Section 1: Fill in the blanks as instructed in each question. Each blank is worth \( \frac{1}{2} \) point.

1. Balance each equation by providing the appropriate coefficients. If you leave a blank before a compound it will be interpreted as a coefficient of 1. This question is worth a total of 11 points.

\[
\begin{align*}
2C_6H_6 + 15O_2 & \rightarrow 12CO_2 + 6H_2O \\
\text{---}Cu + 4HNO_3 & \rightarrow \text{---}Cu(NO_3)_2 + 2NO_2 + 2H_2O \\
4C_3H_5(NO_3)_3 & \rightarrow 12CO_2 + 6N_2 + 10H_2O + \text{---}O_2 \\
3Br_2 + 8NH_3 & \rightarrow 6NH_4Br + \text{---}N_2 \\
2CH_3OH + 3O_2 & \rightarrow 2CO_2 + 4H_2O \\
\end{align*}
\]

2. Indicate whether each species will behave as an electrolyte or a nonelectrolyte when dissolved in water. This question is worth a total of 2 points.

nonelectrolyte \( \text{CH}_3\text{CH}_2\text{OH} \)  electrolyte \( \text{LiCl} \)

\( \text{electrolyte} \) \( \text{ZnBr} \)  nonelectrolyte \( \text{C}_6\text{H}_12\text{O}_6 \)

3. Indicate whether each species is soluble or insoluble in water. This question is worth a total of 5 points.

soluble \( \text{LiOH} \)  insoluble \( \text{Cu(OH)}_2 \)

soluble \( \text{KNO}_3 \)  soluble \( \text{CuCl}_2 \)

insoluble \( \text{CaO} \)  soluble \( \text{FeBr}_2 \)

insoluble \( \text{Ca}_3(\text{PO}_4)_2 \)  soluble \( \text{KI} \)

insoluble \( \text{PbI}_2 \)  insoluble \( \text{Fe}_2(\text{CO}_3)_3 \)

4. Indicate the oxidation number of each element in these species. This question is worth a total of 4 points.

\[
\begin{array}{ccc}
\text{CH}_2\text{Cl}_2 & \text{PO}_4^{3-} & \text{NaBrO}_4 \\
0 \text{ C} & +1 \text{ H} & -1 \text{ Cl} & +5 \text{ P} & -2 \text{ O} & +1 \text{ Na} & +7 \text{ Br} & -2 \text{ O} \\
\end{array}
\]
5. Indicate whether each reaction is a precipitation, acid-base, gas forming, or redox reaction and provide the missing products (with phases), when necessary (do not balance!). This question is worth a total of 7 points.

**Precipitation**

\[ 2 \text{NaI}^{(aq)} + \text{Pb(NO}_3\text{)}_2^{(aq)} \rightarrow 2 \text{NaNO}_3^{(aq)} + \text{PbI}_2^{(s)} \]

**Gas Forming**

\[ \text{CaCO}_3^{(s)} + 2 \text{HCl}^{(aq)} \rightarrow \text{CaCl}_2^{(aq)} + \text{H}_2\text{O}^{(l)} + \text{CO}_2^{(g)} \]

**Redox**

\[ 2 \text{C}_2\text{H}_2^{(g)} + 5 \text{O}_2^{(g)} \rightarrow 4 \text{CO}_2^{(g)} + 2 \text{H}_2\text{O}^{(g)} \]

**Acid-Base**

\[ \text{LiOH}^{(aq)} + \text{HCl}^{(aq)} \rightarrow \text{H}_2\text{O}^{(l)} + \text{LiCl}^{(aq)} \]

**Precipitation**

\[ \text{HCl}^{(aq)} + \text{AgNO}_3^{(aq)} \rightarrow \text{HNO}_3^{(aq)} + \text{AgCl}^{(s)} \]

**Redox**

\[ \text{KI}^{(aq)} + \text{HClO}^{(aq)} \rightarrow \text{KCl}^{(aq)} + \text{HIO}^{(aq)} \]

**Redox**

\[ 2 \text{H}_2\text{O}^{(l)} \rightarrow 2 \text{H}_2^{(g)} + \text{O}_2^{(g)} \]

**Gas Forming**

\[ \text{CaCO}_3^{(s)} \rightarrow \text{CO}_2^{(g)} + \text{CaO}^{(s)} \]

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Section 2: Complete each question. You must show your work in order to earn full credit. Points are indicated in parentheses for each question.

