SHOW YOUR WORK. NO WORK, NO CREDIT
INCLUDE LABELS AND PROPER NUMBER OF SIG FIGS
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Table of Constants

\[ N_0 = 6.022 \times 10^{23} \text{ particles/mole} \]

On my honor, I pledge that I have upheld the Honor Code, and that the work I have done on this assignment has been honest, and that the work of others in this class has, to the best of my knowledge, been honest as well.

Signed __________________________________________________________________________

If you feel you can’t sign this, contact the instructor (e-mail or in person)

Multiple choice - circle the correct answer.

1. (2 pt) What symbol (metric system prefix) is used to represent the factor 10^-6?
   a) n b) µ c) p d) m

2. (2 pt) Which of the following elements has chemical properties similar to aluminum?
   a) boron (B) b) silicon (Si) c) phosphorus (P) d) sulfur (S)

3. (2 pt) What is the charge on the Hg in Hg_2SO_4?
   a) -2 b) -1 c) +1 d) +2

4. (2 pt) If SO_4^{2-} is called sulfate, then SeO_3^{2-} would be named
   a) hydroselinite. b) selinate c) perselinate. d) selinite

5. (2 pt) Which one of the following is not an empirical formula?
   a) C_2H_4O b) C_2H_4O_2 c) CHO d) CH_2O

6. (2 pt) How many milliliters is 0.0055 L?
   a) 0.55 mL b) 5.5 mL c) 0.55 mL d) 0.0000055 mL

7. (2 pt) Which of the following is a chemical change?
   a) boiling of water b) melting wax c) broiling a steak on a grill d) condensing water vapor into rainfall

8. (2 pt) Which of the following is a type of radioactive radiation which has no charge and is unaffected by external electric or magnetic fields?
   a) α rays b) β rays c) γ rays d) δ rays

9. (2 pt) How many protons and electrons are present in one Br^- ion?
   a) 35 p, 35 e b) 80 p, 81 e c) 35 p, 34 e d) 35 p, 36 e
10. (2 pt) Which of the following does not exist as a homonuclear diatomic molecule?
   a) hydrogen  b) phosphorus  c) fluorine  d) nitrogen

11. (2 pt) Which of the following numbers has the least number of significant figures?
   a) 410000  b) 0.50700  c) 6.022 x 10^{23}  d) 0.000201

12. (2 pt) To the correct number of significant figures, what is the volume in the graduated cylinder?
   ________________

13. (2 pts) Write the formula of the compound that results when VO^{2+} combines with MnO_4^{-}.

14. (3 pts each) Name the following compounds.
   a. NO_2 ________________________________
   b. (NH_4)_3PO_4 ________________________________

15. (3 pts each) Write the formula for each of the following compounds.
   a. bromic acid ________________________________
   b. iron (III) sulfide ________________________________

16. (9 pts) What is the mass percent of oxygen in CaSiO_4?

17. (5 pts) Why is it NOT a good idea to store coats and bookbags on the lab benches in lab?

18. When 8.0 mole of iron is reacted with 8.0 mole of water according to the chemical equation shown below:

   \[ 3 \text{Fe} (s) + 4 \text{H}_2\text{O} (l) \rightarrow \text{Fe}_3\text{O}_4 (s) + 4 \text{H}_2 (g) \]

   a. (9 pts) Which one will be the limiting reactant? Show your work or explain your reasoning.
   b. (8 pts) How many moles of the excess reagent are left over?

19. (9 pts) What is the density of a solid in g/cm^3, if a cube measuring 1.3 x 10^2 mm on one side has a mass of 0.385 kg?

20. One qualitative test for arsenic in water is to add a little silver nitrate and look for a chocolate brown precipitate of silver arsenate as shown in the reaction below

   \[ \text{AgNO}_3 (aq) + \text{N}_3\text{AsO}_4 (aq) \rightarrow \text{Ag}_3\text{AsO}_4 (s) + \text{NaNO}_3 (aq) \]

   a. (5 pts) Balance the reaction.
   b. (8 pts) When 100.0 mL of 0.0050 M AgNO_3 was added to a water solution containing excess Na_3AsO_4, 1.00 x 10^{-5} mole of Ag_3AsO_4 (s) was actually recovered. What was the percent yield for this reaction?

