Chemistry 101

Exam #1

VERSION B

October 10, 2007

Name: (Printed) _______________________________________________

Score
Questions 1-15______________________/30
Question 16______________________/10
Question 17______________________/15
Question 18______________________/15
Question 19______________________/10
Question 20______________________/10
Question 21______________________/10
Total______________________/100

Instructions:

Do not open this exam until instructed to do so.

(1) Write your name and signature on the line provided above

(2) Answer questions 1 – 15 by circling the correct answer

(3) Answer the remaining questions in the space provided

(4) When instructed to do so, check to ensure that your exam has 11 pages, including this one.

A periodic table and reference sheet has been included as the last page of this exam.
Part I – Multiple Choice: Circle the answer that best describes the answer to each question. (30 points total, 2 points each)

(1) Which of the following is FALSE according to Dalton’s Atomic Theory?
   (a) All atoms of chlorine have identical properties that distinguish them from other elements.
   (b) Atoms combine in simple whole number ratios to form compounds.
   (c) One carbon atom will combine with one oxygen atom to form a molecule of carbon monoxide.
   (d) Atoms of sodium do not change into another element during a chemical reaction with chlorine.
   (e) An atom of nitrogen can be broken down into smaller particles that will still have the unique properties of nitrogen.

(2) Write the formula for Barium Nitrite
   (a) B(NO₂)₃
   (b) Ba(NO₃)₂
   (c) BN
   (d) Ba(NO₂)₂
   (e) Ba₃N₂

(3) Determine the empirical formula of a compound that contains 36.86% N and 63.14% O by mass.
   (a) N₂O₃
   (b) NO
   (c) N₂O
   (d) NO₂
   (e) NO₃

(4) What element has 20 protons, 20 neutrons and 20 electrons?
   (a) Potassium
   (b) Neon
   (c) Argon
   (d) Zirconium
   (e) Calcium

(5) How many milliliters of a 0.266 M LiNO₃ solution are required to make 150.0 mL of 0.075 M LiNO₃ solution?
   (a) 53.2 mL
   (b) 42.3 mL
   (c) 18.8 mL
   (d) 23.6 mL
   (e) 35.1 mL
(6) A mixture of N₂, O₂ and Ar have mole fractions of 0.25, 0.65, and 0.10, respectively. What is the pressure of N₂ if the total pressure of the mixture is 3.9 atm?

(a) 2.5 atm  
(b) 0.67 atm  
(c) 1.33 atm  
(d) 0.39 atm  
(e) 0.98 atm

(7) What is the root mean velocity of a He atom at room temperature (298 K)?

(a) 1.36 x 10³ m/s  
(b) 1.25 x 10² m/s  
(c) 3.21 x 10³ m/s  
(d) 6.42 x 10³ m/s  
(e) None of the above are correct

(8) “The volume of a fixed amount of gas varies inversely at constant pressure” is a statement that describes:

(a) Avogadro’s Law  
(b) Boyle’s Law  
(c) Charle’s Law  
(d) Dalton’s Law  
(e) None of the above

(9) Which of the following signs on q and w represent a system that is doing work on the surroundings as well as gaining heat from the surroundings?

(a) q = + , w = –  
(b) q = – , w = +  
(c) q = +, w = +  
(d) q = –, w = –  
(e) None of the above

(10) The atomic weight of copper is 63.546. Given that copper is made up of two isotopes: ⁶³Cu and ⁶⁵Cu, what percentage of naturally occurring copper is ⁶³Cu?

(a) 54.6 %  
(b) 2.00 %  
(c) 72.7 %  
(d) 27.3 %  
(e) 99.3 %
(11) Calculate the amount of heat (in kJ) required to raise the temperature of a 79.0 g sample of ethanol from 298 K to 385 K. The specific heat capacity of ethanol is 2.42 J/g°C.

(a) 57.0 kJ  
(b) 16.6 kJ  
(c) 73.6 kJ  
(d) 28.4 kJ  
(e) 12.9 kJ

(12) Which of the following processes is endothermic?

(a) The freezing of water  
(b) The combustion of propane  
(c) A hot coffee cup (as the system) cools on a countertop  
(d) The chemical reaction in a “hot pack” often used to treat sore muscles  
(e) The evaporation of rubbing alcohol

(13) A coffee cup is filled with 100.0 g of water at 25.0 °C. A 5.00 g piece of metal that has been heated to 100.0 °C is added to the coffee cup and the lid is replaced and the water is stirred until the temperature of the water remains constant at 28.0 °C. What is the specific heat capacity of the metal that was added to the coffee cup?

(a) −1255.2 J  
(b) 3.49 J/g°C  
(c) 1255.2 J  
(d) −3.49 J/g°C  
(e) None of the above are correct

(14) Which of the following is NOT a state function?

(a) Pressure  
(b) Temperature  
(c) Enthalpy  
(d) Volume  
(e) Work

(15) Calculate the change in internal energy (ΔE) for a system that is giving off 25.0 kJ of heat and changing from 12.00 L to 6.00 L in volume at 1.50 atm pressure. (Use 101.3 J = 1 L*atm)

(a) +25.9 kJ  
(b) −16.0 kJ  
(c) −25.9 kJ  
(d) −24.1 kJ  
(e) 937 kJ
Part II – Problem Solving. To get full credit, you must show a neat, thorough logical method of solving the problem. Each number must have the appropriate unit, and follow the rules of significant figures throughout your calculation. (60 points total)

16. (10 points) Lithium metal is the only member of Group 1 that reacts directly with nitrogen to produce a nitride, Li₃N:

\[
6\text{Li}_\text{(s)} + \text{N}_2\text{(g)} \rightarrow 2\text{Li}_3\text{N}_\text{(s)}
\]

(molar masses, in g/mol: Li 6.941, N₂ 28.01, Li₃N 34.83)

(a) If 124.0 g of Li and 98.2 g of N₂ are mixed, which is the limiting reactant?

