AP Chemistry Unit 3 Practice Sheet

***Reminders:**

1. Transition Metals make colorful compounds. Transition Metals are in Groups 3 – 12.
2. A precipitate is a solid that is formed in a solution (liquid).
3. Molarity = moles of solute/liter of soln.
4. Physical changes involve a change in a property but NO change in the composition or bonding. Chemical changes involve a change in the composition or bonding. Five common signs that a chemical change has taken place are change in color, formation of a gas, change in temperature, production of light, and formation of a precipitate.
5. Elements in the same group follow similar solubility rules.
6. Gas production: $H_2CO_{3(aq)} \rightarrow H_2O_{(l)} + CO_{2(g)}$ and $2H^+_{(aq)} + S^{2-}_{(aq)} \rightarrow H_2S_{(g)}$
7. Strong acids are HCl, HBr, HI, $HClO_4$, $HClO_3$, HNO_3, and H_2SO_4. Strong bases are LiOH, NaOH, KOH, RbOH, CsOH, $Ca(OH)_2$, $Sr(OH)_2$, and $Ba(OH)_2$. Strong acids and bases listed as aqueous fully dissociate for net ionic equations. Weak acids and bases listed as aqueous do not fully dissociate and function LIKE a solid in net ionic equations.
8. Oxidation-Reduction Rules: **O**xidation **I**s the **L**oss of e^- and **R**eduction **I**s the **G**ain of e^-. **OIL RIG**
    a. For elements, the oxidation # is 0. (Ex: Na = 0 and F_2 = 0)
    b. For ions, the oxidation # is the charge. (Ex: Mg_2N_3; Mg = +2, N = -3)
    c. Hydrogen is +1 with nonmetals and -1 with metals (Ex: HCl; H = +1 and LiH; H = -1)
    d. Oxygen is -2 (except in peroxide, O_2^{2-}, where it is -1). (Ex: CO_2; O = -2 and H_2O_2; O = -1)
    e. Fluorine is always -1. Other halogens are -1 except when combined with oxygen. (Ex: NaF; F = -1 and HBr; Br = -1 and ClO^-; Cl = +1)
    f. The sum of the oxidation # of all atoms in a neutral compound is zero. The sum of the oxidation # in a polyatomic ion equals the charge of the ion. (Ex: P_2O_5; O = -2, so P = +5 and CO_3^{2-}; O = -2, so C = +4)

9. Spectator ions are the ones that are aqueous on both sides of the equation, and they are removed when writing the net ionic equation.
10. Stoichiometry: 1 mole = 6.02×10^{23} r.p. = molar mass = 22.4 L (STP)
11. The 7 diatomic elements are H_2, N_2, O_2, F_2, Cl_2, Br_2, and I_2.
12. Use solubility rules to determine if a precipitate forms. Soluble = aqueous (no precipitate). Insoluble = solid (precipitate)

***Sample Problems:**

1. A student investigates various properties of silver compounds in the lab. First, the student carries out the following procedure to determine the concentration of $Ag^+_{(aq)}$ in a solution of $AgNO_{3(aq)}$. The student adds an excess of 2.0 M $HCl_{(aq)}$ to 300.0 mL of the solution, causing the $AgCl_{(s)}$ to precipitate. The precipitate is separated form the solution by filtering it through a pre-weighed piece of filter paper. The precipitate and filter paper are rinsed with distilled water, dried, and weighed. The data from the experiment are given in the table below.

Initial mass of filter paper	0.650 g
Mass of filter paper + $AgCl_{(s)}$ precipitate after drying	0.793 g

   a. Calculate the number of moles of $AgCl_{(s)}$ that precipitated. (The molar mass of AgCl is 143 g/mol.)
   b. Assuming that all of the $Ag^+_{(aq)}$ ions precipitated, calculate the original molarity of $Ag^+_{(aq)}$ in the solution before $HCl_{(aq)}$ was added.
2. Write a balanced net-ionic equation for the reaction below.

$$Ni_{(s)} + 2AgNO_{3(aq)} \rightarrow 2Ag_{(s)} + Ni(NO_3)_{2(aq)}$$

3. Calculate the volume of 0.1000 M $CuSO_{4(aq)}$ needed to make 50.00 mL of 0.0500 M $CuSO_{4(aq)}$.
4. A sample of a compound contains 3.21 g of sulfur and 11.4 g of fluorine. Which of the following represents the empirical formula of the compound?
   a. SF_2 b. SF_3 c. SF_4 d. SF_5 e. SF_6
5. What is the empirical formula of an oxide of chromium that is 48 percent oxygen by mass?

a. CrO b. CrO_2 c. CrO_3 d. Cr_2O e. Cr_2O_3

6. Shown below is a hypothetical mass spectrum for a sample of Lv containing 10 atoms. Using the information in the graph, determine the average atomic mass of Lv in the sample to **four significant figures**.

