Chemistry 142 Multiple Choice

(a) Before starting, please check to see that your exam has 6 pages, which includes the periodic table.

(b) Fill in your name, section, and student number on Side 1 of the Answer Sheet.

(c) To receive credit, you must mark Test Version A on Side 1 of the answer sheet.

(d) When you are done with the exam, hand the Answer Sheet to a TA at the exit of the room. Please take the questions with you.

(e) The exam is over at 6:20 AM. No answer sheet will be accepted after 6:20 AM.

(e) Our final exam is scheduled for MONDAY, DECEMBER 14 at 6:30 PM in this room.
This is test version A.
To receive credit you must mark version A on side 1 of the Answer Sheet.

1. (3 points) The result of $(3.8621 \times 1.565) - 6.04$ is properly written as
   a. 0.00
   b. 0.004
   c. 0.0042
   d. 0.00419
   e. 0.004186

2. (8 points) 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. $NH_4$
   c. $NH$
   d. $N_2H_3$
   e. $NH_3$

3. (8 points) The transition metal rhenium has two stable isotopes. The atomic mass of rhenium is 186.2 g/mol. Given that 37.1% of natural rhenium is $^{185}_{75}$Re, what is the other stable isotope?
   a. $^{189}_{75}$Re
   b. $^{190}_{75}$Re
   c. $^{183}_{75}$Re
   d. $^{187}_{75}$Re
   e. $^{181}_{75}$Re
4. (8 points) The compound, $P_4S_{10}$, is used in the manufacturing of safety matches. What is the compound’s name?
   a. tetraphosphorus decasulfide
   b. phosphoric sulfide
   c. phosphorus decasulfide
   d. phosphorus sulfide
   e. phosphorus sulfate
5. (8 points) Which is not the correct chemical formula for the compound named?
   a. sodium sulfate \( \text{Na}_2\text{SO}_4 \)
   b. potassium chloride \( \text{KCl} \)
   c. ammonium sulfide \( (\text{NH}_4)_2\text{S} \)
   d. barium hydroxide \( \text{Ba(OH)}_2 \)
   e. calcium oxide \( \text{Ca}_2\text{O} \)

6. (8 points) Calculate the number of oxygen atoms in 29.3 g of sodium sulfate, \( \text{Na}_2\text{SO}_4 \) (molar mass = 142.05 g/mol).
   a. \( 1.24 \times 10^{23} \) O atoms
   b. \( 2.48 \times 10^{23} \) O atoms
   c. \( 4.97 \times 10^{23} \) O atoms
   d. \( 2.94 \times 10^{24} \) O atoms
   e. \( 1.18 \times 10^{25} \) O atoms

7. (8 points) Hydroxylamine nitrate contains 29.17 mass % N, 4.20 mass % H, and 66.63 mass % O. If its molar mass is between 94 and 98 g/mol, what is its molecular formula?
   a. \( \text{N}_2\text{H}_4\text{O}_4 \)
   b. \( \text{NH}_2\text{O}_5 \)
   c. \( \text{N}_3\text{H}_6\text{O}_3 \)
   d. \( \text{N}_4\text{H}_8\text{O}_2 \)
   e. \( \text{N}_3\text{H}_6\text{O}_3 \)

8. (8 points) The Claus reactions, shown below, are used to generate elemental sulfur from hydrogen sulfide.
   \[
   \begin{align*}
   2\text{H}_2\text{S}(g) + 3\text{O}_2(g) & \rightarrow 2\text{SO}_2(g) + 2\text{H}_2\text{O}(g) \\
   \text{SO}_2(g) + 2\text{H}_2\text{S}(g) & \xrightarrow{\text{Fe}_2\text{O}_3} 3\text{S}(s) + 2\text{H}_2\text{O}(g)
   \end{align*}
   
These reactions are performed on an industrial scale. How much sulfur (in metric tons) is produced from 48 metric tons of \( \text{O}_2 \)?
   a. 16 tons
   b. 24 tons
   c. 32 tons
   d. 48 tons
   e. 96 tons
9. (8 points) Consider the fermentation reaction of glucose to produce ethanol and carbon dioxide:

\[ C_6H_{12}O_6(aq) \xrightarrow{\text{yeast}} 2C_2H_5OH(aq) + 2CO_2(g) \]

