1. Which of the following is a geminal dihalide?
   (A) cis-1, 2-dibromocyclopentane
   (B) 3, 3-dichloropentane
   (C) trans-1, 4-diiodocyclohexane
   (D) isobutyl chloride

2. Predict the two most likely mechanisms for the reaction of 2-iodohexane with sodium ethoxide.
   (A) S_N2 and S_N1
   (B) E1 and E2
   (C) S_N2 and E2
   (D) E1 and S_N1

3. Which of the following alkyl chlorides is least likely to undergo rearrangement during a solvolysis reaction?
   (A) 2-chloro-4-methylpentane
   (B) 2-chloro-3-methylpentane
   (C) 2-chloro-2-methylpentane
   (D) *cis*-1-chloro-2-ethylcyclohexane

4. When a high energy electron impacts molecule M in the ionization chamber, what type of species is initially produced?
   (A) cation
   (B) anion
   (C) radical
   (D) radical cation

5. In the allyl radical, which molecular orbital is singly occupied?
   (A) The bonding molecular orbital.
   (B) The nonbonding molecular orbital.
   (C) The antibonding molecular orbital.
   (D) None of the above

6. Which of the following compounds has the most negative heat of hydrogenation?
   (A) 1,4-hexadiene
   (B) 1,5-hexadiene
   (C) 1,2-hexadiene
   (D) 1,3-hexadiene

7. In the carbon NMR, in what region of the spectrum does one typically observe carbons which are part of the aromatic ring?
   (A) -10.0-0.0 ppm
   (B) 40.0-60.0 ppm
   (C) 80.0-100.0 ppm
   (D) 120.0-150.0 ppm

8. In the UV-visible spectra of the following compounds, in which does lambda max appear at the highest wavelength?

(A) 3-phenylpropene
(B) 1-phenylpropene
(C) benzene
(D) n-octylbenzene

9. Which of the following species is attacked by benzene in the electrophilic nitration reaction?
(A) HNO_3
(B) NO
(C) NO_2
(D) NO^+

10. Which of the following is the strongest acid?
(A) acetic acid
(B) chloroacetic acid
(C) bromoacetic acid
(D) fluroacetic acid

11. Among the butane conformers, which occur at energy minima on a graph of potential energy versus dihedral angle?
(A) gauche only
(B) eclipsed and totally eclipsed
(C) gauche and anti
(D) eclipsed only

12. Which of the following is not a common standard solution for acid/ base titrations?
(A) hydrochloric acid
(B) nitric acid
(C) perchloric acid
(D) sulfuric acid

13. Find the ionic strength of a 0.1 M solution of Na_2SO_4.
(A) 0.1 (B) 0.2 (C) 0.3 (D) 0.4 M

14. What is the analytical concentration (or analytical molarity) of a weak base, NaA, in a 100-mL solution containing 0.82 g of NaA? (for NaA, $K_b = 1 \times 10^{-9}$, mw = 82.0 g/mole)
(A) 0 (B) 0.0010 (C) 0.10 (D) 1.0 M

15. Select a pH range which exhibits the best buffer capacity for buffer solutions prepared by acetic acid and sodium acetate. (for acetic acid, $K_a = 1.75 \times 10^{-5}$)
(A) 2~3 (B) 3~4 (C) 4~5 (D) 9~10

16. A solution containing NaOH, Na_2CO_3, and $NaHCO_3$, alone or in compatible combination, was titrated with 0.1202 M HCl. The volumes of acid needed to titrate 25.00-mL portions of each solution to a phenolphthalein and bromocresol green end points are 16.12 and 32.23 mL, respectively. What is the composition of the solutions?

(A) NaOH alone
(B) Na_2CO_3 alone
(C) $NaHCO_3$ and Na_2CO_3
(D) NaOH and Na_2CO_3

17. The isoelectric point is the
(A) pH
(B) temperature
(C) strength of electric field
(D) concentration
at which no net migration of amino acids occurs when they are placed in an electric field.

18. During EDTA titrations, the addition of a complexing agent
(A) causes a decrease in conditional formation constant.
(B) increases the solubility of EDTA.
(C) increases the sharpness of a titration curve at the equivalence point.
(D) decreases the buffer capacity of the solution.

