CHEMISTRY PRACTICE TEST 2

Section I

Multiple Choice Questions

90 minutes

You may NOT use a calculator for this section.

Part A

Directions: Each set of lettered responses refers to the numbered statements or questions immediately below it. Choose the one-lettered response that best fits each statement or question. You may use a response once, more than once, or not at all.

Questions 1–4 refer to the following ions.

A) Na^+
B) Mg^{2+}
C) Al^{3+}
D) C^{4+}
E) F^-

1. Which has the largest radius?

2. Which has outermost electrons that experience the greatest effective nuclear charge?

3. Which is isoelectronic with helium?

4. Which will form the largest lattice energy with chloride?

Questions 5–9 refer to the following aqueous solutions.

A) 1.0 M Na_2CO_3
B) 1.0 M NH_3
C) 1.0 M $(CH_3)_2C{=}O$
D) 1.0 M CH_3COOH
E) 1.0 M $NaNO_3$

5. Which salt solution will not form a precipitate with another solution?

6. Which solution has the lowest pH?

7. Which solution will liberate a gas upon addition of nitric acid?

8. Which solution contains a neutral polar covalent solute?

9. Which solution will form a weakly basic solution upon reaction with an equal molar amount of sodium hydroxide?

Part B

Directions: For each of the following questions or incomplete statements, select the letter of the best answer or completion directly below it.

10. Which of these factors affect the vapor pressure of a liquid at equilibrium?
    I.   Intermolecular forces of attraction within the liquid
    II. The volume and/or surface area of liquid present
    III. The temperature of the liquid

    A) I only
    B) II only
    C) III only
    D) I and II only
    E) I and III only

11. The molar masses of a series of similar polar molecules increase in this order: $A<B<C<D<E$. The boiling points, in degrees Celsius, of molecules A, B, C, D, and E are 20°, 50°, 150°, 100°, and 200°, respectively. Which molecule is likely to form hydrogen bonds?

    A) A
    B) B
    C) C
    D) D
    E) E

12. The normal boiling point of a liquid is
    A) the pressure at which a liquid vaporizes.
    B) the temperature at which a liquid vaporizes.
    C) the temperature at which the vapor pressure of a liquid equals 1 atm.
    D) the temperature at which the vapor pressure of a liquid equals the barometric pressure.
    E) the highest temperature at which it is possible to convert a gas to its liquid.

13. Which gas does not liquefy at standard atmospheric pressure?
    A) carbon dioxide
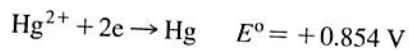   B) nitrogen
    C) ammonia
    D) argon
    E) oxygen

14. Find the empirical formula for a compound only one element of which is a metal. The compound's percent composition by mass is 40.0% metal, 12.0% C, and 48.0% O.

    A) $CaCO_3$
    B) Na_2CO_3
    C) $NaHCO_3$
    D) $Al_2(CO_3)_3$
    E) $MgCO_3$

15. What is the maximum number of grams of $MgCl_2$ that can be prepared from the reaction of 20.0 g of HCl with 20.0 g of $Mg(OH)_2$?

    A) $(20.0/36.5)(1/2)(58.3)$
    B) $(20.0/36.5)(95.3)$
    C) $(20.0/36.5)(1/2)(95.3)$
    D) $(20.0/58.3)(1/2)(95.3)$
    E) $(20.0/58.3)(1/2)(95.3)$

16. What is the maximum number of grams of CO_2 that can be produced from 50.0 g each of sulfuric acid and sodium hydrogen carbonate? The unbalanced equation is:

    $$NaHCO_3 + H_2SO_4 \rightarrow CO_2 + H_2O + Na_2SO_4$$

    A) $(50.0/98.0)(1/2)(44.0)$
    B) $(50.0/98.0)(44.0)$
    C) $(50.0/84.0)(2)(44.0)$
    D) $(50.0/84.0)(44.0)$
    E) $(50.0/98.0)(2)(44.0)$

17. A reaction will always be thermodynamically favored at all temperatures if

    A) it is exothermic with an increase in entropy.
    B) it is exothermic with a decrease in entropy.
    C) it is endothermic with an increase in entropy.
    D) it is endothermic with a decrease in entropy.
    E) $\Delta G = 0$.

