## Unit 4 Review for Midterms <br> Chemical reactions

You should be able to:

- Differentiate between physical and chemical changes and recognize common signs
- Write balanced molecular, complete ionic, and net ionic equations for reactions
- Recognize spectator ions
- Draw particle representations for a given equation
- Understand that chemical processes typically involve breaking and/or forming chemical bonds
- Understand that physical processes typically involve changes in intermolecular interactions
- Perform calculations involving stoichiometry, including gas laws and molarity
- Understand the process of titrations
- Perform titration calculations to determine the concentration of an unknown
- Differentiate between acid-base reactions, precipitation reactions, and oxidation-reduction reactions
- Understand the proton transfer in acid-base reactions
- Identify acid, base, conjugate acid, and conjugate base in an acid-base reaction
- Assign oxidation numbers to atoms in a reaction
- Identify which element is oxidized and which is reduced in a redox reaction
- Remember basic solubility rules
- Construct redox reaction equations from half-reactions

1. For the reaction between aqueous sodium chloride and aqueous lead (II) nitrate,
a. Write the balanced molecular equation
b. Write the complete ionic equation
c. Write the net ionic equation
d. Identify the spectator ions
2. For the reaction between aqueous barium hydroxide and aqueous hydrochloric acid,
a. Write the balanced molecular equation
b. Write the complete ionic equation
c. Write the net ionic equation
d. Identify the spectator ions
3. Aqueous potassium chromate is added to a beaker containing calcium chloride solution.
a. Write the net ionic equation
b. Draw the contents of the beaker before the potassium chromate is added.
c. Draw the contents of the beaker after enough potassium chromate is added to precipitate all the calcium in solution
d. Draw the contents of the beaker after an excess of potassium chromate has been added
4. Answer the following questions about acetylsalicylic acid, the active ingredient in aspirin.
a. The amount of acetylsalicylic acid in a single aspirin tablet is 325 mg , yet the tablet has a mass of 2.00 g . Calculate the mass percent of acetylsalicylic acid in the tablet.
b. The elements contained in acetylsalicylic acid are hydrogen, carbon, and oxygen. The combustion of 3.00 g of the pure compound yields 1.200 g of water and 3.72 L of dry carbon dioxide, measured at $750 . \mathrm{mmHg}$ and $25^{\circ} \mathrm{C}$. Calculate the mass, in grams, of each element in the 3.00 g sample.
5. The reaction between silver ion and solid zinc is represented by the following equation

$$
2 \mathrm{Ag}_{(a q)}^{+1}+\mathrm{Zn}_{(s)} \rightarrow \mathrm{Zn}_{(a q)}^{2+}+2 \mathrm{Ag}_{(s)}
$$

a. A 1.50 g sample of Zn is combined with 250 . mL of $0.110 \mathrm{M} \mathrm{AgNO}_{3}$ at $25^{\circ} \mathrm{C}$.
i. Identify the limiting reactant. Show calculations to support your answer.
ii. On the basis of the limiting reactant that you identified in part (i), determine the value of $\left[\mathrm{Zn}^{2+}\right]$ after the reaction is complete. Assume that volume change is negligible.
6. A sample of an iron ore is dissolved in acid, and the iron is converted to $\mathrm{Fe}^{+2}$. The sample is then titrated with 47.20 mL of $0.02240 \mathrm{M} \mathrm{MnO}_{4}{ }^{-1}$ solution. The oxidation-reduction reaction that occurs during titration is as follows:

$$
\mathrm{MnO}_{4}^{-}+5 \mathrm{Fe}^{2+}+8 \mathrm{H}^{+} \rightarrow \mathrm{Mn}^{2+}+5 \mathrm{Fe}^{3+}+4 \mathrm{H}_{2} \mathrm{O}_{(1)}
$$

a. How many moles of $\mathrm{MnO}_{4}^{-1}$ were added to the solution?
b. How many moles of $\mathrm{Fe}^{+2}$ were in the sample?
c. How many grams of iron were in the sample?
d. If the sample had a mass of 0.8890 g , what is the percentage of iron in the sample?
7. The concentration of hydrogen peroxide in a solution is determined by titrating a 10.0 mL sample of the solution with permanganate ion according to the equation below:

$$
2 \mathrm{MnO}_{4}^{-}+5 \mathrm{H}_{2} \mathrm{O}_{2}+6 \mathrm{H}^{+} \longrightarrow 5 \mathrm{O}_{2}+2 \mathrm{Mn}^{2+}+8 \mathrm{H}_{2} \mathrm{O}
$$

