1. A titration was performed to find the concentration of hydrochloric acid with the following results:

Trial	Molarity (M)
1	0.125
2	0.126
3	0.124

The actual concentration of HCl was determined to be 0.100 M; the results of the titration are:

(A) both accurate and precise.   (B) accurate but imprecise.   (C) precise but inaccurate.   (D) both inaccurate and imprecise.

2. Which of the following are incorrectly paired?

(A) Cadmium, Cd   (B) Potassium, K   (C) Tungsten, T   (D) Tin, Sn

3. Gallium consists of two isotopes of masses 68.95 amu and 70.95 amu with abundances of 60.16% and 39.84%, respectively.   What is the average atomic mass of gallium?

(A) 69.95   (B) 70.15   (C) 70.75   (D) 69.75

4. The limiting reactant in a reaction

(A) has the lowest coefficient in a balanced equation.

(B) is the reactant for which you have the fewest number of moles.

(C) has the lowest ratio of moles available/coefficient in the balanced equation.

(D) has the lowest ratio of coefficient in the balanced equation/moles available.

5. What is the coefficient for oxygen when the following equation is balanced?

$NH_3(g) + O_2(g) \rightarrow NO_2 (g) + H_2O(g)$

(A) 12   (B) 7   (C) 6   (D) 3

6. What mass of calcium chloride, $CaCl_2$, is needed to prepare 500 mL of a 1.56 M solution? (Ca: 40.08, Cl: 35.45)

(A) 86.6 g   (B) 60.8 g   (C) 111 g   (D) 25.6 g

7. Consider two organic molecules, ethanol and benzene.   One dissolves in water and the other does not.   Why?

(A) They have different molar masses.   (B) One is ionic, the other is not.

(C) One is an electrolyte, the other is not.   (D) Ethanol contains a polar OH bond, and benzene does not.

8. A gas sample is held at constant pressure.   The gas occupies 3.62 L of volume when the temperature is 21.6   .   Determine the temperature at which the volume of the gas is 3.45 L.

(A) 0.55   (B) 7.77   (C) 20.6   (D) 45.2

9. Which conditions of P, T, and n, respectively, are most ideal?

(A) low P, high T, low n   (B) low P, low T, low n   (C) high P, low T, high n   (D) low P, high T, high n

10. One mole of an ideal gas is expanded from a volume of 1.00 liter to a volume of 10.00 liters against a constant external pressure of 1.00 atm.   How much work (in joules) is performed on the surroundings?   (T = 300 K; 1 L atm = 101.3 J)

(A) 456 J   (B) 912 J   (C) 2740 J   (D) none of these

11. What is the wavelength of a photon of red light (in nm) whose frequency is 4.60×10^{14} Hz?

(A) 652 nm   (B) 153×10^6 nm   (C) 153 nm   (D) 460 nm

12. Which of the following is not determined by the principal quantum number, n, of the electron in a hydrogen atom?

(A) the energy of the electron   (B) the minimum wavelength of the light needed to remove the electron from the atom.

(C) the size of the corresponding atomic orbital(s)   (D) the shape of the corresponding atomic orbital(s)

13. The electron configuration for Cr^{2+} is
    (A) $[Ar]4s^23d^4$ (B) $[Ar]4s^13d^5$ (C) $[Ar]3d^4$ (D) $[Ar]4s^23d^2$

14. In the gaseous phase, which of the following diatomic molecules would be the most polar?
    (A) CsF   (B) CsCl   (C) NaCl   (D) NaF

15. According to VSEPR theory, which of the following species has a square planar molecular structure?
    (A) $TeBr_4$ (B) BrF_3 (C) IF_5 (D) XeF_4

16. The hybridization of the central atom in SeF_4 is:
    (A) sp   (B) sp^3 (C) dsp^3 (D) d^2sp^2

17. Which of the following has the largest bond order?
    (A) N_2 (B) N_2^- (C) N_2^{2+} (D) N_2^+

18. Order the intermolecular forces (dipole-dipole, London Dispersion, ionic, and hydrogen-bonding) from weakest to strongest.
    (A)   dipole-dipole, London Dispersion, ionic, and hydrogen-bonding
    (B)   London Dispersion, dipole-dipole, hydrogen-bonding, ionic
    (C)   hydrogen-bonding, dipole-dipole, London Dispersion, and ionic
    (D)   dipole-dipole, ionic, London Dispersion, and hydrogen-bonding

