單選題，每題二分，不倒扣

1. Which of the following correctly lists the conformations of cyclohexane in order of increasing energy?
   (A) chair < boat < twist < half-chair
   (B) half-chair < boat < twist < chair
   (C) chair < twist < half-chair < boat
   (D) chair < twist < boat < half-chair

2. Consider the equilibrium of each of the carbonyl compounds with HCN to produce cyanohydrins. Which is the correct ranking of compounds in order of increasing Keq for this equilibrium?
   (A) H_2CO < cyclohexanone < CH_3CHO < 2-methylcyclohexanone
   (B) CH_3CHO < 2-methylcyclohexanone < cyclohexanone < H_2CO
   (C) cyclohexanone < 2-methylcyclohexanone < H_2CO < CH_3CHO
   (D) 2-methylcyclohexanone < cyclohexanone < CH_3CHO < H_2CO

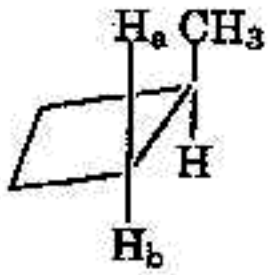
3. The Hofmann elimination proceeds via a(n) _____ pathway.
   (A) E1 (B) E2 (C) Saytzeff (D) S_N2

4. Using Saytzeff's rule, choose the most stable alkene among the following.
   (A) 1-methylcyclohexene (B) 3-methylcyclohexene
   (C) 4-methylcyclohexene
   (D) They are all of equal stability according to Saytzeff's rule.

5. Secondary amines react with the nitrosonium ion to generate:
   (A) diazonium salts (B) N-nitrosoamines
   (C) oximes (D) imines

6. Which of the statements below correctly describes the chair conformations of trans-1,4-dimethylcyclohexane?
   (A) The two chair conformations are of equal energy.
   (B) The lower energy chair conformation contains one axial methyl group and one equatorial methyl group.
   (C) The higher energy methyl group contains two axial methyl groups.
   (D) The lower energy chair conformation contains two axial methyl groups.

7. The protons marked H_a and H_b in the molecule below are _____.



   (A) chemically equivalent (B) enantitopic
   (C) diastereotopic (D) endotopic

8. What descriptive term is applied to the type of diene represented by 2,4-hexadiene?
   (A) conjugated diene (B) cumulated diene
   (C) isolated diene (D) alkynyl diene

9. Which of the following alkyl halides would be suitable to use when forming a Grignard reagent?
   (A) $H_2NCH_2CH_2Br$ (B) $(CH_3)_2NCH_2CH_2Br$
   (C) $CH_3COCH_2CH_2Br$ (D) $BrCH_2CH_2CH_2CN$

10. When (R)-2-butanol is treated with TsCl in pyridine, the product formed is:
   (A) An achial compound (B) a mixture of diastereomers
   (C) a racemic mixture (D) a single enantiomer

11. 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

12. Predict the two most likely mechanisms which occur when 2-iodohexane is heated in ethanol.
(A) E1 and E2 (B) S_N2 and E2
(C) E1 and S_N1 (D) E2 and S_N1

13. What is the approximate chemical shift of an alkynyl carbon in ^{13}C NMR spectroscopy?
(A) 10 ppm (B) 30 ppm (C) 70 ppm (d) 120 ppm

14. A sample is brought into a laboratory and mixed with an equal volume of a preservative solution. For analysis a 5.00-mL sample is diluted to 100 mL, and the concentration of chloride ions in the diluted solution is found to be 3.0×10^{-3}M. What is the chloride concentration of the sample?
(A) 6.0×10^{-3}M (B) 1.5×10^{-4}M
(C) 7.5×10^{-5}M (D) 1.2×10^{-1}M

15. The relative uncertainty in the answer to the calculation $\frac{23.00 \times 1.68}{0.1416 \times 0.1332}$ is
(A) 10 (B) 5×10^{-3} (C) 0.01 (D) 0.0001

