Chem 1061 Exam 2
Fall 2004
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Instructions:

Time: You have 85 minutes to complete this exam.

Allowed items: This exam will require the use of a calculator. A calculator and your writing
instrument are the only personal items allowed on your table while the exam is being
administered. A #2 pencil is required to fill out the Scantron form for the multiple choice
questions. Please use pen on the problems section of the exam if you would like the opportunity
for regrades beyond simple score-addition errors.

Provided information: A periodic table and conversion chart are provided for you inside this
exam booklet.

Contents:

I. Multiple choice, 14 questions, 3 points each. 42 points
II. Fill in the blank, 10 questions, 4 points each. 40 points
III. Problems. 2 questions, 10 points each. 20 points
Total: 100 points

I, ______________________ have read and understand the directions given above, and pledge
that I will follow all regulations with regard to Academic Dishonesty as outlined by this college
when taking this exam.

Signature _________________________________ Date and Time ______________________
I. Multiple choice

Choose the best answer from the choices given, and mark your choice on the provided Scantron sheet with a #2 pencil. (3 points each)

1. What is the molar mass of caffeine, C₈H₁₀N₄O₂?
   a. 102 g/mol
   b. 142 g/mol
   c. 164 g/mol
   d. 182 g/mol
   e. 194 g/mol

2. How many sulfur atoms are there in 25 g of Al₂S₃?
   a. 1.0 x 10²²
   b. 2.0 x 10²³
   c. 3.0 x 10²³
   d. 4.5 x 10²¹
   e. 6.0 x 10²¹

3. Which of the following samples contains the largest number of atoms?
   a. 1 g Li
   b. 1 g F₂
   c. 1 g C
   d. 1 g P₄
   e. 1 g N₂

4. Of the following, the only empirical formula is
   a. C₂H₄
   b. C₅H₁₂
   c. N₂O₄
   d. S₈
   e. N₃H₄

5. Sulfur trioxide, SO₃, is made from the oxidation of SO₂, and the reaction is represented by the equation

   \[ 2\text{SO}_2 + \text{O}_2 \rightarrow 2\text{SO}_3 \]

   A 16-g sample of SO₂ gives 18 g of SO₃. The percent yield of SO₃ is
   a. 60%
   b. 75%
   c. 80%
   d. 90%
   e. 100%
6. If 50.0 g of O\textsubscript{2} are mixed with 50.0 g of H\textsubscript{2} and the mixture is ignited, what mass of water is produced?
   a. 50.0 g
   b. 56.3 g
   c. 65.7 g
   d. 71.4 g
   e. 100.0 g

7. Which of the following is a weak base?
   a. HOC\textsubscript{1}
   b. LiOH
   c. Ba(OH)\textsubscript{2}
   d. KOH
   e. NH\textsubscript{3}

8. Which of the following compounds is \textit{insoluble} in water?
   a. (NH\textsubscript{4})\textsubscript{2}CO\textsubscript{3}
   b. AgBr
   c. CuSO\textsubscript{4}
   d. KI
   e. LiNO\textsubscript{3}

9. Which of the following is a weak electrolyte in aqueous solution?
   a. acetic acid
   b. lithium acetate
   c. ammonium carbonate
   d. sulfuric acid
   e. strontium hydroxide

10. Which of the following reactions could be classified both as a precipitation reaction and an acid-base reaction?
    a. Cu + 2H\textsubscript{2}SO\textsubscript{4} \rightarrow CuSO\textsubscript{4} + SO\textsubscript{2} + 2H\textsubscript{2}O
    b. Ba(OH)\textsubscript{2} + H\textsubscript{2}CO\textsubscript{3} \rightarrow BaCO\textsubscript{3} + 2H\textsubscript{2}O
    c. Ca + 2H\textsubscript{2}O \rightarrow Ca(OH)\textsubscript{2} + H\textsubscript{2}
    d. CaSO\textsubscript{3} + 2H\textsubscript{2}O \rightarrow Ca(C\textsubscript{2}H\textsubscript{3}O\textsubscript{2})\textsubscript{2} + SO\textsubscript{2} + H\textsubscript{2}O
    e. PCl\textsubscript{5} + 4H\textsubscript{2}O \rightarrow H\textsubscript{3}PO\textsubscript{4} + 5HCl