21. (9 pts) How many fluorine atoms are there in 1.875 x 10^{-15} mole of tetrafluoromethane (CF_4)?
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Multiple choice - circle the correct answer.

1. (2 pts) The shape of an atomic orbital is associated with
   A. the principal quantum number \( (n) \).  
   B. the angular momentum quantum number \( (l) \).
   C. the magnetic quantum number \( (m_l) \).
   D. the spin quantum number \( (m_s) \).

2. (2 pts) The number of orbitals in a \( d \) subshell is:
   A. 1  
   B. 2  
   C. 3  
   D. 5  
   E. 7

3. (2 pts) How many valence electrons does a tin (Sn) atom have?
   A. 2  
   B. 4  
   C. 14  
   D. 36  
   E. 50

4. (2 pts) Consider the following reaction: \( 3Li + Z \rightarrow Li_3Z \). What is the formula for the compound if we substitute magnesium for lithium?
   A. MgZ  
   B. Mg_2Z  
   C. MgZ_2  
   D. Mg_3Z  
   E. Mg_3Z_2

5. (2 pts) Which of these atoms has the greatest ionization energy?
   A. S  
   B. P  
   C. Ga  
   D. Li  
   E. Cl

6. (2 pts) Which of the following atoms can expand its valence shell when bonding?
   A. N  
   B. C  
   C. O  
   D. P  
   E. Ne

7. (2 pts) The number of pi bonds in the molecule to the right is:
   A. 1  
   B. 2  
   C. 3  
   D. 5  
   E. 9

8. (2 pts) Which one of these ions is not isoelectronic with Kr?
   A. As^{3+}  
   B. Se^{2-}  
   C. Rb^+  
   D. Sr^{2+}  
   E. Br
9. (2 pts) Which of these compounds is most likely to be ionic?

A. GaAs  
B. SrBr<sub>2</sub>  
C. NO<sub>2</sub>  
D. CBr<sub>4</sub>  
E. H<sub>2</sub>O

10. (2 pts) The spheres in the figure represent atoms of Li, Be, B, and F (not necessarily in that order). Which one of these spheres represents an atom of Li?

A) sphere (a)  
B) sphere (b)  
C) sphere (c)  
D) sphere (d)

11. (2 pts each) Name the following compounds:

Zn(OH)<sub>2</sub>  
SF<sub>6</sub>

12. (2 pts each) Write formulas for the following compounds:

manganese dioxide  
hydroiodic acid

13. (8 pts) What is the electron configuration for 50Sn? You may start with a noble gas core.

14. (6 pts) Write the quantum number (n, \( \ell \), m\( \ell \), m<sub>s</sub>) for the 7th electron in a 5d subshell.

15. (6 pts each) Draw the Lewis structures, including any resonance structures, for: SF<sub>4</sub>, HCO<sub>2</sub>\(^{-1}\)

16. (1 pt each) Fill in the blanks for each Lewis structure.

Shape __________________________
Polar (yes/no) __________________________
Hybrid ________________________________

Shape __________________________
Polar (yes/no) __________________________
Hybrid ________________________________

17. The electron configuration of 28Ni is [Ar] 4s<sup>2</sup> 3d<sup>8</sup>.

A. (3 pts) Is Ni<sup>3+</sup> a stable ion? Explain your reasoning.

B. (3 pts) Is Ni<sup>3+</sup> ion paramagnetic or diamagnetic? Explain your reasoning.

18. (10 pts) Fr is the easiest element to ionize with an ionization energy of 384 kJ/mole. Does ultraviolet light with a wavelength of 200 nm have enough energy to ionize Fr? Show your work or explain your reasoning.

19. (8 pts) Calculate the formal charge on the nitrogen in the Lewis Structure on the right. Show your work.

20. While in lab, your lab partner accidentally slops 10 mL of 1 M HCl onto your bare arm.

A) (3 pts) What action should you take?

B) (3 pts) What action should your lab partner take?
21. (10 pts) Consider the reaction below which takes place in water.

\[ \text{Na}_2\text{SO}_3 + \text{CrBr}_3 \rightarrow \text{NaBr} + \text{Cr}_2(\text{SO}_3)_3 \]

A. (4 pts) Label each reactant and product as (s), (l), (g), or (aq).
B. (6 pts) Write and balance the net ionic reaction.
6. (2 pts) Cold packs, whose temperatures are lowered when ammonium nitrate dissolves in water, are carried by athletic trainers when transporting ice is not possible. Which of the following is true of this reaction?

