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THE OPEN UNIVERSITY OF SRI LANKA
B.Sc. Degree Programme – 2023/24
Level 5 – Continuous Assessment II
CYU 5308– INSTRUMENTAL METHODS IN CHEMICAL ANALYSIS

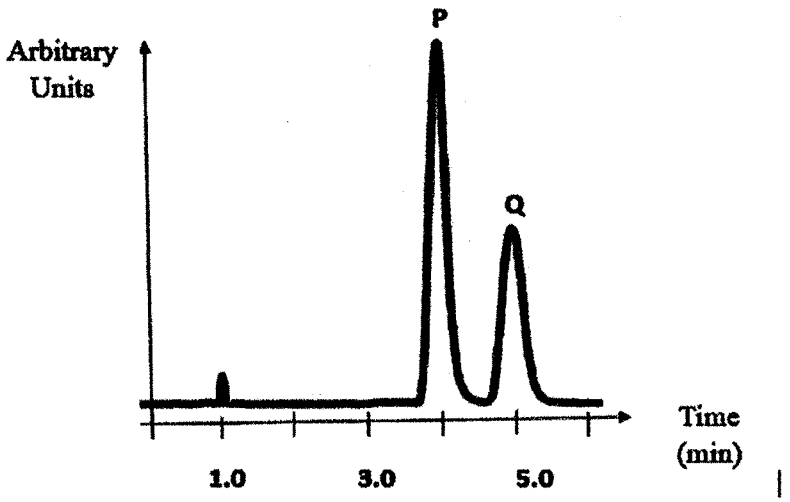
Duration: One hour
Date and time: 09.02.2024, 9.00 a.m. – 10.00 a.m.

Question no.	Max. marks	Marks
1	50	
2	50	
Total	100	

Instructions to students:

Answer all the questions. Write the answers in the spaces given. Additional sheets will not be marked.

1. (A) A student used High Performance Liquid Chromatography (HPLC) to separate the two organic compounds P and Q using normal phase chromatography and the resulted chromatogram is given below.



(i) What is indicated by the first peak in this chromatogram? (02 marks)

(ii) Calculate the retention factor for P and Q. (10 marks)

(iii)Comment on the separation of two peaks of P and Q using the selectivity factor. (08marks)

(iv)Justify the following statement. (08 marks)

"Compound Q is more polar than compound P"

B. The simplest form of the Van Deemter equation is given below.

$$H = A + \frac{B}{u} + Cu$$

(i) Identify the three terms given in the above equation. (06 marks)

(ii) Briefly explain how the particle diameter affects the plate height H. (06 marks)

C. (i) Write down the fuction of follwing components of Gas Chromotograph (GC).

(06 marks)

Component	Function
Oven	
Open coated open tube column	
Detector	

(ii) What is the function of Guard column in High Performance Chromatography (HPLC).

(04 marks)

2. The radioactive isotope $^{121}_{50}Y$ decays emitting a beta radiation resulting the new element D.

(i) Write the equation related to the above decay. (10 marks)

(ii) The half life of $^{121}_{50}Y$ is 20 hrs. If 0.80 g of it undergoes decaying, what is the weight of the fraction left after 80 hrs.? (10 marks)

(iii) The above emitted radiation was able to be detected by Gas Flow Proportional Counters but
not End-window counters.

(a) What may be the reason? (05 marks)

(b) Describe **one** possible error in brief that could have happened when taking measurements of radioactivity and suggest a way of overcoming the error.
(10 marks)

(c) Element Y is used in the production of an alloy mixture and after the mixture is produced, the total amount of Y cannot be isolated or purified. Therefore, it was decided to carry out Isotope Dilution Analysis using $^{121}_{50}Y$. For that, to a sample of the mixture having Y, 30 mg of $^{121}_{50}Y$ with an activity of 1000cpm was added; mixed and purified a sample of 5mg of Y having an activity of 50cpm. Calculate the amount of Y in the original mixture. (15 marks)

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Name:
Address:

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Answer guide

1. (A) A student used High Performance Liquid Chromatography (HPLC) to separate the two organic compounds P and Q using normal phase chromatography and the resulted chromatogram is given below.