11. The balanced net ionic equation for the reaction of calcium carbonate with nitric acid is
    a. CaCO\textsubscript{3}(s) + 2HNO\textsubscript{2}(aq) \rightarrow Ca\textsuperscript{2+}(aq) + 2NO\textsubscript{2}\textsuperscript{2-}(aq) + CO\textsubscript{2}(g) + H\textsubscript{2}O(l)
    b. CaCO\textsubscript{3}(s) + 2HNO\textsubscript{3}(aq) \rightarrow Ca\textsuperscript{2+}(aq) + 2NO\textsubscript{3}(aq) + CO\textsubscript{2}(g) + H\textsubscript{2}O(l)
    c. Ca(HCO\textsubscript{3})\textsubscript{2}(s) + 2HNO\textsubscript{3}(aq) \rightarrow Ca\textsuperscript{2+}(aq) + 2NO\textsubscript{3}(aq) + 2CO\textsubscript{2}(g) + 2H\textsubscript{2}O(l)
    d. Ca\textsuperscript{2+}(aq) + CO\textsubscript{3}\textsuperscript{2-}(aq) + 2H\textsuperscript{+}(aq) + 2NO\textsubscript{3}(aq) \rightarrow Ca(NO\textsubscript{3})\textsubscript{2}(aq) + CO\textsubscript{2}(g) + H\textsubscript{2}O(l)
    e. CaCO\textsubscript{3}(s) + 2H\textsuperscript{+}(aq) \rightarrow Ca\textsuperscript{2+}(aq) + CO\textsubscript{2}(g) + H\textsubscript{2}O(l)
12. The oxidation numbers of nitrogen in N$_2$O and N$_2$F$_4$ are, respectively,
   a. -2 and -3  
   b. -2 and +2  
   c. +1 and -1  
   d. +1 and +2  
   e. +1 and -3  

13. How much 0.54 M NaCl, “physiologic saline,” can be prepared via the dilution of 100 mL of a 6.0 M NaCl solution?
   a. 1.1 L  
   b. 910 mL  
   c. 90 mL  
   d. 540 mL  
   e. 1.9 L  

14. A solution that contains 50.0 g of NaOH in 750.0 mL of solution has what molarity?
   a. 0.600 M  
   b. 0.800 M  
   c. 1.07 M  
   d. 1.25 M  
   e. 1.67 M  

II. Fill in the blank

All fill in the blank questions are 4 points each.

Identify the following reactions as either precipitation, redox, or acid-base.

15. ___acid-base_______ 2NH$_3$ + H$_2$SO$_4$ $\rightarrow$ (NH$_4$)$_2$SO$_4$  
16. ___redox___________ 4Fe + 3O$_2$ $\rightarrow$ 2Fe$_2$O$_3$  
17. ___precipitation_______ Al$_2$(SO$_4$)$_3$ + 6NaOH $\rightarrow$ 2Al(OH)$_3$ + 3Na$_2$SO$_4$
For the following combinations of aqueous solutions, if a precipitate will form, write the \textit{formula} for that precipitate. If no reaction will occur, write NR.

18. potassium carbonate and ammonium chloride \hspace{1cm} \text{NR}

19. lithium sulfate and barium hydroxide \hspace{1cm} \text{BaSO}_4(s)

20. silver(I) acetate and copper(II) chloride \hspace{1cm} \text{AgCl } (s)

For the following redox reactions, write oxidation numbers for every underlined atom or molecule in the boxes above the atom or molecule, and \textit{circle} the species that was oxidized.

\begin{align*}
21. \hspace{0.5cm} & 2\text{Al}(s) + 3\text{Cl}_2(g) \rightarrow 2\text{AlCl}_3(s) \\
& \hspace{1.5cm} ^{0} \hspace{0.5cm} ^{0} \hspace{1.5cm} ^{+3} \hspace{1.5cm} ^{2-} \\
22. \hspace{0.5cm} & \text{Fe}_2\text{O}_3(s) + 3\text{CO}(g) \rightarrow 2\text{Fe}(s) + 3\text{CO}_2(g) \\
& \hspace{1.5cm} ^{+3} \hspace{2cm} ^{0} \hspace{1.5cm} ^{+2} \hspace{1.5cm} ^{4} \\
\end{align*}

