B.Tech. (IEE) 2nd year 2018
2nd Semester

Subject: Analytical Instrumentation

Time: Three Hours | Full Marks: 100

Answer any five questions:

1. a) What are mobile and stationary phases in a gas chromatograph? How the packed columns of a GC are prepared? Compare the different features and specifications between different types of capillary columns and the packed column. 4+4+4
   b) Define the following terms in connection with Gas Chromatography:
      a. Retention time
      b. Band broadening in the chromatogram
      c. Theoretical plate
      d. Height equivalent of a theoretical plate 8

2. a) How does a flame ionization detector and a thermal conductivity detector work? 4+4
   b) Describe the principle of operation of a paramagnetic oxygen analyzer and a zirconia cell oxygen analyser. 6+6

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

   b) The molar absorptivity of a compound is 2.38×10^4 at 755 nm. Calculate the concentration of the compound in a solution which has a percent transmittance of 15.25 at 755 nm in a cell with a pathlength of 2.0 cm. 5

   c) Discuss the principle of operation of a hollow cathode lamp and a diode array detector. 3+2

   d) Why thermal detectors are used in the IR region? Discuss the principle of operation of a bolometer and a pyroelectric detector. 1+4

4. a) Discuss the principle of operation of Czerney – Turner Grating monochromator. 5

   b) For a diffraction grating, how many lines per millimeter would be required in order for the first-order diffraction line at $\lambda = 500$ nm to be observed at a reflection angle of -45° when the angle of incidence is 60°? 3

   c) What is mass spectrometry? Draw the block diagram mass spectrometer to show all the components. Explain briefly the principle of operation of a quadrupole type mass analyzer. 2+2+8

5. a) Explain the working principle of an electrochemical cell. What is liquid junction potential and what is the function of a salt bridge? 4+2+2

b) Describe the commonly used reference electrodes used in electrochemical analysis. 4

c) Write down the Nernst equation and explain the different terms. 2

d) Briefly explain the construction and working principle of a pH meter. What is the composition of the glass in the glass electrode? 5+1

6. a) Explain the principle of operation of a NMR spectrometer. What are the origins of chemical shift and spin-spin splitting and what information are obtained from these data? 5+6

b) Define and mention the units of 2+2
   i) absolute viscosity
   ii) kinematic viscosity

c) With a diagram, explain the principle of operation of a capillary tube viscosity meter. 5

7. Write short notes on (any four): 4 × 5
   a) Electrodeless conductivity meter
   b) Electrical sensor type humidity meter
   c) Photomultiplier tube
   d) Nerst Glower and Globar source
   e) Photovoltaic cell as radiation detector