6. (5 points) Nitric oxide is made from the oxidation of ammonia. How many moles of nitric oxide can be made from the reaction of 3.80 mol NH₃ with 4.25 mol O₂?

\[ 4 \text{NH}_3^{(g)} + 5 \text{O}_2^{(g)} \rightarrow 4 \text{NO}^{(g)} + 6 \text{H}_2\text{O}^{(g)} \]

\[
\text{3.80 mol NH}_3 \times \frac{4 \text{ mol NO}}{4 \text{ mol NH}_3} = 3.80 \text{ mol NO}
\]

\[
\text{4.25 mol O}_2 \times \frac{4 \text{ mol NO}}{5 \text{ mol O}_2} = 3.40 \text{ mol NO}
\]

Therefore, only 3.40 moles of NO will be produced
8. (5 points) What mass of carbon reacts completely with 17.8 grams of SiO₂ according to the following equation?

\[
\text{SiO}_2(s) + 3 \text{C}(s) \rightarrow \text{SiC}(s) + 2 \text{CO}(g)
\]

\[
17.8 \text{ g SiO}_2 \times \frac{1 \text{ mol SiO}_2}{60.09 \text{ g SiO}_2} \times \frac{3 \text{ mol C}}{1 \text{ mol SiO}_2} \times \frac{12.01 \text{ g C}}{1 \text{ mol C}} = 10.7 \text{ g C}
\]

9. (10 points) Aspirin is produced by the reaction of salicylic acid \((M = 138.1 \text{ g/mol})\) and acetic anhydride \((M = 102.1 \text{ g/mol})\).

\[
\text{C}_7\text{H}_6\text{O}_3(s) + \text{C}_4\text{H}_6\text{O}_3(l) \rightarrow \text{C}_9\text{H}_8\text{O}_4(s) + \text{C}_2\text{H}_4\text{O}_2(l)
\]

If 2.04 g of \(\text{C}_9\text{H}_8\text{O}_4\) \((M = 180.2 \text{ g/mol})\) is produced from the reaction of 3.00 g \(\text{C}_7\text{H}_6\text{O}_3\) and 5.40 g \(\text{C}_4\text{H}_6\text{O}_3\), what is the percent yield?

\[
\begin{align*}
3.00 \text{ g C}_7\text{H}_6\text{O}_3 \times & \frac{1 \text{ mol C}_7\text{H}_6\text{O}_3}{138.1 \text{ g C}_7\text{H}_6\text{O}_3} \times \frac{1 \text{ mol C}_9\text{H}_8\text{O}_4}{1 \text{ mol C}_7\text{H}_6\text{O}_3} \times \frac{180.2 \text{ g C}_9\text{H}_8\text{O}_4}{1 \text{ mol C}_9\text{H}_8\text{O}_4} = 3.914 \text{ g C}_9\text{H}_8\text{O}_4 \\
5.40 \text{ g C}_4\text{H}_6\text{O}_3 \times & \frac{1 \text{ mol C}_4\text{H}_6\text{O}_3}{102.1 \text{ g C}_4\text{H}_6\text{O}_3} \times \frac{1 \text{ mol C}_9\text{H}_8\text{O}_4}{1 \text{ mol C}_4\text{H}_6\text{O}_3} \times \frac{180.2 \text{ g C}_9\text{H}_8\text{O}_4}{1 \text{ mol C}_9\text{H}_8\text{O}_4} = 9.531 \text{ g C}_9\text{H}_8\text{O}_4
\end{align*}
\]

Therefore the theoretical yield is 3.91 g \(\text{C}_9\text{H}_8\text{O}_4\), and the percent yield is found

\[
\frac{2.04 \text{ g C}_9\text{H}_8\text{O}_4 \times 100\%}{3.914 \text{ g C}_9\text{H}_8\text{O}_4} = 52.1\%
\]

10. (6 points) What is the mass of solute in 225 mL of \(5.91 \times 10^{-2} \text{ M KIO}_3\)?

\[
\text{moles KIO}_3 = M \times V
\]

\[
= (0.0591 \text{ M})(0.225 \text{ L})
\]

\[
= 0.0133 \text{ moles KIO}_3
\]

\[
0.0133 \text{ moles KIO}_3 \times \frac{214 \text{ g KIO}_3}{1 \text{ mole KIO}_3} = 2.85 \text{ g KIO}_3
\]
11. **(10 points)** Cyclohexene, a hydrocarbon, has a molar mass of 82.1 g/mole. If the combustion of 0.8300 g cyclohexene produces 0.9102 g H₂O and 2.668 g CO₂, what is the molecular formula of this compound?