16. A 35.25-mL sample is needed. The best piece of glassware to use is
(A) a buret (B) a beaker (C) a graduated cyclinder
(D) a volumetric flask

17. A buffer with a pH of 10.0 is needed. Which of the following should be used?
(A) acetic acid with a K_a of 1.8×10^{-5}
(B) ammonia with a K_b of 1.8×10^{-5}
(C) nitrous acid with a K_a of 7.1×10^{-4}

(D) $H_2PO_4^-$ and PO_4^{3-} with a K_a of 4.5×10^{-13}

18. An indicator has a K_a of 6.4×10^{-6}, the conjugated acid is red, and the conjugate base is yellow. At what pH will the solution be red?
(A) 5.2 (B) 5.5 (C) 4.0 (D) 4.7

19. If 50.0 mL of a 0.0134 M HCl solution is mixed with 24.0 mL of a 0.0250 M NaOH solution, what is the pH of the final mixture?
(A) 1.87 (B) 12.40 (C) 5.29 (D) 3.02

20. A solution containing HF is titrated with KOH. At the end point of the titration the solution contains
(A) equal amounts of HF and KOH (B) H_2O, H^+, OH^-, K^+, F^-, and HF
(C) K^+ and F^- (D) KF and H_2O

21. What is the molar solubility of silver chromate?
(K_{sp} for $Ag_2CrO_4 = 1.2 \times 10^{-12}$)
(A) 1.1×10^{-6} (B) 1.1×10^{-4} (C) 6.7×10^{-5} (D) 5.5×10^{-7}

22. What is the major cause of the deviation of the Beer's law for the measurement of the acetic acid absorbance?
(A) the dimer chemical reaction (B) the wavelength band with chosen
(C) the slit width of the monochrameter
(D) the background stray light.

23. For the reduction of MnO_4^- to Mn^{2+}, the correct form of the Nernst equation is
(A) $E = E^o + \frac{0.0591}{3} \log \left(\frac{[Mn^{2+}]}{[MnO_4^-][H^+]^8} \right)$ (B) $E = E^o + \frac{0.0591}{5} \log \left(\frac{[Mn^{2+}]}{[MnO_4^-][H^+]^8} \right)$

(C) $E^o = E + \frac{0.0591}{5} \log \left(\frac{a_{(Mn^{2+})}}{a_{(MnO_4^-)} \cdot a_{(H^+)}^8} \right)$

(D) $E = E^0 + \frac{0.0591}{5} \log \left(\frac{a_{(Mn^{2+})}}{a_{(MnO_4^-)} \cdot a^8_{(H^+)}} \right)$

24. The K_{sp} of AgCl is 1.0×10^{-10}, and the K_{sp} of AgI is 8.3×10^{-17}. A solution is 0.100 M in I^- and Cl^-. What is the molarity of iodide ions when AgCl just starts to precipitate?
(A) 1.0×10^{-5} (B) 9.1×10^{-9} (C) 8.3×10^{-7}
(D) 8.3×10^{-8}

25. What kind of the information will be provided by the IR spectrum?
(A) Electronic transition (B) Nuclear spin (C) Nuclear Vibration
(D) Electron spin

26. For an idealized octahedral complex ML_6, rotation of one L_3 triangular plane by 120° with respect to the opposite L_3 triangle would afford a structure with point group:
(A) C_{3h} (B) D_3 (C) C_{3v} (D) T_d (E) O_h.

27. Which dinuclear compounds listed below possesses a metal-metal double bond ?
(A) $W_2(OMe)_6$ (B) $Mo_2(MeCO_2)_4$, $MeCO_2$ = acetate
(C) $Cp_2Re_2(CO)_4$, $Cp = C_5H_5$ (D) $Cp_2W_2(CO)_6$.

