Chem 1711

Exam 1

September 26, 2013

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**Name**

9:00 OR 10:00

\[ N_A = 6.022 \times 10^{23} \text{ mol}^{-1} \]

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**Periodic Table**

- **Group IA:** H, Li, Na
- **Group IIA:** Be, Mg
- **Group IIIA:** Al, Ga, In
- **Group IIIB:** Sc, Ti, V
- **Group IIIB:** Cr, Mn, Fe
- **Group IIIB:** Co, Ni, Cu
- **Group IIIB:** Zn, Ga, Ge
- **Group IIIB:** As, Se, Br
- **Group IIIB:** Kr
- **Group IIIB:** Rb, Sr, Y
- **Group IIIB:** Zr, Nb, Mo
- **Group IIIB:** Tc, Ru, Rh
- **Group IIIB:** Pd, Ag, Cd
- **Group IIIB:** In, Sn, Sb
- **Group IIIB:** Te, I, Xe
- **Group IIIB:** Cs, Ba, La
- **Group IIIB:** Hf, Ta, W
- **Group IIIB:** Re, Os, Ir
- **Group IIIB:** Pt, Au, Hg
- **Group IIIB:** Tl, Pb, Bi
- **Group IIIB:** Po, At, Rn

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**Atomic Numbers:***

- **Group 1A:** 1
- **Group 2A:** 8
- **Group 1B:** 17
- **Group 2B:** 35
- **Group 3A:** 13
- **Group 3B:** 51
- **Group 4A:** 9
- **Group 4B:** 43
- **Group 5A:** 15
- **Group 5B:** 85
- **Group 6A:** 17
- **Group 6B:** 87
- **Group 7A:** 33
- **Group 7B:** 137
- **Group 8A:** 88
- **Group 8B:** 152
- **Group 9A:** 57
- **Group 9B:** 232

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**Atomic Weights:**

- **Group 1A:** 1.008
- **Group 2A:** 1.008
- **Group 1B:** 26.98
- **Group 2B:** 30.97
- **Group 3A:** 69.72
- **Group 3B:** 126.9
- **Group 4A:** 85.46
- **Group 4B:** 204.3
- **Group 5A:** 137.3
- **Group 5B:** 206.9
- **Group 6A:** 138.9
- **Group 6B:** 208.9
- **Group 7A:** 138.9
- **Group 7B:** 209.9
- **Group 8A:** 140.1
- **Group 8B:** 210.0
- **Group 9A:** 92
- **Group 9B:** 232.0

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**Inert Gases:**

- **He**: 4.003
- **Ne**: 20.17
- **Ar**: 39.95
- **Kr**: 83.80
- **Xe**: 131.3
- **Rn**: 222
Chem 1711: Exam 1

Part 1 (46 points): Short Answer.

1. Give the missing IUPAC name or chemical formula for each of the following:
   - FeBr₃·4H₂O \(\text{iron (II) bromide tetrahydrate}\)
   - IF₅ \(\text{iodine pentafluoride}\)
   - HC₂H₃O₂ (aq) \(\text{acetic acid}\)
   - Ni(COH)₃ \(\text{nickel (III) hydroxide}\)
   - Y(CO₂)₃ \(\text{yttrium chloride}\)
   - N₂O₄ \(\text{dinitrogen tetroxide}\)

2. a. Give the name of one transition metal found in the 5th period of the periodic table. \(\text{options - } Y \text{ or } Cd\)
   b. Give the name of one metalloid in group VA of the periodic table. \(\text{arsenic or antimony}\)
   c. Consider the element with 19 protons in its nucleus. This element is best described as which one of the following?
      - halogen
      - noble gas
      - alkali metal
      - alkaline earth metal

3. Consider the ion \(\text{I}^{3+}\). How many protons, neutrons & electrons are there? \(50\space p\space 71\space n\space 48\space e^-\)

4. Balance the following chemical equation:
   \[3\space \text{IBr} + 4\space \text{NH}_3 \rightarrow 2\space \text{Ni}_3 + 3\space \text{NH}_4\text{Br}\]

5. a. Consider 65 molecules of \(\text{P}_2\text{O}_5\). This collection of molecules contains how many phosphorus atoms? \(65\space \text{molecules} \times \frac{7\text{atoms}}{1\text{molecule}} = 455\text{ atoms}\)
   How many atoms in total are contained in this sample? \(455\)
   b. A 0.200 mol sample of \(\text{P}_2\text{O}_5\) contains how many molecules? \(0.200\space \text{mol} \cdot \text{N}_A = 1.20 \times 10^{28}\text{ molecules}\)
   c. What is the mass of 1 \(\text{P}_2\text{O}_5\) molecule? Circle the one best answer below.
      - 46.97 amu
      - 46.97 g
      - 111.0 amu
      - 111.0 g
      - 141.9 amu
      - 141.9 g

