Name ____________________ **AP Chemistry** **___/___/___**

Chapter 3 Collected AP Exam Free Response Questions 1980 - 2010

1980 – #3b

(b) Elemental analysis of this unknown compound yields the following percentages by weight: H = 9.74%; C = 38.70%; O = 51.56%. Determine the empirical formula of the compound.

1981 – #6a

Assume that you have two different gases that you know are not cyclic (i.e., not ring) compounds, each with the following elementary analysis: C, 85.7 percent; H, 14.3 percent. Each gas has a molecular weight of 56 ± 1.
(a) What is the molecular formula for the compounds?

1982 - #3

Water is added to 4.267 grams of UF_6. The only products are 3.730 grams of a solid containing only uranium, oxygen, and fluorine and 0.970 gram of a gas. The gas is 95.0 percent fluorine, and the remainder is hydrogen.
(a) From these data, determine the empirical formula of the gas.
(b) What fraction of the fluorine of the original compound is in the solid and what fraction in the gas after the reaction?
(c) What is the formula of the solid product?
(d) Write a balanced equation for the reaction between UF_6 and H_2O. Assume that the empirical formula of the gas is the true formula.

1985 - #3a

A hydrocarbon is found to contain 93.46 percent carbon and 6.54 percent hydrogen. Calculate the empirical formula of the unknown hydrocarbon.

1986 - #3b - d

Two volatile compounds Y and Z each contain element Q. The percent by weight of element Q in each compound was determined. Some of the data obtained are given below.

Compound	Percent by Weight of Element Q	Molecular Weight
Y	73.0%	104.
Z	59.3%	64.0

(b) Determine the mass of element Q contained in 1.00 mole of each of the compounds.
(c) Calculate the most probable value of the atomic weight of element Q.
(d) Compound Z contains carbon, hydrogen, and element Q. When 1.00 gram of compound Z is oxidized and all of the carbon and hydrogen are converted to oxides, 1.37 grams of CO_2 and 0.281 gram of water are produced. Determine the most probable molecular formula of compound Z.

1991 - #2a & b

The molecular formula of a hydrocarbon is to be determined by analyzing its combustion products and investigating its colligative properties.
(a) The hydrocarbon burns completely, producing 7.2 grams of water and 7.2 liters of CO_2 at standard conditions.
(b) Calculate the mass in grams of O_2 required for the complete combustion of the sample of the hydrocarbon described in (a).

1993 - #2a

Elemental analysis of an unknown pure substance indicates that the percent composition by mass is as follows:

Carbon - 49.02%
Hydrogen - 2.743%
Chlorine - 48.23%

(a) Determine the empirical formula of the unknown substance.

1998 - #2a
An unknown compound contains only the three elements C,H, and O. A pure sample of the compound is analyzed and found to be 65.60 percent C and 9.44 percent H by mass.
(a) Determine the empirical formula of the compound.

2000 - #3
Answer the following questions about $BeC_2O_4(s)$ and its hydrate.
(a) Calculate the mass percent of carbon in the hydrated form of the solid that has the formula: $BeC_2O_4 * 3H_2O$
(b) When heated to 220.ºC, $BeC_2O_4 * 3H_2O(s)$ dehydrates completely as represented below.

$$BeC_2O_4 * 3H_2O(s) \rightarrow BeC_2O_4(s) + 3H_2O(g)$$

If 3.21 g of $BeC_2O_4 * 3H_2O(s)$ is heated to 220.ºC, calculate
(i) the mass of $BeC_2O_4(s)$ formed, and,
(ii) the volume of the $H_2O(g)$ released, measured at STP.
(c) A 0.345 g sample of anhydrous BeC_2O_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 $KMnO_4(aq)$. The balanced equation for the reaction that occurred is as follows.

$$16\ H^+(aq) + 2\ MnO_4^-(aq) + 5\ C_2O_4^{2-}(aq) \rightarrow 2\ Mn^{2+}(aq) + 10\ CO_2(g) + 8\ H_2O(l).$$

The volume of 0.0150 *M* $KMnO_4(aq)$ 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.
(a.) $MnO_4^-(aq)$
(b.) $C_2O_4^{2-}(aq)$
(iii) Calculate the total number of moles of $C_2O_4^{2-}(aq)$ that were present in the 100. mL of prepared solution.
(iv) Calculate the mass percent of $BeC_2O_4(s)$ in the impure 0.345 g sample.

2000 - #7a
Answer the following questions about the element selenium, Se (atomic number 34).
(a) Samples of natural selenium contain six stable isotopes. In terms of atomic structure, explain what these isotopes have in common, and how they differ.

2001 - #3a
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.

2003B - #3a
In an experiment, a sample of an unknown, pure gaseous hydrocarbon was analyzed. Results showed that the sample contained 6.000 g of carbon and 1.344 g of hydrogen.
(a) Determine the empirical formula of the hydrocarbon.

