour phase when the mole fraction in acetone of the liquid phase is 0.3? (10 marks)

(ii) What is the mole fraction in acetone of the liquid phase when the mole fraction in benzene of the vapour phase is 0.75? (10 marks)

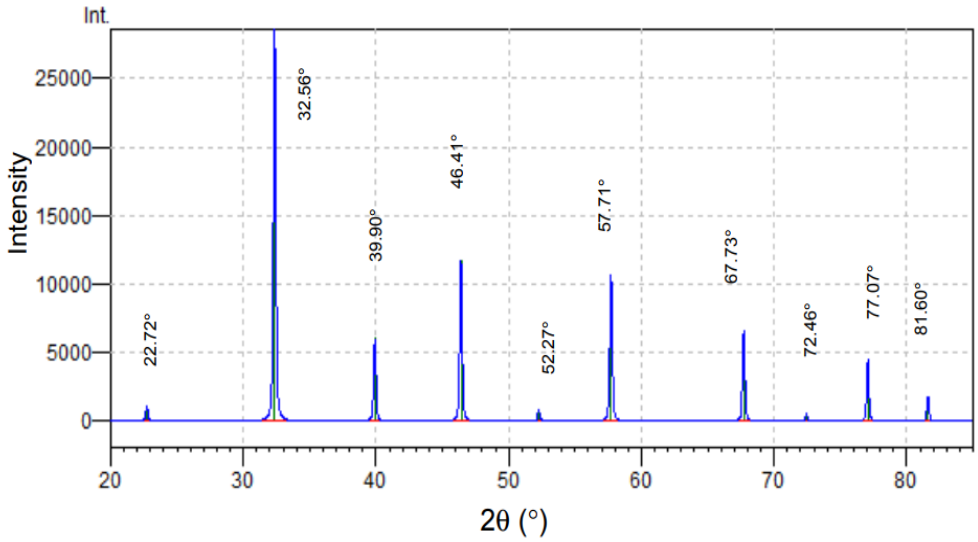
(iii) What is the mole fraction in benzene of the liquid phase when the mole fraction in benzene of the vapour phase is 0.45? (10 marks)

(iv) Calculate the relative volatility of acetone in benzene when the liquid mole fraction of acetone is 0.35 (10 marks)

(v) What would happen to this vle curve if the pressure was increased? (10 marks)



c) The diagram below shows a powder diffraction pattern using Cu K□ radiation from the cubic crystal, $SrTiO_3$. The 2θ position of all the peaks is also given (the first four are: 22.72°, 32.56°, 39.90°, and 46.41°).



(vi) Find the inter-planar spacing, d, for the first four peaks (those with 2θ less than 50°) (10 marks)

(vii) Given that the lattice parameter for $SrTiO_3$, a, is 0.3905nm, calculate the value of $h^2 + k^2 + l^2$ for the first four peaks. (10 marks)

(viii) Suggest Miller Indices, (hkl), for the first four peaks. (10 marks)

(ix) Is $SrTiO_3$ primitive, BCC, or FCC? (10 marks)

LIST OF FORMULAE

$$t = \frac{-1}{k \ln(1 - x_A)}$$

$\tau_R = 1/kC_{A0}$

$\tau_R = 1 + a/kC_{A0}$ where $a = V_A / V_B$

$$Re = \frac{\rho v D}{\mu}$$

$$Re = \frac{\rho N D^2}{\mu}$$

$P = P_0 N^3 D_A^5 \rho$

$\varepsilon_{mean} = P / V\rho$

$Re_c = 6370 / P_0^{1/3}$

$P_0^{1/3} Re\ Fo = 5.2$

$$Fo = \frac{\mu t_{95}}{\rho T^2}$$

The lifetime of an Eddy is τ_K:

$\tau_K = 12[\upsilon / \varepsilon]^{1/2}$

where $\upsilon = \mu / \rho$ (kinematic viscosity)

Engulfment Rate $E = \ln 2 / \tau_K$

$\tau_E = 1/E$

$$C_2 = C_2 (\frac{S_2}{S_1})^n$$

C_2 = capital cost of project with capacity S_2
C_1 = capital cost of project with capacity S_1

$$D = \frac{C}{10\ x\ V}$$

D = depreciation in €/kg
C = capital cost in €
V = production volume in kg/year
10 is the plant life

$Q_r = V(-\Delta H_r)k_0 C_A \exp(-E_A/RT)$

$Q_c = UA(T-T_a)$

$MTSR = T_p + \Delta T_{ad}$

$\Delta T_{ad} = \Delta H.n / m.C_p$

$TMR_{ad} = C_p RT^2 / q_0 E_A$

$$\text{Oxygen balance} = \frac{-[1600(2a + b/2 - c)]}{\text{Mol. Wgt.}}$$

$q = mc\Delta T$

$q = UA\ LMTD$

$$LMTD = \frac{\Delta T_L - \Delta T_R}{\log_e(\Delta T_L / \Delta T_R)}$$

Molar mass CO_2 = 44g/mol

Molar Mass Air = 29g/mol

$n\lambda = 2d \sin\theta$

$$d = \frac{a}{\sqrt{h^2 + k^2 + l^2}}$$

$$\frac{1}{d^2} = \frac{h^2}{a^2} + \frac{k^2}{b^2} + \frac{l^2}{c^2}$$

$\lambda_{Cu\ K_\alpha}$ = 0.154051nm

$$\alpha_{AB} = \frac{y_A / x_A}{y_B / x_B}$$

q = liquid fraction

$$slope = \frac{-q}{1-q}$$

q-line goes between (x_F, y_F) and (0,x_F/(1-q))

rectifying line between (x_D, y_D) and (0,x_D/(R+1))

F = D + B

$F x_F = D x_D + B$