6. a. Which of the following numbers has (unambiguously) 4 significant figures? Circle the one best answer below:
      - 7000
      - 0.005089
      - 3.0 \times 10^2
      - 10.130
      - 4.41 \times 10^{-4}
   b. Give the answer to the following calculation with the correct number of significant figures:
      \[(0.17 - 0.00860) \times (6.710 + 4.859) = 1.9\]

7. 32 molecules of \(\text{NH}_3\) and 35 molecules of \(\text{O}_2\) are combined and allowed to react according to the following equation:
   \[4\space \text{NH}_3 (g) + 5\space \text{O}_2 (g) \rightarrow 4\space \text{NO} (g) + 6\space \text{H}_2\text{O} (g)\]
   a. Identify the limiting reactant.
   b. What is the maximum number of water molecules that can form?
   c. How many molecules of the excess reactant remain unconsumed when the reaction is complete? \(4\)

40 points
8. Perform the following unit conversions:
   \[ 26.2 \text{ lb/in}^2 = \frac{184 \times 10^4}{1 \text{ kg/m}^2} \]
   \[ 1 \text{ lb} = 453.59 \text{ g}; 1 \text{ in} = 2.54 \text{ cm} \]
   \[ 675.9 \text{ kJ} = \frac{0.6759}{\text{ MJ}} \]

9. A 750 g sample of a compound composed of only manganese and oxygen is analyzed and found to contain 210 g O. Determine the mass percent manganese in this compound.
   \[ \text{mass \% Mn} = \frac{540.9 \times 100}{750} = 72.7\% \]

Part II (39 points): Multiple Choice. For each of the following questions, indicate the one best answer by bubbling in the appropriate letter on the provided Scan Tron answer sheet.

1. Calculate the average atomic mass for fictional element El given the following data:

   \[
   \begin{array}{ccc}
   \text{symbol} & \text{isotope mass} & \text{percent abundance} \\
   \underline{^{121}\text{El}} & 121.943 \text{ amu} & 16.26 \\
   \underline{^{124}\text{El}} & 124.009 \text{ amu} & 19.57 \\
   \underline{^{124}\text{El}} & 124.981 \text{ amu} & 64.17 \\
   \end{array}
   \]

   a. 123.6 amu  
   b. 124.3 amu  
   c. 125.0 amu  
   d. 124.5 amu  
   e. 80.20 amu

2. Who is credited with establishing the nuclear structure of the atom?
   a. J.J. Thomson  
   b. Joseph Proust  
   c. John Dalton  
   d. Ernest Rutherford  
   e. Antoine Lavoisier

3. Which one of the following statements about isotopes of a particular element is not true?
   a. Each unique isotope has a different atomic mass.  
   b. Each unique isotope has a different atomic number.  
   c. Each unique isotope has a different number of neutrons.  
   d. Each unique isotope has a different number of nucleons.  
   e. In neutral atoms of each isotope, the number of electrons equals the number of protons.

4. The term that is related to the reproducibility of a measurement is
   a. precision  
   b. accuracy  
   c. qualitative  
   d. intensive  
   e. physical

5. A 0.8650 g sample of an element contains 5.062 x 10^{21} atoms. Identify this element.
   a. I  
   b. Ag  
   c. La  
   d. Pd  
   e. Rh

   \[
   \frac{0.8650 \text{ g}}{5.062 \times 10^{21} \text{ atoms}} \times \frac{6.022 \times 10^{23} \text{ atoms}}{1 \text{ mol}} = 102.93/\text{mol}
   \]

   \[
   \text{molar mass of Rh}
   \]

21 points
6. A 19.0 g sample of lithium is burned in air and converted completely to lithium oxide. The mass of lithium oxide formed must be
   a. exactly 19.0 g    b. less than 19.0 g    c. more than 19.0 g    d. equal to 30.0 g
   e. there is not enough information provided to answer this question

7. Which of the following are binary molecular compounds?
   i. C₂H₆₀    ii. HNO₂    iii. Al₂O₃    iv. Cl₂O₇    v. Na₃PO₄
   a. i, iii, iv    b. i, ii, iv    c. ii, iii, v    d. i and iv    e. none of these

8. Which one of the following is the greatest?
   a. number of nitrogen atoms in 1 mol of nitrogen in its elemental form
   b. number of formula units in 1 mol of ammonium phosphate
   c. number of ammonium ions in 1 mol of ammonium phosphate
   d. number of oxygen atoms in 1 mol of ammonium phosphate
   e. number of molecules in 1 mol of nitrogen dioxide

9. A compound has C₃H₅O₃ as its empirical formula. Which one of the following can not be this compound's molecular formula?
   a. C₃H₅O₃    b. C₅H₁₆O₆    c. C₇H₁₃O₅    d. C₆H₁₄O₄    e. all of these are possible