7. The mass spectrum of element X is presented in the diagram below. Based on the spectrum, which of the following can be concluded about element X?

   a. X is a transition metal, and each peak represents an oxidation state of the metal.
   b. X contains five electron sublevels.
   c. The atomic mass of X is 90.
   d. The atomic mass of X is between 90 and 92.

8. The three stable isotopes of Mg are Mg-24, Mg-25, and Mg-26. A rock sample from another planet has a different distribution of the three stable isotopes than what is found on Earth. A partial mass spectrum for Mg in the rock sample is shown below.

   a. Draw a line of the graph to show the mass of the missing isotope and its percent abundance.
   b. Use the completed mass spectrum to calculate the average atomic mass of Mg on the other planet.

9. The elements I and Te have similar average atomic masses. A sample that was believed to be a mixture of I and Te was run through a mass spectrometer, resulting in the data below. All of the following statements are true. Which one would be the best basis for concluding that the sample was pure Te?
   a. Te forms ions with a -2 change, whereas I forms ions with a -1 charge.
   b. Te is more abundant than I in the universe.
   c. I consists of only one naturally occurring isotope with 74 neutrons, whereas Te has more than one isotope.
   d. I has a higher first ionization energy than Te does.
10. What number of moles of O_2 is needed to produce 14.2 grams of P_4O_{10} from P? (Molecular weight P_4O_{10} = 284)
   a. 0.0500 mole
   b. 0.0625 mole
   c. 0.125 mole
   d. 0.250 mole
   e. 0.500 mole
11. The average atomic mass of naturally occurring neon is 20.18 amu. There are two common isotopes of naturally occurring neon as indicated in the table below.

Isotope	Mass (amu)
Ne-20	19.99
Ne-22	21.99

Using the information above, calculate the percent abundance of each isotope.

12. Which of the following numerical expressions gives the number of particles in 2.0 g of Ne?
    a. (6.02 x 10^{23} particles/mol) ÷ (2.0 g)
    b. (6.02 x 10^{23} particles/mol) ÷ (20.18 g/mol)
    c. (2.0 g x 6.02 x 10^{23} particles/mol) ÷ (20.18 g/mol)
    d. (20.18 g/mol x 6.02 x 10^{23} particles/mol) ÷ (2.0 g)
13. When a 3.22 g sample of an unknown hydrate of sodium sulfate, $Na_2SO_4 \cdot xH_2O_{(s)}$, is heated, H_2O (molar mass 18 g) is driven off. The mass of the anhydrous $Na_2SO_{4(s)}$ (molar mass 142 g) that remains is 1.42 g. The value of the x in the hydrate is
    a. 0.013 b. 1.8 c. 6.0 d. 10. e. 20.
14. The enlarged view of the gas-collecting tube at the end of trial 3 is shown in the diagram below.

    What should the student record as the volume, in mL, of $H_{2(g)}$ collected in trial 3?
15. The color of a salt of silver, $AgI_{(s)}$, is yellow. A student adds a solution of NaI to a test tube containing a small amount of solid, cream-colored AgBr. After stirring the contents of the test tube, the student observes that the solid in the test tube changes color from cream to yellow. Write the balanced net ionic equation for the reaction that occurred in the test tube.
16. Which of the following equations best represents the species that react and the species that are produced when $CaCO_{3(s)}$ and $HCl_{(aq)}$ are combined?
    a. $2H^+_{(aq)} + CaCO_{3(s)} \rightarrow Ca^{2+}_{(aq)} + CO_3^{2-}{}_{(aq)} + H_{2(g)}$
    b. $2H^+_{(aq)} + CaCO_{3(s)} \rightarrow Ca^{2+}_{(aq)} + H_2O_{(l)} + CO_{2(g)}$
    c. $2H^+_{(aq)} + CaCO_{3(s)} \rightarrow Ca^{2+}_{(aq)} + 2OH^-_{(aq)} + CO_{(g)}$
    d. $2HCl_{(aq)} + CaCO_{3(s)} \rightarrow Ca^{2+}_{(aq)} + H_2O_{(l)} + CO_{2(g)} + 2Cl^-_{(aq)}$

17. Equimolar samples of $CH_3OH_{(l)}$ (boiling point = 338 K)and $C_2H_5OH_{(l)}$ (boiling point = 351 K) are placed in separate, previously evacuated, rigid 2.0 L vessels. Each vessel is attached to a pressure gauge, and the temperatures are kept at 300 K. In both vessels, liquid is observed to remain present at the bottom of the container at all times. The change in pressure inside the vessel containing $CH_3OH_{(l)}$ increased for the first 30 seconds and then remained the same. Which of the following best describes the change that take place immediately after the $CH_3OH_{(l)}$ is introduced into the previously evacuated vessel?

a. A chemical change takes place because covalent bonds are broken.
b. A chemical change takes place because intermolecular attractions are overcome.
c. A physical change takes place because covalent bonds are broken.
d. A physical change takes place because intermolecular attractions are overcome.