18. Which condition describes a reaction at equilibrium?

    A) $\Delta G > 0$
    B) $\Delta G < 0$
    C) $\Delta G = 0$
    D) $K = 0$
    E) $K < 0$

19. Which substance has the largest standard molar entropy at 25 °C?

    A) butane gas
    B) ethane gas
    C) methane gas
    D) pentane gas
    E) propane gas

20. Calculate the specific heat capacity of an alloy if 100.0 g of the alloy warms from 20.0 °C to 30.0 °C when 100.0 J of heat are added to it?

A) 100.0 J/g K

B) 10.0 J/g K

C) 1.00 J/g K

D) 0.100 J/g K

E) 0.0100 J/g K

21. Which of the following ions has the smallest ionic radius?

A) Sc^{3+}

B) Ca^{2+}

C) K^+

D) Cl^-

E) S^{2-}

22. Which is the ground-state electronic configuration for the Mn^{3+} ion?

A) $[Ar]4s^23d^2$

B) $[Ar]4s^23d^5$

C) $[Ar]4s^03d^4$

D) $[Ar]4s^13d^3$

E) $[Ar]4s^23d^3$

23. Which species is paramagnetic in the ground state?

A) N^{3-}

B) Zn^{2+}

C) Cu^{2+}

D) O^{2-}

E) Mg

24. Which gas will have the smallest average velocity at the same temperature?

A) He

B) Ne

C) Ar

D) CO_2

E) SO_2

25. At a given temperature and pressure, hydrogen gas reacts with nitrogen gas to produce ammonia gas. How many liters of ammonia can be produced from 5.0 L of hydrogen and 2.0 L of nitrogen at the same temperature and pressure?

A) 2.0 L

B) 3.3 L

C) 4.0 L

D) 5.0 L

E) 7.5 L

26. Which gas deviates the most from ideal behavior?

   A) He
   B) Ne
   C) Ar
   D) Kr
   E) Xe

27. The density of krypton gas at 1.0 atm and 300 K is approximately

   A) 0.1 g/L.
   B) 0.3 g/L.
   C) 1 g/L.
   D) 3 g/L.
   E) 10.0 g/L.

28. A sample of oxygen gas was collected over water at 29.0 °C and a barometric pressure of 725 torr. The sample of oxygen collected was 155 mL and the equilibrium vapor pressure of water at 29 °C is 30.0 torr. How many moles of oxygen were collected?

   A) $(695)(155)/(0.082)(302)(760)$
   B) $(725)(155)/(0.082)(302)(760)$
   C) $(755)(155)/(0.082)(302)$
   D) $(695)(155)(760)/0.082)(302)$
   E) $(695)(155)/(0.082)(302)$

29. Which element commonly found in fossil fuels is a major contributor to acid rain?

   A) phosphorus
   B) carbon
   C) sulfur
   D) nitrogen
   E) hydrogen

30. Graphite and diamond

   A) are both sp^3 hybridized.
   B) have the same crystal structure.
   C) are isotopes.
   D) are the same element, but two different substances.
   E) are both sp^2 hybridized.

31. Which set consists of substances that are not allotropes?

   A) O_2 and O_3
   B) graphite and diamond
   C) white and red phosphorus
   D) uranium-235 and uranium-238
   E) P_2 and P_4

32. How many sigma and pi bonds are in $CH_2=CHC\equiv CCH_2CH=CH_2$?

    A) six sigma and six pi
    B) six sigma and three pi
    C) eight sigma and six pi
    D) eleven sigma and three pi
    E) fourteen sigma and four pi

33. The rate constants for a forward reaction and its corresponding reverse reaction are generally expected to

    A) be independent of temperature.
    B) decrease with increasing temperature.
    C) increase with increasing temperature.
    D) increase with increasing temperature, only for the endothermic reaction.
    E) increase with increasing temperature, only for the exothermic reaction.

34. The half-life of a certain radioactive isotope of mercury is four months. What mass of a 32 g sample of this isotope will remain after one year?

    A) 32 g
    B) 16 g
    C) 8 g
    D) 4 g
    E) 2 g

35. The rate law of the reaction, $2X+2Y\rightarrow 2XY$, is rate $=k[X]^2[Y]$. If [X] is doubled and [Y] is halved, the rate of the reaction will

    A) increase by a factor of 4.
    B) remain the same.
    C) decrease by a factor of 4.
    D) increase by a factor of 2.
    E) decrease by a factor of 2.

36. The rate expression for a first-order reaction could be:

    A) rate $=k[A]$
    B) rate $=k[A]^2[B]$
    C) rate $=k[A][B]$
    D) rate $=k[A]^2[B]^2$
    E) rate $=k[A]^2$

37. Corrosion of buried gasoline tanks can be minimized by attaching a "sacrificial plate" of zinc to the tank. Which statement best explains why this plate corrodes instead of the steel of the tank?