2004 - #2a, b & c

$$2\ Fe(s) + \frac{3}{2}\ O_2(g) \rightarrow Fe_2O_3(s)$$

Iron reacts with oxygen to produce iron(III) oxide, as represented by the equation above. A 75.0 g sample of Fe(*s*) is mixed with 11.5 L of $O_2(g)$ at STP.
(a) Calculate the number of moles of each of the following before the reaction begins.
(i) Fe(*s*)
(ii) $O_2(g)$
(b) Identify the limiting reactant when the mixture is heated to produce $Fe_2O_3(s)$. Support your answer with calculations.
(c) Calculate the number of moles of $Fe_2O_3(s)$ produced when the reaction proceeds to completion.

2005 - #2
Answer the following questions about a pure compound that contains only carbon, hydrogen, and oxygen.
(a) A 0.7549 g sample of the compound burns in $O_2(g)$ to produce 1.9061 g of $CO_2(g)$ and0.3370 g of $H_2O(g)$.
(i) Calculate the individual masses of C, H, and O in the 0.7549 g sample.
(ii) Determine the empirical formula for the compound.

2005 - #7d
A certain element has two stable isotopes. The mass of one of the isotopes is 62.93 amu and the mass of the other isotope is 64.93 amu.
(i) Identify the element. Justify your answer.
(ii) Which isotope is more abundant? Justify your answer.

2006 - #3a
Answer the following questions that relate to the analysis of chemical compounds.
A compound containing the elements C, H, N, and O is analyzed. When a 1.2359 g sample is burned in excess oxygen, 2.241 g of $CO_2(g)$ is formed. The combustion analysis also showed that the sample contained 0.0648 g of H.
(i) Determine the mass, in grams, of C in the 1.2359 g sample of the compound.
(ii) When the compound is analyzed for N content only, the mass percent of N is found to be 28.84 percent. Determine the mass, in grams, of N in the original 1.2359 g sample of the compound.
(iii) Determine the mass, in grams, of O in the original 1.2359 g sample of the compound.
(iv) Determine the empirical formula of the compound.
(v) The molecular mass of the compound is 194.2 g/mol. Determine the molecular formula of the compound.

2006 - #8
Suppose that a stable element, atomic number 119, symbol Q, is discovered.
(a) Would Q be a metal or a non-metal? Explain/justify your answer.
(b) What would be the most likely charge of the Q ion in stable ionic compounds?
(c) An isotope of Q has a mass number of 291. How many neutrons does it have?
(d) Write the formula for the compound formed between Q and the carbonate ion.
(e) Using your solubility rules, would the Q carbonate be soluble in water? Explain your reasoning.

2007B - #2a
Answer the following problems about gases.
(a) 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.
(i) Using the information above, calculate the percent abundance of each isotope.
(ii) Calculate the number of Ne-22 atoms in a 12.55 g sample of naturally occurring neon.

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

2008 - #2
Answer the following questions relating to gravimetric analysis.
In the first of two experiments, a student is assigned the task of determining the number of moles of water in one mole of $MgCl_2 * nH_2O$. The student collects the data shown in the following table.

Mass of empty container	22.347 g
Initial mass of sample and container	25.825 g
Mass of sample and container after first heating	23.982 g
Mass of sample and container after second heating	23.976 g
Mass of sample and container after third heating	23.977 g

(a) Explain why the student can correctly conclude that the hydrate was heated a sufficient number of times in the experiment.
(b) Use the data above to
(i) calculate the total number of moles of water lost when the sample was heated, and
(ii) determine the formula of the hydrated compound.

(c) A different student heats the hydrate in an uncovered crucible, and some of the solid spatters out of the crucible. This spattering will have what effect on the calculated mass of the water lost by the hydrate? Justify your answer.

In the second experiment, a student is given 2.94 g of a mixture containing anhydrous $MgCl_2$ and KNO_3. To determine the percentage by mass of $MgCl_2$ in the mixture, the student uses excess $AgNO_3(aq)$ to precipitate the chloride ion as $AgCl(s)$.
(d) Starting with the 2.94 g sample of the mixture dissolved in water, briefly describe the steps necessary to quantitatively determine the mass of the AgCl precipitate.
(e) The student determines the mass of the AgCl precipitate to be 5.48 g. On the basis of this information, calculate each of the following.

(i) The number of moles of $MgCl_2$ in the original mixture
(ii) The percent by mass of $MgCl_2$ in the original mixture

2009 - #3

$$CH_4(g) + 2\ Cl_2(g) \rightarrow CH_2Cl_2(g) + 2\ HCl(g)$$

Methane gas reacts with chlorine gas to form dichloromethane and hydrogen chloride, as represented by the equation above.
(a) A 25.0 g sample of methane gas is placed in a reaction vessel containing 2.58 mol of $Cl_2(g)$.

(i) Identify the limiting reactant when the methane and chlorine gases are combined. Justify your answer with a calculation.
(ii) Calculate the total number of moles of $CH_2Cl_2(g)$ in the container after the limiting reactant has been totally consumed.