19. Find the thermodynamic potential of the following cell:
$Cu|Cu^{2+}(0.0100\ M)||Ag^{+}(0.0100\ M)|Ag$
($E^{\circ}_{Ag^{+}/0} = 0.799$ V, $E^{\circ}_{Cu^{2+}/0} = 0.337$ V)
(A) -0.462 (B) -0.403 (C) 0.462 (D) 0.403 Volt

20. The signal-to-noise ratio of a spectral is proportional to
(A) N (B) $N^{1/2}$ (C) $N^{-1/2}$ (D) N^{-1},
where N is the number of repetitive measurements.

21. Which of the following light sources for spectroscopic instruments is a line source?
(A) hollow cathode lamp
(B) D_2 lamp
(C) Nernst glower
(D) nichrome wire

22. Which of the following detectors is <u>not</u> utilized to record the whole absorption spectra simultaneously (i.e. taking data at a range of wavelength at the same time)?
(A) photodiode arrays
(B) charge coupled devices
(C) photomultiplier tubes
(D) a photographic plate.

23. Which of the following techniques is relatively difficult to provide quantitative measurements?
(A) FTIR
(B) mass spectrometry
(C) atomic emission spectrometry
(D) coulometry

24. Mathematical approximation of the behavior of chromatographic columns is described by the van Deemter equation:

$$H = A + B/u + (C_S + C_M)u$$

For an open tubular column, which factor listed above can be neglected?
(A) A (B) B (C) C_S (D) C_M

25. Which one of the following is the point group for BrF_5?
(A) D_{3h} (B) C_{4v} (C) C_{3v} (D)D_{3d}

26. The order of trans effect in platinum chemistry is
(A) $CO > H_2O > B_r^- > NH_3$
(B) $CO > I^- > Cl^- > OH^-$
(C) $CO > NH_3 > Br^- > H_2O$
(D) $CO > Cl^- > NO_2^- > I^-$

27. The order of increasing rate of substitution by H_2O is
(A) $[Ir(NH_3)_6]^{3+} < [Ni(OH_2)_6]^{2+} < [Co(NH_3)_6]^{3+} < [Mn(OH_2)_6]^{2+}$
(B) $[Mn(OH_2)_6]^{2+} < [Co(NH_3)_6]^{3+} < [Ni(OH_2)_6]^{2+} < [Ir(NH_3)_6]^{3+}$
(C) $[Ir(NH_3)_6]^{3+} < [Co(NH_3)_6]^{3+} < [Ni(OH_2)_6]^{2+} < [Mn(OH_2)_6]^{2+}$
(D) $[Ir(NH_3)_6]^{3+} < [Co(NH_3)_6]^{3+} < [Mn(OH_2)_6]^{2+} < [Ni(OH_2)_6]^{2+}$

28. The substitution reaction $L_5MX + Y \rightarrow L_5MY + X$ involves two steps:

$$L_5MX \rightleftarrows L_5M + X$$
$$L_5MX + Y \rightarrow L_5MY$$

The mechanism of this reaction is
(A) dissociation (D)
(B) dissociative interchange (I_d)
(C) associative interchange (I_a)
(D) association (A)

29. Pyrex glass is formed by adding an oxide of ___ to soda-lime glass.
(A) lead (B) cobalt (C) boron (D) silver

30. Why are silicate minerals not commonly used as sources of metals?
(A) they are rare.
(B) they usually do not contain important metals.
(C) they are difficult to reduce and concentrate.
(D) they are only found at excessive depths in the oceans.

31. Based on the activity series, which reaction below will not occur?
(A) $Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$
(B) $Ag(s) + 2HNO_3(aq) \rightarrow 2AgNO_3(aq) + H_2(g)$
(C) $Ni(s) + H_2SO_4(aq) \rightarrow NiSO_4(aq) + H_2(g)$
(D) $2Al(s) + 6HBr(aq) \rightarrow 2AlBr_3(aq) + 3H_2(g)$

32. The respective hybridizations of bromine in BrF_5 and arsenic in AsF_5 are
(A) sp^3 and sp^3d (B) sp^3d and sp^3d^2
(C) sp^3 d and sp^3 (D) sp^3d^2 and sp^3d

33. Chemical treatment of municipal water supplies commonly entails use of CaO, $Al_2(SO_4)_3$, and Cl_2 . The purpose of adding CaO is to
(A) remove all SO_4^{2-} as solid $CaSO_4$.
(B) remove all Cl^- as solid $CaCl_2$.
(C) selectively kill anaerobic (but not aerobic) bacteria.
(D) made the water slightly basic so that addition of $Al_2(SO_4)_3$ will afford a gelatinous precipitate of $Al(OH)_3$.