    A) The zinc behaves as a cathode and is oxidized more readily than iron.
    B) The zinc behaves as an anode and is oxidized more readily than iron.
    C) The steel hull behaves as a cathode and is reduced more readily than zinc.
    D) The steel hull behaves as an anode and is reduced more readily than zinc.
    E) Iron oxidizes more readily than zinc.

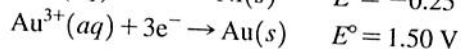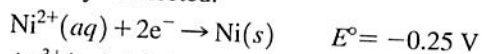38. Which of the following is the most easily oxidized?

$$Al^{3+} + 3e \rightarrow Al \quad E^\circ = -1.66 \text{ V}$$

$$Zn^{2+} + 2e \rightarrow Zn \quad E^\circ = -0.763 \text{ V}$$

$$Hg^{2+} + 2e \rightarrow Hg \quad E^\circ = +0.854 \text{ V}$$

$$Pb^{2+} + 2e \rightarrow Pb \quad E^\circ = -0.126 \text{ V}$$

$$F_2 + 2e \rightarrow 2F^- \quad E^\circ = +2.87 \text{ V}$$

A) Al
B) Zn
C) Hg
D) Pb
E) F^-

39. Calculate the voltage of a cell consisting of the following half-cells that are suitably connected.

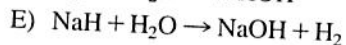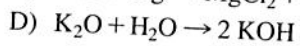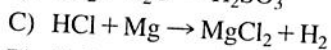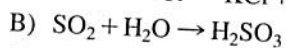$$Ni^{2+}(aq) + 2e^- \rightarrow Ni(s) \quad E^\circ = -0.25 \text{ V}$$
$$Au^{3+}(aq) + 3e^- \rightarrow Au(s) \quad E^\circ = 1.50 \text{ V}$$

A) 1.25 V
B) 1.75 V
C) 2.50 V
D) 4.00 V
E) 5.00 V

40. Which is not an acid–base reaction?

A) $KOH + HCl \rightarrow KCl + H_2O$
B) $SO_2 + H_2O \rightarrow H_2SO_3$
C) $HCl + Mg \rightarrow MgCl_2 + H_2$
D) $K_2O + H_2O \rightarrow 2 KOH$
E) $NaH + H_2O \rightarrow NaOH + H_2$
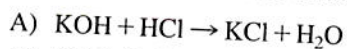
41. A 0.10 molar solution of a weak monoprotic acid, HA, has a pH of 4.00. What is the value of K_a, the ionization constant of this acid?

A) 1.0×10^{-3}
B) 1.0×10^{-4}
C) 1.0×10^{-7}
D) 1.0×10^{-8}
E) 1.0×10^{-9}

42. Which of the following characteristics is common to SO_2, CO_2, B_2O_3, P_2O_5?

A) They form weak acids in water.
B) They form strong acids in water.
C) They form weak bases in water.
D) They form strong bases in water.
E) They are base anhydrides.

43. Which of the following is the correct equilibrium expression for the hydroly-
sis of SO_3^{-2}?

A) $K = [HSO_3^-]/[SO_3^{-2}][H_3O^+]$
B) $K = [HSO_3^-][OH^-]/[SO_3^{-2}]$
C) $K = [SO_3^{-2}][OH^-]/[HSO_3^-]$
D) $K = [SO_3^{-2}]/[SO_2][OH^-]^2$
E) $K = [SO_3^{-2}][H_3O^+]/[HSO_3^-]$

44. Which salt will give an aqueous solution whose pH is significantly greater
than 7?

A) NH_4NO_3
B) $NH_4C_2H_3O_2$
C) $Ca(NO_3)_2$
D) $NaCl$
E) $Ca(C_2H_3O_2)_2$

45. The Bronsted–Lowry theory of acids and bases would predict which of the
following species would not act as a base?

A) NaH
B) CH_4
C) Mg_3N_2
D) NH_2^-
E) O_2^-

46. Which oxide dissolves in water to give the strongest acid?

A) SO_3
B) CaO
C) P_4O_{10}
D) CO_2
E) SO_2

47. Which forms a basic aqueous solution?

A) KBr
B) $NaNO_3$
C) BaI_2
D) $NaHCO_3$
E) $LiCl$

48. According to Le Châtelier's principle, which effect will decrease the amount
of $CO(g)$ present at equilibrium in the following reaction?

$$\text{Heat} + CO_2(g) + H_2(g) \rightleftharpoons CO(g) + H_2O(g)$$

A) Decrease the concentration of $H_2O(g)$.
B) Increase the concentration of $H_2(g)$.
C) Increase the volume of the container.
D) Increase the temperature of the container.
E) Decrease the concentration of $CO_2(g)$.