19. Thyroxine, an important hormone that controls the rate of metabolism in the body, can be isolated from the thyroid gland.   If 0.455 g of thyroxine is dissolved in 10.0 g of benzene, the freezing point of the solution is 5.144   .   Pure benzene freezes at 5.444   and has a value for the molal freezing point depression constant of Kf of 5.12   /m.   What is the molar mass of thyroxine?
    (A) 9980 g/mol   (B) 777 g/mol   (C) 2330 g/mol   (D) 285 g/mol

20. If the concentration of the product were to double, what would happen to the equilibrium constant?
    (A)   It would double its value.   (B) It would become half its current value.
    (C)   It would quadruple its value.   (D) It would not change its value.

21. What statement about equilibrium is true?
    (A) When two opposing processes proceed at identical rates, the system is at equilibrium.
    (B) The equilibrium constant is independent of temperature.
    (C) An endothermic reaction shifts toward reactants when heat is applied.
    (D) Catalysts shifts the position of an equilibrium.

22. How many moles of solid NaF would have to be added to 1.0 L of 1.90 M HF solution to achieve a buffer of pH 3.35?   Assume there is no volume change.   (Ka for HF = 7.2×10^{-4})
    (A) 3.1   (B) 2.3   (C) 1.6   (D) 1.0

23. Find the solubility (in mol/L) of lead chloride ($PbCl_2$) at 25   .   Ksp = 1.6×10^{-5}
    (A) 1.6×10^{-5} (B) 1.6×10^{-2} (C) 0.020   (D) 0.21

24. As water is heated, its pH decreases.   This means that
    (A)   the water is no longer neutral.   (B) the K_w value is decreasing.
    (C)   the water has a lower $[OH^-]$ than cooler water.   (D) the dissociation of water is an endothermic process.

25. Which of the following is true for the cell shown here?
    Zn(s) Zn^{2+}(aq) Cr^{3+}(aq)   Cr(s)
    (A)   The electrons flow from the cathode to the anode.   (B) The electrons flow from the zinc to the chromium.
    (C)   The electrons flow from the chromium to the zinc.   (D) The chromium is oxidized.

26. When 3.0 L of hydrogen gas (H_2) reacts with 1.0 L of nitrogen gas (N_2), 2.0 L of gaseous product are formed.   All volumes of gases are measured at the same temperature and pressure.   What is the formula of the product?
    (A) N_2H_6 (B) NH_3 (C) NH_4 (D) NH

27. Which is the correct formula for aluminum oxide?
    (A) AlO   (B) Al_2O_3 (C) AlO_3 (D) Al_3O_2

28. The average mass of a boron atom is 10.81. If you were able to isolate a single boron atom, what is the chance that you would randomly get an atom with mass 10.81?
    (A) 0%   (B) 0.81%   (C) about 11%   (D) 10.81%

29. For which of the following compounds does 1.0 g represent 2.27×10^{-2} mol?
    (A) H_2O (B) CO_2 (C) NH_3 (D) C_2H_6

30. A sample of nitrogen gas has a volume of 160.0 mL at STP. What volume does the gas occupy if the absolute temperature and pressure are each doubled?
    (A) 40.00 mL   (B) 80.00 mL   (C) 160.0 mL   (D) 320.0 mL

31. Which gas has the highest density?
    (A) He   (B) Cl_2 (C) CH_4 (D) NH_3

32. For the hypothetical reactions 1 and 2, $K_1 = 10^2$ and $K_2 = 10^{-4}$.
    1. $A_2(g) + B_2(g) \rightleftharpoons 2AB(g)$
    2. $2A_2(g) + C_2(g) \rightleftharpoons 2A_2C(g)$
    3. $A_2C(g) + B_2(g) \rightleftharpoons 2AB(g) + (1/2)C_2(g)$

    What is the value for K for reaction 3?
    (A) 10^{-2} (B) 10^4 (C) 10^6 (D) 10^2

33. The value of the equilibrium constant K depends on
        I)   the initial concentrations of the reactants.
        II) the initial concentrations of the products.
        III) the final concentrations of the reactants.
        IV) the final concentrations of the products.

