B.E. (Inst. & Electronics Engg.) 3rd Year Examination 2024
1st Semester
Subject: Analytical Instrumentation

Time: Three Hours | Full Marks: 100

Group A
Answer any five questions

1. What is band broadening in a gas chromatograph? What are the measures taken to reduce it? Why particle size of the support material is crucial for efficient separation of the components of a gas mixture? 1+2+2
2. a) Derive the expressions for the number of theoretical plates and the height equivalent of theoretical plates in a chromatographic column. 3
   b) A substance is found to have the retention time 12.30 min on a 48.0 cm column. An unretained species passes through the column in 1.75 min. The peak width at the base is 1.20 min. Find the number of plates in the column. 2
3. With a diagram, explain the principle of operation of a flame ionization detector. Compare the advantages and disadvantages with thermal conductivity detector. 4+1
4. Draw the block diagram of a mass spectrometer. Describe the principle of operation of discrete type electron multiplier for use as the detector in a mass spectrometer. 2+3
5. a) Describe the chromatographic inlet for coupling a gas chromatograph with a mass spectrometer. 2
   b) Calculate the resolution of a mass spectrometer required to resolve peaks for CH_2N (Mol. Wt. 28.0187) and N_2^+ (mol. Wt. 28.0061). 3
6. Explain the principle of operation of a magnetic sector mass analyzer? 5

Group B
Answer any five questions

7. Define absorbance, transmittance and molar absorptivity in the context of absorption spectroscopy. Write the Beer Lambert's law and explain the terms. 3 + 2

8. a) The molar absorptivity of a compound is 2.26×10^4 at 650 nm. Calculate the concentration of the compound in a solution which has a percent transmittance of 18.75 at 650 nm in a cell with a pathlength of 1.0 cm. 3
   b) Name one radiation source for the IR region and discuss its principle of operation. 2
9. Explain the principle of operation of a photomultiplier tube. 5
10. With a diagram, discuss in short the principle of operation of a FTIR spectrometer. 5
11. For a dispersive type grating, how many lines per millimeter would be required in order for the first-order diffraction line at $\lambda = 625$ nm to be observed at a reflection angle of -30° when the angle of incidence is 45°? 5

12. Why thermal detectors are used in the IR region? Discuss the principle of operation of a bolometer and a pyroelectric detector. 1+2+2

Group C
Answer any five questions

13. Explain with a diagram the working principle of an electrochemical cell. 5
14. What is liquid junction potential and what is the function of a salt bridge? Mention the difference between activity and concentration. 1+2+2

15. Describe the commonly used reference electrodes used in electrochemical analysis. 4
16. Write down the Nernst equation and explain the different terms. Mention the features and differences between potentiometry, voltametry and amperometry. 2+3

17. What is the role of a glass electrode in pH measurement? Briefly explain the construction and working principle of a combination type pH meter. 1+4

18. Mention one application where oxygen analysers are used in the industries. Briefly describe the zirconia oxygen analyser. 1+4

Group D
Answer any five questions

19. What is relative humidity? How are a resistive type sensor and a hair hygrometer used for the measurement of humidity? 1+2+2

20. a) Explain briefly the principle of operation of a NMR spectrometer. What are differences between the 'cw' mode and 'FT' modes of functioning? 4+1

21. Write down the Hagen Poiseuille equation for the pressure drop of a fluid in a capillary. Define the following terms and mention the units: 2+3
    i) absolute viscosity
    ii) kinematic viscosity

22. Explain the working principle of a paramagnetic oxygen analyser. 5

23. What is cell constant in a conductivity meter? Explain the working principle of an electrodeless conductivity meter. 1+4

24. Explain with a diagram the arrangement of a dual beam type turbidity meter. 5