A. \(\Delta H < 0\), process is exothermic   
B. \(\Delta H > 0\), process is exothermic   
C. \(\Delta H < 0\), process is endothermic   
D. \(\Delta H > 0\), process is endothermic   
E. \(\Delta H = 0\), since cold packs are sealed

7. (2 pts) Which of these species has the highest entropy \((S^\circ)\) at \(25^\circ C\)?

A. \(\text{CH}_3\text{OH}(l)\)   
B. \(\text{CO}(g)\)   
C. \(\text{MgCO}_3(s)\)   
D. \(\text{H}_2\text{O}(l)\)   
E. \(\text{Ni}(s)\)

8. (2 pts) Which salt is expected to be acidic when dissolved in water?

A. \(\text{NaCl}\)   
B. \(\text{CuBr}_2\)   
C. \(\text{Sr(NO}_3)_2\)   
D. \(\text{Ba(OH)}_2\)   
E. \(\text{CaSO}_3\)

9. (2 pts) It’s getting a bit chilly when you are camping. One way to take the chill out of the tent is to heat and object on the fire and then place the warm object in the tent. Which of the following 15-pound objects when each heated to \(150^\circ C\), would work best for heating the tent? The specific heat for each substance is given in parentheses.

A. \(\text{Fe} \ (0.450 \text{ J/(g·K)}\)   
B. \(\text{Cu} \ (0.387 \text{ J/(g·K)}\)   
C. \(\text{granite} \ (0.79 \text{ J/(g·K)}\)   
D. \(\text{Au} \ (0.129 \text{ J/(g·K)}\)   
E. \(\text{H}_2\text{O} \ (4.184 \text{ J/(g·K)}\)

10. (2 pts each) Name the following compounds.

\(\text{Cl}_2\text{O}_7\) _________________________________   
\(\text{Ni(NO}_2)_2\) _________________________________

11. (2 pts each) Write formulas for the following compounds.

ammonium chlorate _________________________________   
arsenic (V) hydride _________________________________

12. All of the reactions below take place in aqueous solution. Some reactions may fit more than one category, and some may not fit any category. Some categories may have no reactions. Which of the reactions are:

a. (2 pts) redox reactions? _________________

b. (2 pts) acid-base reactions? _________________

c. (2 pts) precipitation reactions? _________________

1) \(3 \text{Zn} + 2 \text{H}_3\text{PO}_4 \rightarrow \text{Zn}_3(\text{PO}_4)_2 + 3 \text{H}_2\)   
2) \(\text{H}_2\text{CO}_3 \rightarrow \text{H}_2\text{O} + \text{CO}_2\)

3) \(\text{Pb(NO}_3)_2 + \text{Na}_2\text{SO}_4 \rightarrow \text{PbSO}_4 + 2 \text{NaNO}_3\)   
4) \(\text{CaSO}_4 + 2 \text{HI} \rightarrow \text{CaI}_2 + \text{H}_2\text{SO}_3\)

13. (6 pts) Carbon dioxide dissolved in water gives soda pop its fizz. It also makes soda pop slightly acidic. However, \(\text{CO}_2\) does not have any hydrogens to donate, so how can it make anything acidic?

14. (8 pts) Write and balance the net ionic reaction:

\(\text{HI} + \text{Ba}_3(\text{PO}_4)_2 \rightarrow \text{H}_3\text{PO}_4 + \text{BaI}_2\)

15. (8 pts) The highly exothermic thermite reaction (below) has been used by railroad repair crews to weld rails together.