    (A) I, II   (B) II, III   (C) III, IV   (D) none of these

34. Which of the following represents a conjugate acid-base pair?
    (A) $H_2PO_4^-$ and PO_4^{3-} (B) HSO_4^- and SO_3^{2-} (C) HNO_3 and NO_3^- (D) HCl and NaOH

35. The following acids are listed in order of decreasing acid strength in water
            $HI > HNO_2 > CH_3COOH > HClO > HCN$
    According to Bronsted-Lowry theory, which of the following ions is the weakest base?
    (A) I^- (B) NO_2^- (C) CH_3COO^- (D) ClO^-

36. Calculate the $[H^+]$ in a 0.010 M solution of HCN, $K_a = 6.2 \times 10^{-10}$.
    (A) 1.0×10^{-7} M   (B) 2.5×10^{-6} M   (C) 3.6×10^{-3} M   (D) 6.2×10^{-10} M

37. Which of the following will not produce a buffered solution?
    (A) 100 mL of 0.1 M Na_2CO_3 and 50 mL of 0.1 M HCl   (B) 100 mL of 0.1 M $NaHCO_3$ and 25 mL of 0.2 M HCl
    (C) 100 mL of 0.1 M Na_2CO_3 and 75 mL of 0.2 M HCl   (D) 100 mL of 0.1 M Na_2CO_3 and 50 mL of 0.1 M NaOH

38. The following reaction occurs in basic solution:
        $F_2 + H_2O \quad O_2 + F^-$
    When the equation is balanced, the sum of the coefficients is:
    (A) 10   (B) 11   (C) 12   (D) 13

39. What is the oxidation state of Hg in Hg_2Cl_2?
    (A) +2   (B) –1   (C) –2   (D) +1

40. Which form of electromagnetic radiation has the longest wavelengths?
    (A) gamma rays   (B) microwaves   (C) radio waves   (D) infrared radiation

41. In Bohr's atomic theory, when an electron moves from one energy level to another energy level more distant from the nucleus
    (A) energy is emitted.   (B) energy is absorbed.   (C) no change in energy occurs.   (D) light is emitted.

42. Based on electronegativities, which of the following would you expect to be most ionic?
    (A) N_2 (B) CaF_2 (C) CO_2 (D) CH_4

43. The rate constant k is dependent on

      I. the concentration of the reactant.   II. the nature of the reactants.
     III. the temperature.   IV. the order of the reaction.

  (A)   none of these   (B) one of these   (C) two of these   (D) three of these

44. For the reaction A + B products, the following data were obtained:

Initial rate (mol/L · s)	0.30	0.059	0.060	0.090	0.090
$[A]_0$ (mol/L)	0.10	0.20	0.20	0.30	0.30
$[B]_0$ (mol/L)	0.20	0.20	0.30	0.30	0.50

What is the experimental rate law?

  (A)   Rate = k[A]   (B) Rate = k[B]   (C) Rate = k[A][B]   (D) Rate = k[A]^2[B]

45. Which of the following should have the lowest boiling point?

  (A) Na_2S (B) HF   (C) NH_3 (D) N_2

46. Which one of the following decreases as the strength of the attractive intermolecular forces increases?

  (A)   The heat of vaporization.   (B) The normal boiling temperature.
  (C)   The extent of deviations from the ideal gas law.   (D) The vapor pressure of a liquid.

47. A solution of hydrogen peroxide is 30.0% H_2O_2 by mass and has a density of 1.11 g/cm^3. The molarity of the solution is:

  (A)   7.94 M   (B) 8.82 M   (C) 9.79 M   (D) 0.980 M

48. Which of the following chemical or physical changes is an endothermic process?

  (A)   the evaporation of water   (B) the combustion of gasoline
  (C)   the mixing of sulfuric acid and water   (D) the freezing of water

49. Choose the metal with the largest first ionization energy.

  (A)   Na   (B) Mg   (C) Al   (D) K

50. Choose the species with the largest radius.

  (A)   F   (B) F$^-$ (C) Cl   (D) Cl$^-$