18. A particulate representation of the reactants is shown below in the box on the left. In the box below on the right, draw a particulate representation of all the molecules that would be produced from these four reactant molecules.

$$2H_2O_{2(l)} \rightarrow 2H_2O_{(l)} + O_{2(g)}$$

19. While investigating chemical and physical properties of metallic element E, a student conducts an experiment by combining $E_{(s)}$ and $HBr_{(aq)}$, which react according to the following equation.

$$E_{(s)} + 2HBr_{(aq)} \rightarrow EBr_{2(aq)} + H_{2(g)}$$

a. Write the net-ionic equation for the reaction.
b. In the reaction, is $E_{(s)}$ oxidized or reduced? Justify your answer in terms of oxidation numbers.

20. A student had two dilute, colorless solutions, $HCl_{(aq)}$ and $NaOH_{(aq)}$, which were at the same temperature. The student combined the solutions, and the reaction represented below occurred. Which of the following results would be evidence that a chemical reaction took place?

$$HCl_{(aq)} + NaOH_{(aq)} \rightarrow NaCl_{(aq)} + H_2O_{(l)}$$

a. The resulting solution is colorless.
b. The temperature of the reaction mixture increases.
c. The total volume of the mixture is approximately equal to the sum of the initial volumes.
d. The resulting solution conducts electricity.

21. A 20 mL sample of 0.50 M $HC_2H_3O_{2(aq)}$ is titrated with 0.50 M $NaOH_{(aq)}$. Which of the following best represents the species that react and the species produced in the reaction?

a. $H^+_{(aq)} + OH^-_{(aq)} \rightarrow H_2O_{(l)}$
b. $H^+_{(aq)} + C_2H_3O_2^-{}_{(aq)} + Na^+_{(aq)} + OH^-_{(aq)} \rightarrow H_2O_{(l)} + NaC_2H_3O_{2(aq)}$
c. $HC_2H_3O_{2(aq)} + OH^-_{(aq)} \rightarrow C_2H_3O_2^-{}_{(aq)} + H_2O_{(l)}$
d. $HC_2H_3O_{2(aq)} + NaOH_{(aq)} \rightarrow H_2O_{(l)} + Na^+_{(aq)} + C_2H_3O_2^-{}_{(aq)}$

22. A particulate representation from before and after a reaction is shown below. The contents of the container before the reaction are represented in the box on the left, and the contents of the container after the reaction are shown in the box on the right.

A student claims that N_2 is the limiting reactant. Do you agree or disagree? Justify your answer.

23. Which of the following particulate diagrams best shows the formation of water vapor from hydrogen gas and oxygen gas in a rigid container at 125°C?

24. A mixture of $H_{2(g)}$ and $O_{2(g)}$ is placed in a container as represented below. The $H_{2(g)}$ and $O_{2(g)}$ react to form $H_2O_{(l)}$. Which of the following best represents the container after the reaction has gone to completion?

25. A 20.0 milliliter sample of 0.200 molar K_2CO_3 solution is added to 30.0 milliliters of 0.400 molar $Ba(NO_3)_2$ solution. Barium carbonate precipitates. The concentration of barium ion, Ba^{2+}, in solution after the reaction is

a. 0.150 M b. 0.160 M c. 0.200 M d. 0.240 M e. 0.267 M

26. Equimolar amounts of $Cl_{2(g)}$ and $O_{2(g)}$ are injected into an evacuated, rigid container, where they react according to the equation below.

$$2Cl_{2(g)} + O_{2(g)} \rightleftharpoons 2Cl_2O_{(g)} \qquad \Delta H^\circ_{rxn} = +161 \text{ kJ/mol}_{rxn}$$

a. If 6.4 g of $O_{2(g)}$ is consumed in the reaction with excess $Cl_{2(g)}$, how many moles of $Cl_2O_{(g)}$ are produced?

b. Which element is oxidized in this reaction? Justify your answer in terms of oxidation numbers.