49. What is the partial pressure of $CO_2(g)$ if K_p for the reaction at a certain temperature is 0.50 atm^{-1}?

$$MgO(s) + CO_2(g) \leftrightarrows MgCO_3(s) + heat$$

A) 2.0 atm
B) 0.50 atm
C) 0.25 atm
D) 1.0 atm
E) 4.0 atm

50. An endothermic reaction at equilibrium will

A) proceed at a faster rate while its K_c increases at higher temperatures.
B) proceed at a faster rate while its K_c decreases at higher temperatures.
C) proceed at a slower rate while its K_c increases at higher temperatures.
D) proceed at a slower rate while its K_c decreases at higher temperatures.
E) not change K_c with a change in temperature.

51. K_c for the reaction $2A(g) + B(g) \leftrightarrows 2C(g)$ is 10.0.
The reaction will proceed to the right when:

A) $[A] = 2.0$ M, $[B] = 2.0$ M, and $[C] = 1.0$ M
B) $[A] = 0.20$ M, $[B] = 0.20$ M, and $[C] = 1.0$ M
C) $[A] = 0.20$ M, $[B] = 2.0$ M, and $[C] = 5.0$ M
D) $[A] = 2.0$ M, $[B] = 0.10$ M, and $[C] = 10.0$ M
E) $K_c = Q$

52. Which statement describing a chemical system at equilibrium is NOT correct?

A) The molar concentrations of reactants and products are constant.
B) The rates of the forward and reverse reactions are equal.
C) The concentrations of reactants and products are equal.
D) Reactant and product concentrations change when the temperature is changed.
E) There is no observable macroscopic change in the system.

53. Consider the reaction at equilibrium:

$$2SO_2(g) + O_2(g) \leftrightarrows 2SO_3(g)$$

Increasing temperature decreases the amount of $SO_3(g)$. Which statement is correct?

A) The reaction is exothermic.
B) The reaction is endothermic.
C) The reaction is catalyzed by heat.
D) The reactants have enthalpies that are lower than products.
E) The reaction shifts toward $SO_3(g)$ with increasing temperature.

54. Calculate the molar solubility of lead(II) fluoride ($K_{sp} = 3.6 \times 10^{-8}$) in 0.10 M sodium fluoride?

A) 3.6×10^{-8} M
B) 3.6×10^{-7} M
C) 3.6×10^{-6} M
D) $(3.6 \times 10^{-6})^{1/2}$ M
E) $(3.6 \times 10^{-8})^{1/2}$ M

55. Which species has the smallest bond angles?

A) CH_4
B) NH_3
C) H_2O
D) BF_3
E) BrF_3

56. If 10.0 g samples of each of four elements are heated to 100 °C and placed into 100 mL insulated containers of water at 25 °C, which container shows the greatest increase in temperature? The specific heat of each element in units of J/g K is listed next to its symbol.

A) Cu   0.385
B) Ni   0.444
C) Al   0.90
D) Pb   0.129
E) All containers would increase by the same amount.

57. From the given data, determine the heat of formation of carbon dioxide in kJ/mol.

$$2C(s) + O_2(g) \rightarrow 2CO(g) \quad \Delta H = -220 \text{ kJ}$$

$$2CO(g) + O_2(g) \rightarrow 2CO_2(g) \quad \Delta H = -560 \text{ kJ}$$

A) $(-220) + (-560)$
B) $[(-220) + (-560)]/2$
C) $(-220) - (-560)$
D) $[(-220) - (-560)]/2$
E) $-(-220) + (-560)$

58. Which is the best explanation for the fact that at 20 °C and 1 atm pressure, chlorine is a gas, bromine is a liquid, and iodine is a solid?

A) Chlorine is more reactive than bromine and bromine is more reactive than iodine.
B) Iodine sublimes and bromine evaporates.
C) Dipole–dipole interactions are greater for lower-mass particles.
D) The covalent bonds of iodine are stronger than those of bromine and bromine's covalent bonds are stronger than those of fluorine.
E) Dispersion forces become greater as the number of electrons increase.