34. The basis for the carbon-14 dating method is that
(A) the amount of carbon-14 in all objects is the same.
(B) carbon-14 is very unstable and is readily lost from the atmosphere.
(C) the ratio of carbon-14 to carbon-12 in the atmosphere is a constant.
(D) living tissue will not absorb carbon-14 but will absorb carbon-12.

35. Which one of the following is used as a radiotracer to study blood?
(A) iron-59 (B) technetium-99 (C) sodium-23 (D)iodine-131

36. Which one of the following is the least abundant in nature?
(A) iodine (B) bromine (C)chlorine (D) fluorine

37. Interhalogen compounds
(A) are exceedingly reactive.
(B) contain halogens in a positive oxidation state.
(C) are powerful oxidizing agents .
(D) all of these.

38. Assuming that at S.T. P. gas A has a density of 0.09 g/l and gas B has a density of 1.43 g/l, the relative rate of diffusion of gas A to that of gas B is
(A) 1 to 16 (B) 16 to 1 (C) 2 to 1 (D) 4 to 1.

39. From Trouton's rule, the latent heat of evaporation per gm-molecular weight of a liquid divided by its boiling point is constant which is about
(A) 6.3 (B) 3.0 (C) 10.0 (D) 21.0

40. The anomalous boiling point of water is generally attributed to which one of the following?
(A) van der Waal's forces (B) hydrogen bonding (C) covalent bonding (D) ionic bonding

41. Solutions which distill without change in composition or temperature are called
(A) amorphous (B) azeotropic mixtures (C) supersaturated (D) ideal solution.

42. Which of the followings is a zero order reaction?
(A) Thermal isomerization of cis-stilbene to trans-stilbene
(B) enzyme oxidation of glucose to gluconic acid.
(C) decay of radioactivity of ^{60}Co.
(D) decay of triplet excited C_{60} to ground state.

43. Which of the following equations is not correct?
(A) $dG = Vdp - SdT$ (B) $\varepsilon = \varepsilon^\circ - (nF/RT)\ln(Q)$ (C) $(\partial S/\partial P)_T = -(\partial V/\partial T)_p$
(D) $dP/dT = \Delta H_m/T\Delta V_m$.

44. Which of the followings absorbs radiowave?
(A) vibrational transitions (B) rotional transition. (C) nuclear spin transitions (D) electron spin transitions.

45. 1 eV is equivalent to about
(A) 23 kcal/mol (B) 15 kcal/mol. (C) 32 kcal/mol (D) none of the above

46. In a closed container, there are equal moles of N_2 and O_2. Which of the following description is not correct?
(A) N_2 and O_2 molecules have the same kinetic energy.
(B) N_2 and O_2 molecules have the same velocities.
(C) The partial pressures produced by N_2 and O_2 are the same.
(D) The momentum of N_2 and O_2 molecules are not the same.

47. When an electron and a hole encounter together, the probability to have triplet state is
(A) 25% (B) 50% (C) 75% (D) 100%.

48. A substance which absorbs strongly at ~ 630 nm wavelength, will show up as
(A) red (B) yellow (C) green (D) blue color.

49. Consider a reaction wherer the enthalpy change is negative and the entropy change is also negative. Which set of conditions will lead to the reaction being nonspontaneous?
(A) The ΔH is small and temperature is high
(B) The ΔH is large and the temperature is low
(C) The ΔH is small and temperature is low
(D) none of the above.

50. The redox potential of a molecule will not be affected by which of the following factors?
(A) the ratio of the oxidation and the reduction states
(B) temperature
(C) pH
(D) external pressure.