BINDURA UNIVERSITY OF SCIENCE EDUCATION

CHEMISTRY DEPARTMENT

COURSE: CH304 ANALYTICAL CHEMISTRY III
BSc. (HONS) CHEMICAL TECHNOLOGY PART IV
BSc.ED (HONS) CHEMISTRY EDUCATION

OCT 2024

2 HOURS

ANSWER QUESTION ONE AND FOUR OTHERS.TWO FROM EACH OF THE SECTIONS, A AND B. EACH QUESTION CARRIES 20 MARKS

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1. a) Describe with the help of a diagram, how a faraday cup functions. [5 marks]

   b) Explain why emitted X-rays are characteristic of an element. [2 marks]

   c) What are the benefits of coupling mass spectrometer to a High performance liquid chromatography or gas chromatography instrument? [8 marks]

   d) Why is half-life ($t_{½}$) such an important parameter in the analysis of radioactive elements? [3 marks]

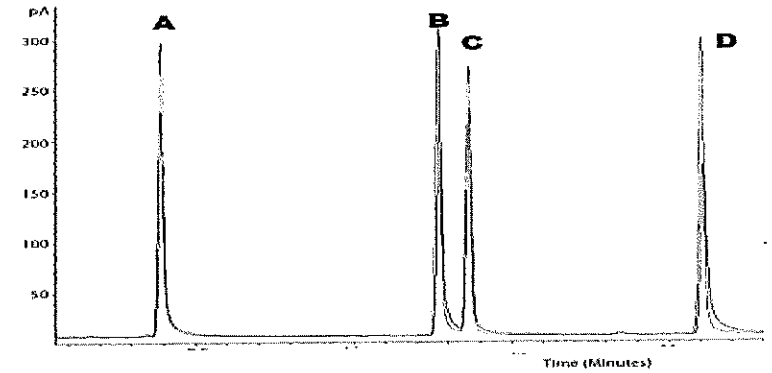
   e) What determines the sensitivity of the secondary electron multiplier? [2 marks]

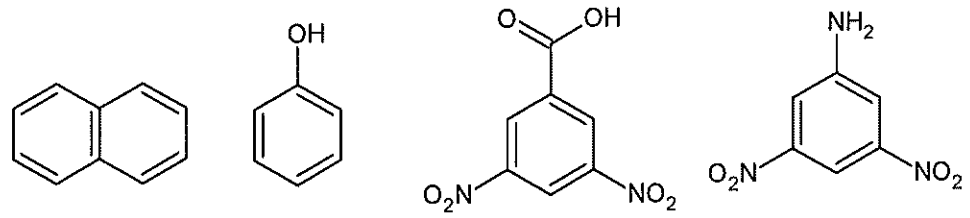
SECTION A: ANSWER ANY TWO QUESTIONS

2. a) What are the advantages and disadvantages of a fluorescence detector? [5 marks]

   b) Distinguish between bulky property detector and specific property detector. [5 marks]

   c) The following analytes were separated on a C_{18} stationary phase and the chromatogram shown below was obtained.





Analyte-A **Analyte-B** **Analyte-C** **Analyte-D**

i) What type of a stationary phase is a C_{18}? [2 marks]

ii) Predict elution sequence by assigning peaks. Give reasons. [4 marks]

iii) How can the retention time of the last eluting analyte be shortened without causing overlapping of peaks? [4 marks]

3. a) Explain how gel-filtration and gel-permeation chromatography. differ. [5 marks]

b) i) Sketch a well labelled cyclic voltammogram of a hypothetical reversible redox couple: $A + e^- \leftrightarrow A^-$. [5 marks]

ii) Indicate the approximate E^o_{red} of the redox species in part (i) on the sketch graph. [2 marks]

c) Sketch a cyclic voltamogram in which the electrode product, P is consumed in a competing chemical reaction. Assume that the product, D is not observed in any further electrochemical reaction. [5 marks]

$A + e^- \leftrightarrow P$
$P \rightarrow D$

d) Define the retardation factor, R_f as applied to thin layer

chromatography. [3 marks]

4. a) Complete the following radioactive decay reactions
i) $^{214}_{82}Pb \rightarrow {}^{y}_{z}X + {}^{0}_{-1}\beta$
ii) $^{Y}_{z}X \rightarrow {}^{30}_{14}Si + {}^{0}_{1}\beta$ [2×2 marks]

b) The activity in a 10-ml sample of radioactive waste water containing a radioactive isotope with t½ of 28.1 years was found to be 9.07×10^6 disintegrations/s. What is the molar concentration of the radioactive isotope in the sample? [6 marks]

c) Using Al as an example, explain the principle behind neutron activation analysis (NAA). [5 marks]

d) What is the principle behind carbon-14 dating? [5marks]

SECTION B: ANSWER <u>ANY TWO</u> QUESTIONS FROM THIS SECTION.

5. a) Distinguish between Rayleigh and Compton scattering. [4 marks]

b) What is the difference between a precursor ion and product ion in tandem mass spectrometry. [4 marks]

c) Why are fragments often produced with electron impact ionization. [2 marks]

d) With the help of appropriate diagrams, the principle behind X-ray fluorescence spectrophotometry. [5 marks]

e) Describe how X-rays interact with matter, with the aid of a diagram [5 marks]

6. a) What is the purpose of high-performance liquid derivatization? [5 marks]

b) Discuss the advantages and disadvantages of neutron activation analysis. [10 marks]

c) Outline the principles of isotope dilution analysis. [5 marks]

7. a) Two 5 ml aliquots of river water were taken for NAA. Exactly 1.00 ml of standard solution containing 1.00 µg of Al^{3+} was added to one aliquot. 1.00 ml of deionized water was introduced to the other. The two samples were then irradiated simultaneously in a homogeneous neutron flux. After a brief cooling period, the gamma radiation of ^{28}Al was counted for each sample. The solution diluted with water gave a counting rate of 2315 cpm, whereas the solution containing added Al^{3+} gave 4197 cpm. Calculate the mass of Al in the 5 ml sample. [7 marks]

b) Discuss the advantages and disadvantages of fast atom bombardment (FAB). [8 marks]

c) Explain the principle behind energy dispersive systems. [5 marks]

END OF PAPER