(ii) What is indicated by the first peak in this chromatogram? (2 marks)

Dead time/ time taken to elute the unretained compounds by the mobile phase

i) Calculate the retention factor for P and Q. (10 marks)

$$k'_P = \frac{t_p - t_m}{t_m}$$

$$= \frac{4.0-1..0}{1.0} = 3.0$$

$$k'_Q = \frac{t_Q - t_m}{t_m}$$

$$= \frac{5.0-1.0}{1.0} = 4.0$$

ii) Comment on the separation of two peaks of P and Q using the selectivity factor. (8marks)

$$\alpha = \frac{k'_Q}{k'_P}$$

$$= \frac{4}{3} = 1.33$$

α is 2 and it shows good separation

iii) Justify the following statement. (8 marks)

" Compound Q is more polar than compound P"

This is normal phase chromatography. Then the stationary phase is polar. So polar compounds retained in stationary phase more than the less polar. In the chromatogram, P eluted first. Therefore, P is less polar.

B. The simplest form of the Van Deemter equation is given below.

(i) Identify the three terms given in the above equation (6 marks)

A: Eddy diffusion term/ multiple path term

B: Longitudinal diffusion term/ due to the migration from low concentration to high

C: Mass transfer term

(ii) Briefly explain how the particle diameter affects the plate height H.(6 marks)

$A = \lambda d_p$ or A is directly proportional to the particle diameter. C_m is also proportional to the particle diameter and C_m is proportional to C (mass transfer). H increases with increasing the A and C. Therefore, H increases with increasing particle diameter.

C.(i) Write down the fuction of follwing components of Gas Chromotography (GC) intrumentation (6 marks)

Component	Function
Oven	To control the temperature
Open coated open tube column	Act as a stationary phase
Detector	To monitor the response of compounds

(ii) What is the function of Guard column in High Performance Chromatography (HPLC). (4 marks)

To remove the particles and components before entering the to the column, which might have damaged the analytical column if entered.

2. The radioactive isotope ${}^{121}_{50}Y$ decays emitting a beta radiation resulting the new element D.

(i) Write the equation related to the above decay. (10 marks)

$${}^{121}_{50}Y \rightarrow {}^{121}_{51}D + {}^{0}_{-1}\beta$$

(ii) The half life of ${}^{121}_{50}Y$ is 20 hrs. If 0.80 g of it undergoes decaying, what is the weight of the fraction left after 80 hrs.? (10 marks)

No. of half-lives= 80/20 = 4

Fraction left = $\left(\frac{1}{2}\right)^{n}$ n= no. of half-lives = 4

Fraction left = $\left(\frac{1}{2}\right)^{4}$ = 1/16

Weight of the fraction left = 0.80 x 1/16 = 0.05 g

(ii) The above emitted radiation was able to be detected by Gas Flow Proportional Counters but not end-window counters.

(a) What may be the reason? (05 marks)

The beta radiation has low energy (or beta radiation could not penetrate the window).

(b) Describe **one** possible error in brief that could have happened when taking measurements of radioactivity and suggest a way of overcoming the error. (10 marks)

(section 2.4 pgs 26-27)

(c) Element Y is used in the production of an alloy mixture and after the mixture is produced, the total amount of Y cannot be isolated or purified. Therefore, it was decided to carry out Isotope Dilution Analysis using ${}^{121}_{50}Y$. For that, to a sample of the mixture having Y, 30 mg of ${}^{121}_{50}Y$ with an activity of 1000cpm was added; mixed and purified a sample of 5mg of Y having an activity of 50cpm. Calculate the amount of Y in the original mixture. (15 marks)

$$M_x = \frac{R_t M_s}{R_s} - M_t$$

R_t= 1000, M_s = 5mg, R_s= 50cpm, M_t= 30mg

M_x = (1000 x 5)/50 - 30 = 70mg