Exam question on analytical chemistry

1. The Nature of Analytical Chemistry. Analytical objectives. Qualitative and quantitative analysis. General analytical procedure. Different analytical methods. Analytical chemistry in medicine.

2. Analytical reactions. The sensitivity of the reaction (detectable minimum; concentration limit; maximum dilution).

3. Qualitative analysis of cation mixture (previous researches; fractional analysis for presence of certain types of some cations; systematic analysis of cation mixture).

4. Qualitative analysis of cations. Principles of acid-base classification of cations.

5. Qualitative analysis of anions. Principles of anion classification into groups.

6. Types of equilibria in analytical chemistry. The equilibrium constant. Types of equilibrium constants in analytical chemistry.

7. The activity of the ion and activity coefficient. The ionic strength of solution. Original Debye-Huckel equation, the extended Debye–Huckel equation, Davies modification.

8. Equilibrium calculations – solution concentration. Mass balance equations. Principle of electroneutrality. Distribution diagrams.

9. Definitions of acids and bases (Brønsted–Lowry, the Arrhenius definition, Lewis theory). Qualitative considerations, concerning the strength of acids and bases in water.

10. The solvent, different type of solvents. Autoprotolysis of solvent, ion-product constant for water. pH scale.

11. Differentiating solvent and leveling solvent. The strength concept of acids and bases.

12. Calculation of pH in solutions of strong acids and weak acids. pH of a mixture of a acids.

13. Calculation of pH in Solutions of strong base and weak base. pH of a mixture of a bases. pH of an ampholyte solution.

14. A buffer solutions, the buffering mechanism. Henderson–Hasselbalch equation. The buffer capacity.

15. General definitions concerning complexes. Different type of stability constant of complexes. Kinetics of complexes' formation: labile and and inert complexes.

16. Factors influencing the stability of complexes: The ability to complex metallic ions and ligands. The concept of hard and soft acids and bases. The extent of the formation of a complex. Stability of chelates: chelate and macrocyclic effects.

17. Factors influencing the stability of complexes: pH value and ionic strength, concentration of reagents.

18. Organic complexing agents in analytical chemistry. Classification. Examples of applications.

19. Precipitation phenomenon. Intrinsic, ionic, and total solubilities; solubility product and precipitation. The concept of solubility product. Predicting precipitation reactions.

20. Dependence of the solubility on the solution's ionic strength and on the presence of common ions. Separation by precipitation. Solubility as a function of pH. Dissolution of a precipitate.

21. Oxidation/reduction reaction; electrochemical cell, standard cell potential, half-cell potentials. The standard hydrogen electrode; electrode potential (relative electrode potential).

22. Effect of concentration on electrode potentials: the Nernst equation. Redox equilibrium constants.

23. The formal potential. Ox-red systems involving precipitates or complex ions. Effect of ionic strength on the potential. Dependence of potential on pH. Redox phenomena and analytical applications.

24. Type of sample. Processing the sample for analysis. Handling and storing the samples. Dissolving the samples. Sampling uncertainties.

25. Methods of separation and concentration. Classification of separation techniques.

26. Separation by extraction. Using in analytical chemistry. Distribution constant. Factors influents on distribution constant. Distribution coefficient (factor). Factors influents on distribution coefficient.

27. Mechanisms of extraction process. Properties of organic solvents for extraction.

28. Analytical signal. Standard substances and standard samples. Blank determinations. Calibration and standardization process. Absolute methods. Calculations of the content of defined substances on a method of additives, calibration chart, comparison method.

29. Types of errors in experimental data. Some common determinate (systematic) errors. Minimizing errors in analytical procedures. Random errors in chemical analysis.

30. Statistical data treatment and evaluation. Some practical problems with relevant statistical tests (Q-,F-, t-tests).

31. Fundamental types of gravimetric analysis. Precipitation gravimetry. Gravimetric precipitating agent. Steps of a gravimetric analysis.

32. Mechanism of precipitate formation. The effect of relative supersaturation. Factors that determine the particle size of precipitates. Structure of colloidal particle.

33. Impurities in precipitates. Practical treatment of colloidal precipitates. Applications of gravimetric methods.

34. General principle and terms of titrimetric methods. The titration. Types of chemical reactions used in titrations. Some titration forms.

35. Glassware used in titrimetry and its characteristics. Rules of using volumetric equipment. Techniques for calibrating glassware.

36. A standard substances and standard solution. The standardization of the titrant solution. Requirements for a primary standard. Calculating in the titrimetric methods.

37. Equivalence point and end point. Methods of detection. Indicators (type of indicators).

38. The acid–base titrations. Classification. The standard substances and solutions for neutralization titrations. Preparation and standartization of titrants.

39. Acid-base indicators. Origin of the color change of acid-base indicators. Color-change interval of acid-base indicators.

40. Neutralization titration curve. Titration a strong acid with a strong base and vice versa.

41. Neutralization titration curve. Titration of a weak acid with a strong base and weak base with a strong acid.

42. Titration curve: the effect of concentration and strength of acid or base. Choice of the indicator. Titration error.

43. Titration of polyfunctional acids and bases. Determination of $NaHCO_3$ and Na_2CO_3 in presence of each other.

44. Determination of organic nitrogen by Kjeldahl method. Applications of neutralization titrations in aqua solutions.

45. Titration in nonaqueous solutions. Titrant, indicators and standart solutions for titration in nonaqueous solutions. Application of titration procedure in nonaqueous solutions in pharmanalysis.