27. $HCl_{(g)}$, can be prepared by the reaction of concentrated $H_2SO_{4(aq)}$, with $NaCl_{(s)}$, as represented by the following equation.

$$H_2SO_{4(aq)} + 2NaCl_{(s)} \rightarrow 2HCl_{(g)} + Na_2SO_{4(aq)}$$

A student claims that the reaction is a redox reaction. Is the student correct? Justify your answer.

28. If 0.40 mol of $H_2$and 0.15 mol of O_2 were to react as completely as possible to produce H_2O, what mass of reactant would remain?

a. 0.20 g of H_2 c. 3.2 g of O_2 e. 4.4 g of O_2

b. 0.40 g of H_2 d. 4.0 g of O_2

29. What is the percentage yield of O_2 if 12.3 g of $KClO_3$ (molar mass 123 g) is decomposed to produce 3.2 g of O_2 (molar mass 32 g) according to the equation below?

$$2KClO_{3(s)} \rightarrow 2KCl_{(s)} + 3O_{2(g)}$$

a. 100% b. 67% c. 50% d. 33% e. 10%

30. Which of the following identifies the element(s) being oxidized and reduced in the reaction below?

$$2H_2O_{2(aq)} \rightarrow 2H_2O_{(l)} + O_{2(g)} \quad DH^\circ = -196\ kJ/mol_{rxn}$$

a. Hydrogen is oxidized and oxygen is reduced.

b. Oxygen is oxidized and hydrogen is reduced.

c. Oxygen is both oxidized and reduced.

d. No elements are oxidized or reduced; the reaction is not a redox reaction.

31. Which element is being oxidized in the following reaction, and what is the element's change in oxidation number?

$$5H_2O_{2(aq)} + 2MnO_4^-{}_{(aq)} + 6H^+{}_{(aq)} \rightarrow 2Mn^{2+}{}_{(aq)} + 8H_2O_{(l)} + 5O_{2(g)}$$

a. Oxygen, which changes from -1 to 0

b. Oxygen, which changes from 0 to -2

c. Manganese, which changes from -1 to +2

d. Manganese, which changes from +7 to +2

32. Which of the following represents a process in which a species is reduced?

a. $Ca_{(s)} \rightarrow Ca^{2+}{}_{(aq)}$ c. $Fe^{2+}{}_{(aq)} \rightarrow Fe^{3+}{}_{(aq)}$ e. $SO_3^{2-}{}_{(aq)} \rightarrow SO_4^{2-}{}_{(aq)}$

b. $Hg_{(l)} \rightarrow Hg_2^{2+}{}_{(aq)}$ d. $NO_3^-{}_{(aq)} \rightarrow NO_{(g)}$

33. Which of the following compounds at 25°C and 1.0atm contains an element in a +1 oxidation state?

a. CO_2 b. PbO_2 c. CaO d. N_2O_5 e. Cu_2O

34. An oxidation-reduction reaction that is also a synthesis reaction
    a. $2Mg_{(s)} + O_{2(g)} \rightarrow 2MgO_{(s)}$
    b. $Pb^{2+}_{(aq)} + CrO_4^{2-}{}_{(aq)} \rightarrow PbCrO_{4(s)}$
    c. $SO_{3(g)} + 2H_2O_{(l)} \rightarrow H_3O^+_{(aq)} + HSO_4^-{}_{(aq)}$
    d. $2H_2O_{(g)} \rightarrow 2H_{2(g)} + O_{2(g)}$
    e. $Ag^+_{(aq)} + 2NH_{3(aq)} \rightarrow [Ag(NH_3)_2]^+_{(aq)}$
35. Draw three water molecules surrounding an Al^{3+} ion and three water molecules surrounding a NO_3^- ion.
36. Predict the products for the following reactions. Balance the equations and list the type of reaction.
    a. $KI + Br_2 \rightarrow$
    b. $H_2 + O_2 \rightarrow$
    c. $AlCl_3 \rightarrow$
    d. $C_2H_6 + O_2 \rightarrow$
    e. $NaCN + Li_3PO_4 \rightarrow$
37. Calculate the molarity of Cl^- ions in a solution when 3.0 L of 4.0 M NaCl and 4.0 L of 2.0 M $CaCl_2$ are mixed.
38. What is the mass of oxygen in a 25.0 g sample of TiO_2?
39. How many milliliters of 3.4 M H_2SO_4 will be required to neutralize 2100 mL of 2.0 M KOH?
40. After combustion with excess oxygen, a 12.501 g of a petroleum compound produced 38.196 g of carbon dioxide and 18.752 of water. A previous analysis determined that the compound does not contain oxygen. Establish the empirical formula of the compound.