a. If it takes 16.8 mL of $0.124 \mathrm{M} \mathrm{MnO}_{4}^{-1}$ solution to reach the equivalence point, what is the molarity of the hydrogen peroxide?
b. Draw a particle diagram representing the sample solution before titration.
c. Draw a particle diagram representing the sample solution after the equivalence point has been reached.
8. What is the molarity when 250 mL of a 3.0 M solution is diluted to one liter?
9. How many grams of glucose $\left(\mathrm{C}_{6} \mathrm{H}_{12} \mathrm{O}_{6}\right)$ must be used to make $500 . \mathrm{mL}$ of 0.500 M glucose solution? How would you make this solution?
10. The following reactions can be classified as two different types. Identify both types.
a. $\mathrm{Mg}(\mathrm{s})+\mathrm{Zn}\left(\mathrm{NO}_{3}\right)_{2}(\mathrm{aq}) \rightarrow \mathrm{Zn}(\mathrm{s})+\mathrm{Mg}\left(\mathrm{NO}_{3}\right)_{2}(\mathrm{aq})$
b. $\mathrm{AgNO}_{3}+\mathrm{NaCl} \rightarrow \mathrm{AgCl}+\mathrm{NaNO}_{3}$
c. $\mathrm{H}_{2} \mathrm{SO}_{4}+2 \mathrm{NaOH} \rightarrow 2 \mathrm{H}_{2} \mathrm{O}+\mathrm{Na}_{2} \mathrm{SO}_{4}$
d. $2 \mathrm{FeCl}_{3}+3 \mathrm{Zn} \rightarrow 2 \mathrm{Fe}+3 \mathrm{ZnCl}_{2}$
e. $\mathrm{Na}_{2} \mathrm{CO}_{3}+\mathrm{CaCl}_{2} \rightarrow \mathrm{CaCO}_{3}+2 \mathrm{NaCl}$
11. Predict the products, balance the equation, then classify the types of reactions (listing 2 types where possible):
a. Potassium sulfate and lead (II) nitrate
b. Magnesium hydroxide and hydrochloric acid
c. Zinc and hydrochloric acid
d. $\mathrm{C}_{5} \mathrm{H}_{12}$ combusts
e. Magnesium reacts with nitrogen
f. Acetic acid and sodium hydroxide
12. For the equation $\mathrm{NH}_{3}(\mathrm{aq})+\mathrm{H}_{2} \mathrm{O}(\mathrm{aq}) \rightarrow \mathrm{NH}_{4}{ }^{+}(\mathrm{aq})+\mathrm{OH}^{-}(\mathrm{aq})$
a. Why is this considered an acid-base reaction?
b. Identify the acid-base pairs. Label the acid, base, conjugate acid, and conjugate base.
13. For the equation that occurs in a Breathalyzer,

$$
3 \mathrm{C}_{2} \mathrm{H}_{5} \mathrm{OH}+2 \mathrm{Cr}_{2} \mathrm{O}_{7}^{2-}+16 \mathrm{H}^{+} \rightarrow 4 \mathrm{Cr}^{3+}+3 \mathrm{CH}_{3} \mathrm{COOH}+11 \mathrm{H}_{2} \mathrm{O}
$$

a. Why is this considered a redox reaction?
b. Assign each atom an oxidation number. (In acetic acid, one carbon has an oxidation number of +3 while the other is -3 ).
c. *Which element is oxidized? Reduced?
14. Balance the following redox reaction in acidic solution: $\mathrm{Ag}+\mathrm{NO}_{3}{ }^{-} \rightarrow \mathrm{Ag}^{+}+\mathrm{NO}$
15. Balance the following redox reaction in basic solution: $\mathrm{ClO}^{-}+\mathrm{Fe}(\mathrm{OH})_{3} \rightarrow \mathrm{Cl}^{-}+\mathrm{FeO}_{4}{ }^{2-}$

## AP Questions

1. 

$$
\mathrm{CH}_{3} \mathrm{CH}_{2} \mathrm{COOH}(a q)+\mathrm{H}_{2} \mathrm{O}(/) \rightleftarrows \mathrm{CH}_{3} \mathrm{CH}_{2} \mathrm{COO}^{-}(a q)+\mathrm{H}_{3} \mathrm{O}^{+}(a q)
$$

Propanoic acid, $\mathrm{CH}_{3} \mathrm{CH}_{2} \mathrm{COOH}$, is a carboxylic acid that reacts with water according to the equation above.
a. Identify a Brønsted-Lowry conjugate acid-base pair in the reaction. Clearly label which is the acid and which is the base.

A student is given the task of determining the concentration of a propanoic acid solution of unknown concentration. A 0.173 M NaOH solution is available to use as the titrant. The student uses a 25.00 mL volumetric pipet to deliver the propanoic acid solution to a clean, dry flask. After adding an appropriate indicator to the flask, the student titrates the solution with the 0.173 M NaOH , reaching the end point after 20.52 mL of the base solution has been added.
b. Calculate the molarity of the propanoic acid solution.
2. Answer the following questions that relate to chemical reactions.
(a) Iron(III) oxide can be reduced with carbon monoxide according to the following equation.

$$
\mathrm{Fe}_{2} \mathrm{O}_{3}(\mathrm{~s})+3 \mathrm{CO}(\mathrm{~g}) \rightarrow 2 \mathrm{Fe}(\mathrm{~s})+3 \mathrm{CO}_{2}(\mathrm{~g})
$$