46. Applications of neutralization titrations in aqua solutions in pharmanalysis.

47. Complexation titrimetry and its classification. Mercurimetry: an essence, titrant, Stanardization of titrant, the indicator, titration conditions, practical application.

48. Complexonometry: basic concepts, peculiarities. Specific and metallochromic indicators.

49. Complexonometry. Chemistry and properties of EDTA. Preparation and standardization of EDTA. Complexes of EDTA and metal ions.

50. Complexonometric titration curve. Influence of pH, concentration and value of formation constants.

51. Types of EDTA titrations. Quantitative applications.

52. Classification of precipitation titration. Mercurometry: an essence, titrant, standardization of titrant, the indicator, titration conditions, practical application.

53. Titration Curves in precipitation titration. Influence of solution concentration, solubilities of compounds and temperature on size inflection points.

54. Argentometry (Mohr method, Fajans method, Volhard method): an essence, titrant, standardization of titrant, the indicator, titration conditions, practical application.

55. Oxidation-reduction (redox) titration: basic concepts, classification, titration curves.

56. Detection of endpoint in redox titration.

57. Iodometry: an essence, titrant, standardization of titrant, the indicator, titration conditions, practical application.

58. Iodometry: determination of water with the Karl Fischer reagent; determination of active chlorine.

59. Iodatometry: an essence, titrant, standardization of titrant, the indicator, titration conditions, practical application.

60. Chloriodimetry: an essence, titrant, standardization of titrant, the indicator, titration conditions, practical application.

61. Nitritometry: an essence, titrant, standardization of titrant, the indicator, titration conditions, practical application.

62. Bromo – and bromatometry: an essence, titrant, standardization of titrant, the indicator, titration conditions, practical application.

63. Permanganatometry: an essence, titrant, standardization of titrant, the indicator, titration conditions, practical application.

64. Cerimetry: an essence, titrant, standardization of titrant, the indicator, titration conditions, practical application.

65. Dichromatometric titration: an essence, titrant, standardization of titrant, the indicator, titration conditions, practical application.

66. Classification of physical-chemical methods of the analysis.

67. Classification of optical methods of the analysis. Properties of electromagnetic radiation.

68. Interaction of Electromagnetic Radiation with Matter. The fundamental law of light absorption. Optical density. Molar absorptivity.Deviation from Beer's Law.

69. Atomic absorption spectrometry. Origins of atomic spectra. Instrumentation. Application.

70. Ultraviolet/Visible absorption and molecular structure. Origins of molecular spectra. Instrumentation. Application.

71. Infrared absorption and molecular structure. Infrared spectra. Infrared spectroscopy. Instrumentation. Application.

73. Atomic Emission Spectroscopy. Origins of atomic spectra. Instrumentation. Application.

74. Theory of Molecular Fluorescence. Relaxation Processes - nonradiative relaxation and fluorescence emission. Fluorescent Species: fluorescence quenching, quantum yield, inner-filter effects.

75. Fluorescence Instrumentation. Spectrofluorometer. Applications of Fluorescence Methods. Phosphorescence and Chemiluminescence.

76. Theoretical bases of chromatographic methods. Classification of chromatographic methods.

77. Chromatogram and its characteristics: retention time, adjusted time, peak width on half of height.

78. Chromatographic process: the theory of theoretical plates and the kinetic theory.

79. Ion-exchange chromatography.

80. Theoretical bases of gas chromatography. A principle of the qualitative and quantitative analysis. The main parts of gas chromatograph. Application.

81. Instruments for gas-liquid and gas-solid chromatography. Gas Chromatography columns. Stationary phases. Gas Chromatography detectors. Application.

82. Theoretical bases of liquid chromatography. A principle of the qualitative and quantitative analysis. The main parts of liquid chromatograph. Application.

83. High-performance liquid chromatography: an essence, equipment, detector systems, the qualitative and quantitative analysis; application.

84. Paper and thin-layer chromatography: an essence, kinds, the qualitative and quantitative analysis, application.

85. Size-Exclusion chromatography. Gel-chromatography.

86. Potentiometry. General principles and classification. Different type of potentiometric electrodes and its characteristics.

87. Ion-Selective Electrodes. Classification. Measurement with Ion-selective electrodes. Direct potentiometric measurements.

88. Potentiometric titrations. Methods for detecting the End Point.

89. Electrochemical methods of analysis. Classification. Electrochemical cells.

90. Coulometry. Theory and classification. Controlled-Potential Coulometry. Controlled-Current Coulometry (coulometric titrimetry). Instrumentation. Application.

91. Coulometric Titrations. Detecting the End Point. Instrumentation. Applications.

92. Voltammetric Methods of Analysis. Excitation Signals. Classification. Instrumentation. Application.

93. Amperometric Titrations. Application.

94. Polarography. Dropping Mercury Electrode.