1982

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% 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.

1986

Three volatile compounds X, 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
X	64.8%	?
Y	73.0%	104.
Z	59.3%	64.0

(a) The vapor density of compound X at 27°C and 750. mm Hg was determined to be 3.53 grams per liter. Calculate the molecular weight of compound X.
(b) Determine the mass of element Q contained in 1.00 mole of each of the three 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

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. What is the empirical formula of the hydrocarbon?
(b) Calculate the mass in grams of O_2 required for the complete combustion of the sample of the hydrocarbon described in (a).
(c) The hydrocarbon dissolves readily in $CHCl_3$. The freezing point of a solution prepared by mixing 100. grams of $CHCl_3$ and 0.600 gram of the hydrocarbon is −64.0°C. The molal freezing-point depression constant of $CHCl_3$ is 4.68°C/molal and its normal freezing point is −63.5°C. Calculate the molecular weight of the hydrocarbon.
(d) What is the molecular formula of the hydrocarbon?

1993

I. $2\ Mn^{2+} + 4\ OH^- + O_2(g) \rightarrow 2\ MnO_2(s) + 2\ H_2O$

II. $MnO_2(s) + 2\ I^- + 4\ H^+ \rightarrow Mn^{2+} + I_2(aq) + 2\ H_2O$

III. $2\ S_2O_3^{2-} + I_2(aq) \rightarrow S_4O_6^{2-} + 2\ I^-$

The amount of oxygen, O_2, dissolved in water can be determined by titration. First, $MnSO_4$ and NaOH are added to a sample of water to convert all of the dissolved O_2 to MnO_2, as shown in equation I above. Then H_2SO_4 and KI are added and the reaction represented by equation II proceeds. Finally, the I_2 that is formed is titrated with standard sodium thiosulfate, $Na_2S_2O_3$, according to equation III.

(a) According to the equation above, how many moles of $S_2O_3^{2-}$ are required for analyzing 1.00 mole of O_2 dissolved in water?

(b) A student found that a 50.0-milliliter sample of water required 4.86 milliliters of 0.0112-molar $Na_2S_2O_3$ to reach the equivalence point. Calculate the number of moles of O_2 dissolved in this sample.

(c) How would the results in (b) be affected if some I_2 were lost before the $S_2O_3^{2-}$ was added? Explain.

(d) What volume of dry O_2 measured at 25°C and 1.00 atmosphere of pressure would have to be dissolved in 1.00 liter of pure water in order to prepare a solution of the same concentration as that obtained in (b)? (cont.)

(e) Name an appropriate indicator for the reaction shown in equation III and describe the change you would observe at the end point of the titration.

1998

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.

(b) A solution of 1.570 grams of the compound in 16.08 grams of camphor is observed to freeze at a temperature 15.2 Celsius degrees below the normal freezing point of pure camphor. Determine the molar mass and apparent molecular formula of the compound. (The molal freezing-point depression constant, K_f, for camphor is 40.0 $kg \cdot K \cdot mol^{-1}$.)

(c) When 1.570 grams of the compound is vaporized at 300 °C and 1.00 atmosphere, the gas occupies a volume of 577 milliliters. What is the molar mass of the compound based on this result?

(d) Briefly describe what occurs in solution that accounts for the difference between the results obtained in parts (b) and (c).

2000

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 $BeC_2O_4 \bullet 3\ H_2O$

(b) When heated to 220.°C, $BeC_2O_4 \bullet 3\ H_2O(s)$ dehydrates completely as represented below.

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

If 3.21 g of $BeC_2O_4 \bullet 3\ H_2O(s)$ is heated to 220.°C, calculate

(i) the mass of $BeC_2O_4(s)$ formed, and,

(ii) the volume of the $H_2O(g)$ released, measured at 220.°C and 735 mm Hg.

(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.

- $MnO_4^-(aq)$
- $C_2O_4^{2-}(aq)$

(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.

2003B

Answer the following questions that relate to chemical reactions.

(a) Iron(III) oxide can be reduced with carbon monoxide according to the following equation.

$$Fe_2O_3(s) + 3\ CO(g) \rightarrow 2\ Fe(s) + 3\ CO_2(g)$$

A 16.2 L sample of $CO(g)$ at 1.50 atm and 200.°C is combined with 15.39 g of $Fe_2O_3(s)$.

(i) How many moles of CO(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 Fe(s) are formed in the reaction?

(b) In a reaction vessel, 0.600 mol of $Ba(NO_3)_2(s)$ and 0.300 mol of $H_3PO_4(aq)$ are combined with deionized water to a final volume of 2.00 L. The reaction represented below occurs.

$$3\ Ba(NO_3)_2(aq) + 2\ H_3PO_4(aq) \rightarrow Ba_3(PO_4)_2(s) + 6\ HNO_3(aq)$$

(i) Calculate the mass of $Ba_3(PO_4)_2(s)$ formed.

(ii) Calculate the pH of the resulting solution.

(iii) What is the concentration, in mol L^{-1}, of the nitrate ion, $NO_3^-(aq)$, after the reaction reaches completion?