\(2\text{Al(s)} + \text{Fe}_2\text{O}_3(s) \rightarrow 2\text{Fe(s)} + \text{Al}_2\text{O}_3(s)\)

When \(0.0235\) mole of \(\text{Fe}_2\text{O}_3\) is reacted with excess \(\text{Al}\), \(19,975\) J of energy is produced. What is the \(\Delta H\) for the reaction?
16. Given that the $\Delta H^\circ_{\text{f}[\text{CO}_2(\text{g})]} = -393.5 \text{ kJ/mol}$ and $\Delta H^\circ_{\text{f}[\text{H}_2\text{O}(\text{l})]} = -285.8 \text{ kJ/mol}$ and the $\Delta H^\circ$ and reaction for the combustion of octane ($\text{C}_8\text{H}_{18}$) shown below, is -22.040 kJ. The balanced reaction is

$$2\text{C}_8\text{H}_{18}(\text{l}) + 25\text{O}_2(\text{g}) \rightarrow 16\text{CO}_2(\text{g}) + 18\text{H}_2\text{O}(\text{l}) \quad \Delta H^\circ = -22.040 \text{ kJ}$$

a. (10 pts) What is the standard enthalpy of formation of octane?

b. (10 pts) If $\Delta S^\circ$ for this reaction is -682.6 J/K, is the reaction spontaneous? Show your work or explain your reasoning. Recognize this is at standard conditions.

17. (10 pts) Balance the following redox reaction that takes place in acidic solution:

$$\text{Ce}^{4+} + \text{C}_2\text{H}_6\text{O}_2 \rightarrow \text{CO}_2 + \text{Ce}^{3+}$$

18. (8 pts) It takes 78.2 J to raise the temperature of 45.6 g of lead by 13.3°C. What is the molar specific heat ($\text{J/mol} \cdot \text{°C}$) of lead?

19. (8 pts) In lab you need a 25.00 mL of 0.0500 M $\text{FeCl}_3$. On the cart you discover there is no 0.0500 M $\text{FeCl}_3$, but there is 1 L of 0.2000 M $\text{FeCl}_3$. What volume of the more concentrated solution, when diluted to 25.00 mL, will produce the solution you need?

Chemistry 120 B

Exam 4

Name _________________

December 2, 2009

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Signed __________________________________________________________________________

If you feel you can’t sign this, contact the instructor (e-mail or in person)

Table of Constants

- $N_0 = 6.022 \times 10^{23}$ particles/mole
- $c = 2.998 \times 10^8 \text{ m/s}$
- $h = 6.626 \times 10^{-34} \text{ J} \cdot \text{s}$
- $R_H = 2.18 \times 10^{-18} \text{ J}$
- $\text{C}_p(\text{H}_2\text{O}) = 4.184 \text{ J/g} \cdot \text{deg}$
- $R = 0.08206 \text{ L} \cdot \text{atm}/\text{K} \cdot \text{mole}$
- $62.36 \text{ L} \cdot \text{torr}/\text{K} \cdot \text{mole}$
- $8.314 \text{ J/K} \cdot \text{mole}$
- $1 \text{ atm} = 760 \text{ mm Hg} = 101.3 \text{ kPa}$
- $K_w = 1.00 \times 10^{-14}$

(2 pts each) Multiple choice - circle the correct answer.

1. Nitrogen will behave most like an ideal gas

A. at high temperature and high pressure.

B. at high temperature and low pressure.

C. at low temperature and high pressure.

D. at low temperature and low pressure.

E. at intermediate (moderate) temperature and pressure.
2. One reason ionic compounds do not dissolve well in nonpolar solvents is that
   A. not all cations and anions have the same magnitude of charge and therefore do not form neutral ion pairs.
   B. attractive forces within the solvent are too large for ions to insert themselves between the solvent molecules.
   C. attractive forces between the ion and solvent are not strong enough to pull the ionic compound apart.
   D. there are no forces of attraction between ions and nonpolar molecules.

3. What statement is most consistent for an acid with a pH = 6?
   A. It is twice as strong as an acid with a pH of 3.  
   B. It is half as strong as an acid with a pH = 3.
   C. It is one thousandth as strong as an acid with a pH of 3.  
   D. It is one thousand times as strong as an acid with a pH = 3.

4. What types of intermolecular forces exist in lithium fluoride?
   I. London forces
   II. dipole-dipole interactions
   III. ion-ion interactions
   A. I only  
   B. II only  
   C. III only  
   D. I and II  
   E. I and III

5. Which one of the following substances should exhibit hydrogen bonding in the liquid state?
   A. PH₃  
   B. CH₂F₂  
   C. H₂S  
   D. CH₄  
   E. CH₂OH

6. Which of the following substances should have the highest boiling point?
   A. CH₃CH₂  
   B. F₂  
   C. Ar  
   D. CH₃F  
   E. N₂

7. Which of the following should have the lowest surface tension at a given temperature?
   A.  
   B.  
   C.  
   D.  
   E. 