28. Which of the following parameters are belongs to the hexagonal crystal system.
(A) $a = b = c$; $\alpha = \beta = \gamma = 90°$ (B) $a \neq b \neq c$; $\alpha = \beta = 90°$, $\gamma \neq 90°$
(C) $a \neq b \neq c$; $\alpha \neq \beta \neq \gamma \neq 90°$ (D) $a = b \neq c$; $\alpha = \beta = 90°$, $\gamma = 120°$.

29. Crown ethers are polydentate ligands in which the ligating oxygen atoms are constrained in a large ring encircling the metal atom. How many carbon atoms can be found in the compound 18-crown-6?
(A) 18 (B) 12 (C) 10 (D) 8 (E) 6.

30. Thermolysis of $Co_2(CO)_8$ leads to the formation of a high nuclearity cluster complex with four cobalt metal atoms. Using the EAN rule, predict the total number of CO groups that are still associated with this tetrametallic compound.
(A) 8 (B) 9 (C) 12 (D) 15.

31. Which of the following compound is most likely to crystallize in the crystal system called pervoskites?
(A) $MgCl_2$ (B) $BaTiO_3$ (C) CsCl (D) Nb_2O_5 (E) $MgAl_2O_4$.

32. Which of the following platinum compound possesses extremely high anti-tumor activity?
(A) $PtCl_4^{2-}$ (B) *trans*-$PtCl_2(NH_3)_2$ (B) *cis*-$PtCl_2(NH_3)_2$ (C) $Pt(NH_3)_4^{2+}$.

33. What is the most convenient technique to probe the structure of a volatile inorganic molecule, such as SiF_4 in gaseous phase?
(A) X-ray diffraction method (B) Electron diffraction method
(C) Extended X-ray absorption fine structure, EXAFS method
(D) Neutron diffraction method. (E) UV-Visible Spectroscopy.

34. Which of the following compound possesses the maximum number of unpaired electrons in the ground state.
(A) $Co(CN)_6^{3-}$ (B) $LaCl_3$ (C) O_2 (D) P_4O_{10} (E) $Cu(H_2O)_4^{2+}$.

35. Which of the following phosphorus-bearing ligands PR_3 would form the strongest W-P bond in the tungsten carbonyl complexes $W(CO)_5(PR_3)$.
(A) R = F (B) R = Cl (C) R = OMe (D) R = Me (E) R = Ph.

36. Which of the following statements is not true of diborane?
(A) It is an electron-deficient compound.
(B) It has two three center bonds.
(C) It is a highly reactive oxidizing agent.
(D) It is a Lewis acid. (E) It has two different types of hydrogen atoms.

37. The NO_2^- ion forms linkage isomers in which either the nitrogen or the oxygen is bound to a transition metal ion. Which of the following ligands can also forms linkage isomers?
(A) CO_2 (B) SCN^- (C) OH^- (D) CO_3^{2-}.

38. Which is correct for the binding energy of the following species?
(A) $N_2^+ > N_2$, (B) $O_2^+ > O_2$, (C) $O_2 > N_2$, (D) $O_2 > N_2^+$

39. Which spin wave function is not associated with a $^3\Pi$ state?
(A) $\frac{1}{\sqrt{2}}(\alpha\beta + \beta\alpha)$, (B) $\alpha\alpha$, (C) $\frac{1}{\sqrt{2}}(\alpha\beta - \beta\alpha)$, (D) $\beta\beta$

40. If the vibrational frequency of HF is 4000 cm^{-1}, what is the vibrational frequency of DF?
(A) ~4000 cm^{-1}, (B) ~2800 cm^{-1}, (C) ~2000 cm^{-1}, (D) ~3600 cm^{-1}.