10. Consider the following reaction: I₂ (s) + 2 Na₂S₂O₃ (aq) → Na₂S₄O₆ (aq) + 2 NaI (aq). Determine the mass (in g) of I₂ required to react completely with 10.97 g Na₂S₂O₃. For I₂, molar mass = 253.8 g/mol; for Na₂S₂O₃, molar mass = 158.1 g/mol.

   a. 8.805 g    b. 17.61 g    c. 35.22 g
   d. 16.05 g    e. 5.485 g

11. Calculate the density (in g/cm³) of technetium if 0.246 mol occupies a volume of 2.11 cm³.
   a. 24.3 g/cm³    b. 8.58 g/cm³    c. 46.9 g/cm³
   d. 0.519 g/cm³    e. 11.5 g/cm³

12. Which one of the following statements about lab measurements is correct?
   a. A 50-mL burette is not as precise as a 50-mL graduated cylinder.
   b. Extrapolation is a more reliable method of estimation than interpolation.
   c. In a linear graph of time vs. distance, the slope can have units of cm/s.
   d. Standard deviation is an indication of the accuracy of a set of measurements.
   e. A 25-mL pipette is precise to 4 significant figures.
13. Based on the observations you made during the Reactions and Solubility lab, which one of the following ions is generally not soluble?

a. Na⁺  b. K⁺  c. NH₄⁺  d. Ag⁺  e. NO₃⁻

Part III (15 points): Problems. Work each of the following problems. Show all work clearly; work with units in all steps; report your answers with correct units and significant figures. No partial credit will be given if I cannot follow your work.

1. A compound is composed of potassium, chromium, and oxygen. After analysis, it is found to be 26.58% potassium and 35.35% chromium by mass. Determine the empirical formula of this compound.

\[
\begin{align*}
26.58 \text{ g K} & \times \frac{1 \text{ mol K}}{39.10 \text{ g}} = 0.6798 \text{ mol K} \\
35.35 \text{ g Cr} & \times \frac{1 \text{ mol Cr}}{52.00 \text{ g}} = 0.6798 \text{ mol Cr} \\
38.67 \text{ g O} & \times \frac{1 \text{ mol O}}{16.00 \text{ g}} = 2.379 \text{ mol O}
\end{align*}
\]

Assume a 100 g sample:

\[
\begin{align*}
1 \text{ mol K} : 1 \text{ mol Cr} : 3.5 \text{ mol O}
\end{align*}
\]

[Draw a diagram or describe the calculations to obtain the formula.] 

\[K_2Cr_2O_7\]

2. Consider saccharin (C₇H₃NO₃S) to answer a – c below.

a. Determine the molar mass of saccharin. Include units with your answer.

\[183.2 \text{ g/mol}\]

b. Determine the amount (in mol) of saccharin that contains \(2.8 \times 10^{12}\) carbon atoms.

\[
2.8 \times 10^{12} \text{ C atoms} \times \frac{1 \text{ mol C}}{6.022 \times 10^{23} \text{ atoms}} \times \frac{1 \text{ mol sac.}}{7 \text{ mol C}} = 6.6 \times 10^{-13} \text{ mol saccharin}
\]

C. Determine the mass (in g) of oxygen in 825 mg saccharin.

\[
0.216 \text{ g}
\]

3. Consider the following reaction:

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

1.000 kg \(\text{Fe}_3\text{O}_4\) and 500.0 g \(\text{H}_2\) are combined and allowed to react. Determine the mass (in g) of iron collected if the reaction proceeds in 88.22% yield.

\[
\begin{align*}
1.000 \times 10^3 \text{ g} \text{ Fe}_3\text{O}_4 & \times \frac{1 \text{ mol Fe}_3\text{O}_4}{231.6 \text{ g}} = 4.318 \text{ mol Fe}_3\text{O}_4 \quad ; \quad 500.0 \text{ g} \text{ H}_2 & \times \frac{1 \text{ mol H}_2}{2.016 \text{ g}} = 248.0 \text{ mol H}_2
\end{align*}
\]

\[
\text{Fe}_3\text{O}_4 + 4 \text{ H}_2 \rightarrow 3 \text{ Fe} + 4 \text{ H}_2\text{O}
\]

\[
\begin{align*}
\text{before} & \quad 4.318 \text{ mol} & 248.0 \text{ mol} & 0 \\
\triangle & \quad +12.95 \text{ mol} & +17.27 \text{ mol} & +17.27 \text{ mol}
\end{align*}
\]

\[
\text{after} & \quad 230.7 \text{ mol} & 12.95 \text{ mol} & 17.27 \text{ mol}
\]

Theoretical yield \(\text{Fe} = 12.95 \text{ mol} \times \frac{55.85 \text{ g}}{1 \text{ mol Fe}} = 723.3 \text{ g Fe}\)

\[638.1 \text{ g}\]