8. Which of the following compounds should be most soluble in CCl₄?
   A. NaCl  
   B. H₂O  
   C. CH₃Cl  
   D. PF₅  
   E. All have about the same solubility

9. For the following reaction at equilibrium, which choice gives a change that will shift the position of equilibrium to favor formation of more products?
   \[ 2\text{NOBr}(g) \rightleftharpoons 2\text{NO}(g) + \text{Br}_2(g) \quad \Delta H°_{\text{rxn}} = +30 \text{ kJ/mol NOBr} \]
   A. Increase the total pressure by decreasing the volume.  
   B. Add more NO.  
   C. Remove Br₂.  
   D. Lower the temperature.  
   E. Remove NOBr selectively.

10. What is the conjugate base of HSO₄⁻ in the reaction \[ \text{CO}_3^{2-} + \text{HSO}_4^- \rightleftharpoons \text{HCO}_3^- + \text{SO}_4^{2-}. \]
    A. H₂SO₄  
    B. CO₃²⁻  
    C. OH⁻  
    D. H₂O⁺  
    E. SO₄²⁻

11. Hard water deposits (calcium carbonate) have built up around your bathroom sink. Which one of these substances would be most effective in dissolving the deposits?
A. ammonia  B. bleach (sodium hypochlorite)  C. lye (sodium hydroxide)  D. vinegar (acetic acid)

12. The primary safety concern when using NaOH is
A. it is especially caustic (“eats skin”).  B. it is especially poisonous.  C. it is a suspected carcinogen.
D. it is flammable.  E. none of the above, but handle it carefully anyway.

13. (2 pts each) Name the following compounds.

BaCrO₄  __________________________________  KHCO₃  __________________________________

14. (2 pts each) Write formulas for the following compounds.

ammonia  __________________________________  iron (III) oxide  __________________________________

15. (8 pts) Write the equilibrium constant expression for the following balanced, net ionic reaction.

\[
2 \text{H}_3\text{PO}_3 + 3 \text{Ba}^{2+} + 6 \text{OH}^- \rightleftharpoons \text{Ba}_3(\text{PO}_4)_2 + \text{H}_2\text{O}
\]

16. (10 pts) What is the percent CsCl by mass in a 0.711 M aqueous CsCl solution that has a density of 1.091 g/mL?

17. (10 pts) On a nice, sunny day when the air pressure was 700.0 mm Hg and the temperature was 27°C, an industrious student decided to do an experiment using a bicycle tire pump. She first raised the plunger on the pump to its highest position and then screwed a pressure gauge into the end of the hose forming a closed system (no air leaks). She adjusted the gauge so it read atmospheric pressure (700.0 mm Hg). Just after she set the pressure gauge, the phone rang. During the next 30 minutes while she was visiting with a friend, the pump sat in the hot sun. When she looked at the pump again, the temperature inside the pump was 54°C. What pressure did she read on the gauge?

18. (10 pts) The pH of a strontium hydroxide solution is 11.25. What is the concentration (molarity) of the Sr(OH)₂?

19. (10 pts) When 0.243 mole of magnesium metal is reacted with excess hydrochloric acid (like you did in lab), how many liters of hydrogen gas will be produced at STP (standard temperature and pressure for gases)?

20. (10 pts) The equilibrium constant for the net ionic reaction below is 0.1216.

\[
\text{C}_2\text{O}_4^{2-} + 2 \text{HF} \rightleftharpoons 2 \text{F}^- + \text{H}_2\text{C}_2\text{O}_4
\]

Shortly after mixing a solution of Na₂C₂O₄ with another solution of HF, the solution contained the following concentrations: 0.0035 M C₂O₄²⁻, 0.0016 M H₂C₂O₄, 0.0065 M HF, and 0.0030 M F⁻. Is this mixture at equilibrium? If it is not at equilibrium, will the reaction have to shift toward the reactants or toward the products to get to equilibrium? Show your work or explain your reasoning.

21. (10 pts) What is the pH of 0.050 M NaOCN (sodium cyanate)? The K₆ of cyanic acid (HOCN) is 3.3 x 10⁻⁴.