Lithium is the LR

(b) If 195 g of Li₃N are actually obtained from the reaction, what is the percent yield?

94.0%
(17) (15 points) Butyric acid, an organic compound with an extremely unpleasant odor, contains only carbon, hydrogen and oxygen. When 1.20 g of butyric acid was burned, 2.41 g CO$_2$, and 0.982 g H$_2$O were produced.

(a) How many grams of C, H, and O were present in the original sample?

0.658 g C, 0.110 g H, 0.432 g O

(b) Calculate the empirical formula of butyric acid.

C$_2$H$_4$O

(c) In a separate experiment, the molar mass of butyric acid was determined to be 88.1 g/mol. What is butyric acid’s molecular formula?

C$_4$H$_8$O$_2$
(18) (15 points) For each of the following reactions, write the molecular, ionic, and net ionic equations. Also circle the appropriate category to which the reaction belongs.

(a) Aqueous sodium sulfate is mixed with aqueous silver (I) nitrate.
   Formula of sodium sulfate: ______________
   Formula of silver (I) nitrate: ____________
   Molecular Equation: 
   Ionic Equation: 
   Net Ionic Equation: 
   \[ 2 \text{Ag}^+ (aq) + \text{SO}_4^{2-} (aq) \rightarrow \text{Ag}_2\text{SO}_4(s) \]
   Type of Reaction (circle one): Acid-base, Oxidation-Reduction, **Precipitation**

(b) Aqueous sulfuric acid is mixed with aqueous potassium hydroxide
   Formula of sulfuric acid: ______________
   Formula of potassium hydroxide: ___________
   Molecular Equation: 
   Ionic Equation: 
   Net Ionic Equation: 
   \[ \text{H}^+ (aq) + \text{OH}^- (aq) \rightarrow \text{H}_2\text{O}(l) \]
   Type of Reaction (circle one): Acid-base, Oxidation-Reduction, Precipitation

(c) A chunk of Aluminum metal is dropped into an aqueous solution of hydrochloric acid. (Just like you did in lab)
   Formula of Aluminum metal: _____________
   Formula of hydrochloric acid: ____________
   Molecular Equation: 
   Ionic Equation: 
   Net Ionic Equation: 
   \[ 2\text{Al}(s) + 6\text{H}^+ (aq) \rightarrow 2\text{Al}^{3+} (aq) + 3 \text{H}_2(g) \]
   Type of Reaction (circle one): Oxidation-Reduction, Precipitation, Acid-Base
(19) (10 points) Given the following equations and ΔH values, determine the heat of reaction at 298 K for the reaction:

$$C_{(s)} + 2 \ H_{2(g)} \rightarrow \ CH_{4(g)}$$

$$C_{(s)} + O_{2(g)} \rightarrow \ CO_{2(g)} \quad ΔH = -393.5 \ kJ$$

$$H_{2(g)} + 1/2 \ O_{2(g)} \rightarrow \ H_{2}O_{(l)} \quad ΔH = -285.8 \ kJ$$

$$CO_{2(g)} + 2 \ H_{2}O_{(l)} \rightarrow \ CH_{4(g)} + 2 \ O_{2(g)} \quad ΔH = +890.3 \ kJ$$

$$-74.8 \ kJ$$
(20) (10 points) Use the given standard enthalpies of formation to determine the heat of reaction of the following reaction. Assume that the products, silver and oxygen, are pure and in their standard states. (10 points):

\[
2 \text{Ag}_2\text{S}_\text{(s)} + 2 \text{H}_2\text{O}_\text{(l)} \rightarrow 4 \text{Ag}_\text{(s)} + 2 \text{H}_2\text{S}_\text{(g)} + \text{O}_2\text{(g)}
\]

\[
\Delta H^\circ_{\text{f} \text{Ag}_2\text{S}_\text{(s)}} = -32.6 \text{ kJ/mol}
\]
\[
\Delta H^\circ_{\text{f} \text{H}_2\text{S}_\text{(g)}} = -20.6 \text{ kJ/mol}
\]
\[
\Delta H^\circ_{\text{f} \text{H}_2\text{O}_\text{(l)}} = -285.8 \text{ kJ/mol}
\]

\[596 \text{ kJ/mol}\]
(21) (10 points) Zinc metal reacts with hydrochloric acid according to the following balanced equation:

\[
\text{Zn(s)} + 2 \text{HCl(aq)} \rightarrow \text{ZnCl}_2 \text{(aq)} + \text{H}_2 \text{(g)}
\]

When 0.103 g of Zn\text{(s)} is combined with enough HCl to make 50.0 mL of solution in a coffee-cup calorimeter, all of the zinc reacts, raising the temperature of the solution from 22.5 °C to 23.7 °C. Find \( \Delta H_{\text{rxn}} \) in kJ. Use 1.0 g/mL for the density of the solution and 4.18J/g°C as the specific heat capacity.

\[ -0.250 \text{ kJ} \]