A 2.00-mole sample of \( C_6H_{12}O_6 \) was placed in a vat with 125 g of yeast and enough water to make a total volume of 3.85 L. If 92 grams of \( C_2H_5OH \) (molar mass = 46.068 g/mol) was obtained after fermentation, what was the percent yield of \( C_2H_5OH \)?

a. 42%
b. 50%
c. 56%
d. 100%
e. 70%

10. (8 points) In the reaction

\[ 2\text{MnO}_4^-(aq) + 5\text{H}_2\text{O}_2(aq) + 6\text{H}^+(aq) \rightarrow 2\text{Mn}^{2+}(aq) + 8\text{H}_2\text{O}(l) + 5\text{O}_2(g) \]

what volume of 0.150 M \( \text{KMnO}_4 \) solution is needed to titrate 75.0 mL of a 0.150 M \( \text{H}_2\text{O}_2 \) solution?

a. 30.0 mL
b. 15.0 mL
c. 60.0 mL
d. 45.0 mL
e. 75.0 mL

11. (8 points) Balance the following oxidation-reduction equation using the smallest integers possible and select the correct coefficient for the bromide anion, \( \text{Br}^- \).

\[ \text{Br}_2(aq) + \text{OH}^-(aq) \rightarrow \text{Br}^-(aq) + \text{BrO}_3^-(aq) + \text{H}_2\text{O}(l) \]

a. 6
b. 10
c. 2
d. 5
e. 3
12. (8 points) In the reaction $\text{Zn}(s) + \text{H}_2\text{SO}_4(aq) \rightarrow \text{ZnSO}_4(aq) + \text{H}_2(g)$, which, if any, element is oxidized?
   a. hydrogen
   b. sulfur
   c. oxygen
   d. zinc
   e. none of these

13. (8 points) Which of the following are oxidation-reduction reactions?
   I. $\text{PCl}_3(l) + \text{Cl}_2(g) \rightarrow \text{PCl}_5(s)$
   II. $\text{Cu}(s) + 2\text{AgNO}_3(aq) \rightarrow \text{Cu(NO}_3)_2(aq) + 2\text{Ag}(s)$
   III. $\text{CO}_2(g) + 2\text{LiOH}(aq) \rightarrow \text{Li}_2\text{CO}_3(aq) + \text{H}_2\text{O}(l)$
   IV. $\text{FeCl}_2(aq) + 2\text{NaOH}(aq) \rightarrow \text{Fe(OH)}_2(s) + 2\text{NaCl}(aq)$
   a. III
   b. IV
   c. I and II
   d. I, II, and III
   e. I, II, III, and IV
1. (3 points) The result of \((3.8621 \times 1.565) – 6.04\) is properly written as
   a. 0.00  68%
   b. 0.004  18
   c. 0.0042  1
   d. 0.00419  9
   e. 0.004186  3

\[(3.8621 \times 1.5650) – 6.04 = 6.0441865 – 6.04 = 0.00\]

2. (8 points) 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. \(N_2H_6\) 19%
   b. \(NH_4\) 13
   c. \(NH\) 8
   d. \(N_2H_3\) 7
   e. \(NH_3\) 54

*From Avogadro’s law, three moles of hydrogen react with one mole of oxygen to produce 2 moles of product. From the conservation of mass, the two moles of product must have six moles of hydrogen atoms and two moles of nitrogen atoms. One mole of product has three moles hydrogen and one mole nitrogen atoms: \(NH_3\).*

3. (8 points) The transition metal rhenium has two stable isotopes. The atomic mass of rhenium is 186.2. Given that 37.1% of natural rhenium is \(^{185}\text{Re}\), what is the other stable isotope?
   a. \(^{189}\text{Re}\) 3%
   b. \(^{190}\text{Re}\) 3
   c. \(^{183}\text{Re}\) 8
   d. \(^{187}\text{Re}\) 85
   e. \(^{181}\text{Re}\) 0

\[186.2 \text{ g/mol} = 0.371 \times 185 + 0.629 \times X; X = 186.9 \approx 187; \text{ the isotope is } ^{187}\text{Re}\]
4. (8 points) The compound, P₄S₁₀, is used in the manufacture of safety matches. What is the compound’s name?