\[
\begin{align*}
0.9102 \text{ g H}_2\text{O} &\times \frac{1 \text{ mol H}_2\text{O}}{18.02 \text{ g H}_2\text{O}} \times \frac{2 \text{ mol H}}{1 \text{ mol H}_2\text{O}} = 0.1010 \text{ mol H} \div 0.06062 = 1.66 \times 3 = 5 \\
2.668 \text{ g CO}_2 &\times \frac{1 \text{ mol CO}_2}{44.01 \text{ g CO}_2} \times \frac{1 \text{ mol C}}{1 \text{ mol CO}_2} = 0.06062 \text{ mol C} \div 0.06062 = 1 \times 3 = 3
\end{align*}
\]

empirical formula = C₅H₅ \(\Rightarrow\) empirical mass = 41.07 g

\[
\frac{\text{molecular mass}}{\text{empirical mass}} = \frac{82.1 \text{ g}}{41.07 \text{ g}} = 2 \Rightarrow \text{molecular formula} = \text{C}_6\text{H}_{10}
\]

12. **(6 points)** If 5.00 mL of 0.314-M KOH is diluted to exactly 125 mL with water, what is the concentration of the resulting solution?

\[
M_1 V_1 = M_2 V_2 \\
M_2 = \frac{M_1 V_1}{V_2} \\
= \frac{(0.314 \text{ M})(0.00500 \text{ L})}{(0.125 \text{ L})} \\
= 0.0126 \text{ M}
\]

13. **(9 points)** An aqueous hydrochloric acid solution has a pH of 4.15. What mass of HCl is present in 1.00 L of this solution?

\[
pH = -\log [H^+] \\
[H^+] = 10^{-pH} \\
= 10^{-4.15} \\
= 7.08 \times 10^{-5} \text{ M} \\
[H^+] = [\text{HCl}]
\]

moles HCl = \(M \times V = (7.08 \times 10^{-5} \text{ M})(1.00 \text{ L}) = 7.08 \times 10^{-5}\) moles HCl

7.08 \times 10^{-5} \text{ moles HCl} \times \frac{36.46 \text{ g HCl}}{1 \text{ mol HCl}} = 0.0026 \text{ g HCl}
14. (5 points) Balance this redox reaction and indicate which species is the oxidizing agent and which is the reducing agent.

\[ \text{C}_2\text{H}_2(l) + 2 \text{Cl}_2(g) \rightarrow \text{C}_2\text{H}_2\text{Cl}_4(l) \]

_____ C _____ is the element oxidized

_____ Cl _____ is the element reduced

_____ Cl_2 _____ is the oxidizing agent

_____ C_2H_2 _____ is the reducing agent

4 mol _______ is the number of electrons transferred when 1 mol of C_2H_2 reacts.

15. (5 points) Balance this redox reaction and indicate which species is the oxidizing agent and which is the reducing agent.

\[ \text{K}_2\text{Cr}_2\text{O}_7(aq) + 14 \text{HI}(aq) \rightarrow 2 \text{KI}(aq) + 2 \text{CrI}_3(aq) + 3 \text{I}_2(s) + 7 \text{H}_2\text{O}(l) \]

Iodine _____ is the element oxidized

Cr _____ is the element reduced

K_2Cr_2O_7 _____ is the oxidizing agent

HI _____ is the reducing agent

6 mol _______ is the number of electrons transferred when 1 mol of K_2Cr_2O_7 reacts.

16. (10 points) The active ingredient in many hair bleaches is hydrogen peroxide. The amount of hydrogen peroxide (H_2O_2) in 13.8 g of hair bleach was determined by titration with standard potassium permanganate solution. It required 43.2 mL of the 0.105-M KMnO_4 to titrate the hair bleach. What is the mass percent of hydrogen peroxide in the hair bleach?

\[ 2 \text{MnO}_4^{1-}(aq) + 5 \text{H}_2\text{O}_2(aq) + 6 \text{H}^{1+}(aq) \rightarrow 5 \text{O}_2(g) + 2 \text{Mn}^{2+}(aq) + 8 \text{H}_2\text{O}(l) \]

moles KMnO_4 = M×V = (0.105 M)(0.0432 L) = 0.00454 mol KMnO_4

0.00454 mol KMnO_4 × \frac{5 \text{ mol H}_2\text{O}_2}{2 \text{ mol KMnO}_4} × \frac{34.02 \text{ g H}_2\text{O}_2}{1 \text{ mol H}_2\text{O}_2} = 0.386 \text{ g H}_2\text{O}_2

\[ \frac{0.386 \text{ g H}_2\text{O}_2}{13.8 \text{ g bleach}} \times 100\% = 2.80\% \]