Write the net ionic equations with appropriate phase labels (\textit{aq}), (\textit{s}), (\textit{l}), or (\textit{g}) for the following reactions in aqueous solution:

\begin{align*}
23. \hspace{1cm} & 3\text{Ba(OH)}_2 + 2\text{H}_3\text{PO}_4 \rightarrow \text{Ba}_3(\text{PO}_4)_2 + 6\text{H}_2\text{O} \\
& 3\text{Ba}^{2+}(aq) + 6\text{OH}^-(aq) + 2\text{H}_3\text{PO}_4(aq) \rightarrow \text{Ba}_3(\text{PO}_4)_2(s) + \text{H}_2\text{O}(l) \\
24. \hspace{1cm} & \text{Al}_2(\text{SO}_4)_3 + 6\text{NaOH} \rightarrow 2\text{Al(OH)}_3 + 3\text{Na}_2\text{SO}_4 \\
& 2\text{Al}^{3+}(aq) + 6\text{OH}^-(aq) \rightarrow 2\text{Al(OH)}_3(s)
\end{align*}
III. Problems

25. 15.0 mL of NaOH was titrated with 4.38 mL of 6.00 M H₂SO₄. How many grams of NaOH are present in that 15.0 mL, and what is the molarity of the NaOH solution? *Hint:* a balanced chemical equation is necessary! Draw boxes around your answers. Show all your work for full credit. As always, round your final answer to the correct number of significant figures at the end of your calculation. (9 points)

\[
2\text{NaOH (aq)} + \text{H}_2\text{SO}_4 (aq) \rightarrow \text{Na}_2\text{SO}_4 (aq) + 2\text{H}_2\text{O}
\]

\[
4.38 \text{ mL H}_2\text{SO}_4 \times \frac{6.00 \text{ mmol H}_2\text{SO}_4}{1 \text{ mL H}_2\text{SO}_4} \times \frac{2 \text{ mmol NaOH}}{1 \text{ mmol H}_2\text{SO}_4} = 52.56 \text{ mmol NaOH}
\]

\[
\frac{52.56 \text{ mmol NaOH}}{15.0 \text{ mL}} = 3.50 \text{ M NaOH}
\]

\[
52.56 \text{ mmol NaOH} \times \frac{39.998 \text{ mg NaOH}}{1 \text{ mmol NaOH}} \times \frac{10^{-3} \text{ g NaOH}}{1 \text{ mg NaOH}} = 2.10 \text{ g NaOH}
\]
26. Combustion analysis has shown that a certain sample contains 68.9% carbon, 4.92% hydrogen, and 26.2% oxygen. What is the empirical formula for this substance? Show all your work and place a box around your answer. (10 points)

Assume 100.0 g of sample. This would contain 68.9 g C, 4.92 g H, and 26.2 g O.

\[
\begin{align*}
68.9 \text{ g C} \times \frac{1 \text{ mol C}}{12.01 \text{ g C}} &= 5.737 \text{ mol C} \\
4.92 \text{ g H} \times \frac{1 \text{ mol H}}{1.008 \text{ g H}} &= 4.881 \text{ mol H} \\
26.2 \text{ g O} \times \frac{1 \text{ mol O}}{16.00 \text{ g O}} &= 1.638 \text{ mol O}
\end{align*}
\]

\[
\frac{5.737 \text{ mol C}}{1.638 \text{ mol O}} = 3.50 \times 2 = 7 \\
\frac{4.881 \text{ mol H}}{1.638 \text{ mol O}} = 2.98 \times 2 = 6 \\
\frac{1.638 \text{ mol O}}{1.638 \text{ mol O}} = 1.00 \times 2 = 2
\]

The empirical formula is \( \text{C}_7\text{H}_6\text{O}_2 \).