A 16.2 L sample of $\mathrm{CO}(\mathrm{g})$ at 1.50 atm and $200 .{ }^{\circ} \mathrm{C}$ is combined with $15.39 \mathrm{~g} \mathrm{of} \mathrm{Fe}_{2} \mathrm{O}_{3}(\mathrm{~s})$.
(i) How many moles of $\mathrm{CO}(\mathrm{g})$ are available for the reaction?
(ii) What is the limiting reactant for the reaction? Justify your answer with calculations.
(iii) How many moles of $\mathrm{Fe}(\mathrm{s})$ are formed in the reaction?
(b) In a reaction vessel, 0.600 mol of $\mathrm{Ba}\left(\mathrm{NO}_{3}\right)_{2}(s)$ and 0.300 mol of $\mathrm{H}_{3} \mathrm{PO}_{4}(a q)$ are combined with deionized water to a final volume of 2.00 L . The reaction represented below occurs.

$$
3 \mathrm{Ba}\left(\mathrm{NO}_{3}\right)_{2}(a q)+2 \mathrm{H}_{3} \mathrm{PO}_{4}(a q) \rightarrow \mathrm{Ba}_{3}\left(\mathrm{PO}_{4}\right)_{2}(s)+6 \mathrm{HNO}_{3}(a q)
$$

*For (ii), this is something we'll cover in unit 8*
(i) Calculate the mass of $\mathrm{Ba}_{3}\left(\mathrm{PO}_{4}\right)_{2}$ (s) formed.
(ii) Calculate the pH of the resulting solution.
(iii) What is the concentration, in $\mathrm{mol} \mathrm{L}^{-1}$, of the nitrate ion, $\mathrm{NO}_{3}^{-}(a q)$, after the reaction reaches completion?
3. Answer the following questions about $\mathrm{BeC}_{2} \mathrm{O}_{4}(s)$ and its hydrate.
(a) Calculate the mass percent of carbon in the hydrated form of the solid that has the formula $\mathrm{BeC}_{2} \mathrm{O}_{4} \bullet 3 \mathrm{H}_{2} \mathrm{O}$
(b) When heated to $220{ }^{\circ} \mathrm{C}, \mathrm{BeC}_{2} \mathrm{O}_{4} \bullet 3 \mathrm{H}_{2} \mathrm{O}(s)$ dehydrates completely as represented below.

$$
\mathrm{BeC}_{2} \mathrm{O}_{4} \bullet 3 \mathrm{H}_{2} \mathrm{O}(\mathrm{~s}) \rightarrow \mathrm{BeC}_{2} \mathrm{O}_{4}(\mathrm{~s})+3 \mathrm{H}_{2} \mathrm{O}(\mathrm{~g})
$$

If 3.21 g of $\mathrm{BeC}_{2} \mathrm{O}_{4} \cdot 3 \mathrm{H}_{2} \mathrm{O}(s)$ is heated to $220 .{ }^{\circ} \mathrm{C}$, calculate
(i) the mass of $\mathrm{BeC}_{2} \mathrm{O}_{4}(s)$ formed, and,
(ii) the volume of the $\mathrm{H}_{2} \mathrm{O}(\mathrm{g})$ released, measured at $220{ }^{\circ} \mathrm{C}$ and 735 mm Hg .
(c) A 0.345 g sample of anhydrous $\mathrm{BeC}_{2} \mathrm{O}_{4}$, which contains an inert impurity, was dissolved in sufficient water to produce 100 mL of solution. A 20.0 mL portion of the solution was titrated with $\mathrm{KMnO}_{4}(a q)$.
The balanced equation for the reaction that occurred is as follows.

$$
16 \mathrm{H}^{-}(a q)+2 \mathrm{MnO}_{4}^{-}(a q)+5 \mathrm{C}_{2} \mathrm{O}_{4}^{2-}(a q) \rightarrow 2 \mathrm{Mn}^{2+}(a q)+10 \mathrm{CO}_{2}(\mathrm{~g})+8 \mathrm{H}_{2} \mathrm{O}(l) .
$$

The volume of $0.0150 \mathrm{M} \mathrm{KMnO}_{4}(a q)$ required to reach the equivalence point was 17.80 mL .
(i) Identify the reducing agent in the titration reaction.
(ii) For the titration at the equivalence point, calculate the number of moles of each of the following that reacted.

- $\mathrm{MnO}_{4}^{-}(a q)$
*For (i), identify the element that is reduced instead*
- $\mathrm{C}_{2} \mathrm{O}_{4}^{2-}(a q)$
(iii) Calculate the total number of moles of $\mathrm{C}_{2} \mathrm{O}_{4}{ }^{2-}(a q)$ that were present in the 100 mL of prepared solution.
(iv) Calculate the mass percent of $\mathrm{BeC}_{2} \mathrm{O}_{4}(s)$ in the impure 0.345 g sample.