41. Which one is <u>INCORRECT</u> in a reversible adiabatic expansion of an ideal gas if $\gamma = C_p/C_v$
(A) $P_1V_1^{\gamma} = P_2V_2^{\gamma}$, (B) $(T_2/T_1) = (V_1/V_2)^{\gamma-1}$, (C) $P_2V_2/P_1V_1 = T_2/T_1$,
(D) $(T_2/T_1) = (P_2/P_1)^{1-\gamma}$

42. Which one of the following equations is <u>INCORRECT</u>?
(A) $\left(\frac{\partial T}{\partial V}\right)_S = \left(\frac{\partial P}{\partial S}\right)_V$, (B) $\left(\frac{\partial T}{\partial P}\right)_S = \left(\frac{\partial V}{\partial S}\right)_P$,

(C) $\left(\frac{\partial S}{\partial T}\right)_V = \frac{C_v}{T}$, (D) $\left(\frac{\partial G}{\partial T}\right)_P = -S$

43. What is the number density of 1 torr gas at 300 K?
(A) ~1×10^{18} molecule cm^{-3}, (B) ~2×10^{17} molecule cm^{-3},
(C) ~3×10^{16} molecule cm^{-3}, (D) ~4×10^{15} molecule cm^{-3}

44. For a system with $C_p = a + bT$, which one is correct?

(A) $\Delta H = \Delta H_0 + aT + \frac{b}{2}T^2$, (B) $\Delta S = a \ln T$, (C) $\Delta A = \Delta A_0 + b \ln T$,
(D) $\Delta G = \Delta H_0 - aT\ln T - \frac{b}{2}T^2$

45. Which one is NOT colligative property (which depends on concentration rather than the identity of the molecules)
(A) frezing point depression, (B) vapor pressure lowering,
(C) capillary rise, (D) osmotic pressure

46. Which one is INCORRECT? The saturated solution has a concentration y_m°
(A) $A_{(s)} \rightarrow A$ (saturated solution, concentration = y_m°), $\Delta G = RT \ln y$,
(B) $A_{(s)} \rightarrow A$ (solution, x_m°), $\Delta G = RT \ln \frac{x}{y}$,
(C) $A_{(s)} \rightarrow A$ (solution, 1_m°), $\Delta G = -RT \ln y$
(D) A (solution, x_m°) $\rightarrow$ A (solution, 1_m°), $\Delta G = -RT \ln x$

47. In a second-order reaction $A + B \rightarrow C + D$, the rate coefficient is k and the initial concentrations are $[A]_0 >> [B]_0$. To a reasonably good approximation, which one is correct?
(A) $\ln [B]/[B]_0 = -kt$, (B) $[B]/[B]_0 = \exp(-k[A]_0 t)$,
(C) $\ln \frac{[A]/[A]_0}{[B]/[B]_0} = \{[A]_0 - [B]_0\}kt$, (D) $\frac{1}{[B]} - \frac{1}{[B]_0} = kt$

48. For a first-order consecutive reaction

$$A \xrightarrow{k_1} B \xrightarrow{k_2} C,$$

the initial concentrations are $[B]_0 = [C]_0 = 0$. Choose the INCORRECT one
(A) If $k_1 >> k_2$, $[C] = [A]_0 (1 - e^{-k_2 t})$
(B) If $k_2 >> k_1$, $[C] = [A]_0 (1 - e^{-k_1 t})$
(C) $[B] \approx [A]_0 e^{-k_2 t}$ at the later stage of reaction
(D) $[C] = [A]_0$ at $t \rightarrow \infty$

49. At temperature T what is the fraction of Ar that has an energy exceeding E_0?

(A) $(\frac{3}{2}RT - E_0)/\frac{3}{2}RT$, (B) $\int_{E_0}^{\infty} e^{-E/RT} E\, dE / \int_0^{\infty} e^{-E/RT} E\, dE$,

(C) $\int_{E_0}^{\infty} e^{-E/RT}\, dE / \int_0^{\infty} e^{-E/RT}\, dE$, (D) $\int_{E_0}^{\infty} e^{-E/RT} E^{1/2}\, dE / \int_0^{\infty} e^{-E/RT} E^{1/2}\, dE$

50. What is the symmetry group of ethylene (C_2H_4)?

(A) C_{2v}, (B) C_{2h}, (C) D_{2h}, (D) D_{2d}