a. tetraphosphorus decasulfide 84%
b. phosphoric sulfide 2
c. phosphorus decasulfide 7
d. phosphorus sulfide 6
e. phosphorus sulfate 1

P₄S₁₀ is a type III binary compound; it is named tetraphosphorus decasulfide
5. (8 points) Which is not the correct chemical formula for the compound named?
   a. sodium sulfate \( \text{Na}_2\text{SO}_4 \) 3%
   b. potassium chloride KCl 0
   c. ammonium sulfide \((\text{NH}_4)_2\text{S}\) 15
   d. barium hydroxide \(\text{Ba(OH)}_2\) 9
   e. calcium oxide \(\text{Ca}_2\text{O}\) 72

   *These are type I binary compounds. The formula for calcium oxide is in error; the correct formula is CaO.*

6. (8 points) Calculate the number of oxygen atoms in 29.3 g of sodium sulfate, \(\text{Na}_2\text{SO}_4\).
   a. \(1.24 \times 10^{23} \) O atoms 29%
   b. \(2.49 \times 10^{23} \) O atoms 6
   c. \(4.97 \times 10^{23} \) O atoms 61
   d. \(2.92 \times 10^{24} \) O atoms 3
   e. \(1.18 \times 10^{25} \) O atoms 1

   \[ 29.3 \text{ g} \times \frac{1 \text{ mol} \text{Na}_2\text{SO}_4}{142.05 \text{ g}} \times 4 \text{ mol} \text{O}/1\text{molNa}_2\text{SO}_4 \times 6.022 \times 10^{23} \text{ atoms/mol} = 4.98 \times 10^{23} \text{ atoms} \]

7. (8 points) Hydroxylamine nitrate contains 29.17 mass % N, 4.20 mass % H, and 66.63 mass % O. If its molar mass is between 94 and 98 g/mol, what is its molecular formula?
   a. \(\text{N}_2\text{H}_4\text{O}_4\) 84%
   b. \(\text{NH}_2\text{O}_3\) 7
   c. \(\text{N}_3\text{H}_6\text{O}_3\) 6
   d. \(\text{N}_4\text{H}_8\text{O}_2\) 2
   e. \(\text{N}_3\text{H}_6\text{O}_3\) 1

   *Assume 100 g compound.*

   \[ 29.17 \text{ g} \times 1 \text{ mol}/14.01 \text{ g} = 2.082 \text{ mol} \]
   \[ 4.20 \text{ g} \times 1 \text{ mol}/1.008 \text{ g} = 4.17 \text{ mol} \]
   \[ 66.63 \text{ g} \times 1 \text{ mol}/16.00 \text{ g} = 4.164 \text{ mol} \]

   *Divide by 2.082, empirical formula = NH\(_2\)O\(_2\)*

   *Empirical formula weight = 48.03 g/mol\]
   \[ 96/48 = 2 \]

   *Molecular formula = N\(_2\)H\(_4\)O\(_4\)*
8. (8 points) The Claus reactions, shown below, are used to generate elemental sulfur from hydrogen sulfide.

\[
2\text{H}_2\text{S} + 3\text{O}_2 \rightarrow 2\text{SO}_2 + 2\text{H}_2\text{O} \\
\text{SO}_2 + 2\text{H}_2\text{S} \xrightarrow{\text{Fe}_2\text{O}_3} 3\text{S} + 2\text{H}_2\text{O}
\]

These reactions are performed on an industrial scale. How much sulfur (in metric tons) is produced from 48 metric tons of \( \text{O}_2 \)?

a. 16 tons 9%
b. 24 tons 11%c. 32 tons 12%d. 48 tons 18’e. 96 tons 49%

\[
48 \times 10^6 \text{ g} \times \frac{1 \text{ mol}}{32.00 \text{ g}} = 1.5 \times 10^6 \text{ mol} \text{ O}_2 \times 2 \text{ SO}_2 / 3 \text{ O}_2 \times 3 \text{ S} / \text{ISO}_2 \times 32.07 \text{ g/mol S} \\
= 96.2 \times 10^6 \text{ g} = 96 \text{ ton}
\]

9. (8 points) Consider the fermentation reaction of glucose to produce ethanol and carbon dioxide:

\[
\text{C}_6\text{H}_{12}\text{O}_6 \xrightarrow{\text{yeast}} 2\text{C}_2\text{H}_5\text{OH} + 2\text{CO}_2
\]

A 2.00-mole sample of \( \text{C}_6\text{H}_{12}\text{O}_6 \) was placed in a vat with 125 g of yeast and enough water to make a total volume of 3.85 L. If 92 grams of \( \text{C}_2\text{H}_5\text{OH} \) (molar mass = 46.068 g/mol) was obtained after fermentation, what was the percent yield of \( \text{C}_2\text{H}_5\text{OH} \)?

a. 42% 6%
b. **50.%** 56%c. 56% 15%d. 100.% 14%e. 70.% 9%

*Calculate theoretical yield*

\[
1.00 \text{ mol } \text{C}_6\text{H}_{12}\text{O}_6 \times 2 \text{ mol } \text{C}_2\text{H}_5\text{OH} / 1 \text{ mol } \text{C}_6\text{H}_{12}\text{O}_6 = 2 \text{ mol } \text{C}_2\text{H}_5\text{OH} \times 46 \text{ g/mol} = 92\text{g}
\]

\[
\%\text{yield} = \frac{\text{actual/theoretical} \times 100\%}{46/92 \times 100\%} = 50.\%
\]

10. (8 points) In the reaction

\[
2\text{MnO}_4^- + 5\text{H}_2\text{O}_2 + 6\text{H}^+ \rightarrow 2\text{Mn}^{2+} + 8\text{H}_2\text{O} + 5\text{O}_2
\]

what volume of 0.150 M \( \text{KMnO}_4 \) solution is needed to titrate 75.0 mL of a 0.150 M \( \text{H}_2\text{O}_2 \) solution?

a. **30.0 mL** 58%
b. 15.0 mL 5%c. 60.0 mL 11%d. 45.0 mL 8%e. 75.0 mL 19%

\[
0.0750 \text{ L} \times 0.150 \text{ M } \text{H}_2\text{O}_2 = 0.01125 \text{ mol } \text{H}_2\text{O}_2 \times 2 \text{ MnO}_4^- / 5 \text{ H}_2\text{O}_2 = 0.00450 \text{ mol } \text{MnO}_4^-
\]

\[
\times 1 \text{ L} / 0.150 \text{ mol} = 0.0300 \text{L} = 30.0 \text{ L}
\]
11. (8 points) Balance the following oxidation-reduction equation using the smallest integers possible and select the correct coefficient for the bromide anion, Br\(^{-}\).

\[ 3\text{Br}_2\text{(aq)} + 6\text{OH}^-\text{(aq)} \rightarrow 5\text{Br}^-\text{(aq)} + \text{BrO}_3^-\text{(aq)} + 3\text{H}_2\text{O(l)} \]

\[
\begin{array}{cccc}
0 & -2/+1 & -1 & +5/-2 & +1/-2 \\
\end{array}
\]

a. 6  15%  
b. 10  11  
c. 2  28  
d. 5  28  

Br\(_2\) is both reduced and oxidized. It gains one electron to form Br\(^-\) and gains five electrons to form BrO\(_3^-\)!. Five Br\(^-\) must be formed for every BrO\(_3^-\)!

d. 5  28  
e. 3  19

12. (8 points) In the reaction Zn + H\(_2\)SO\(_4\) → ZnSO\(_4\) + H\(_2\), which, if any, element is oxidized?

a. hydrogen  10%  
b. sulfur  5  
c. oxygen  0  
d. zinc  69  
e. none of these  16

Zinc starts as OS = 0 and ends as OS = +2; it is oxidized

d. zinc  69  
e. none of these  16

13. (8 points) Which of the following are oxidation-reduction reactions?

I. PCl\(_3\) + Cl\(_2\) → PCl\(_5\)  
II. Cu + 2AgNO\(_3\) → Cu(NO\(_3\))\(_2\) + 2Ag  
III. CO\(_2\) + 2LiOH → Li\(_2\)CO\(_3\) + H\(_2\)O  
IV. FeCl\(_2\) + 2NaOH → Fe(OH)\(_2\) + 2NaCl

a. III  15%  
b. IV  10  
c. I and II  45  
d. I, II, and III  18  
e. I, II, III, and IV  12

I and II are reactions where an element (with OS = 0) is converted to a compound; they are oxidation-reduction reactions. III is an acid-base reaction, and IV is a precipitation reaction.