

**1982**

Water is added to 4.267 grams of  $\text{UF}_6$ . 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.

- From these data, determine the empirical formula of the gas.
- What fraction of the fluorine of the original compound is in the solid and what fraction in the gas after the reaction?
- What is the formula of the solid product?
- Write a balanced equation for the reaction between  $\text{UF}_6$  and  $\text{H}_2\text{O}$ . 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.

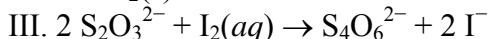
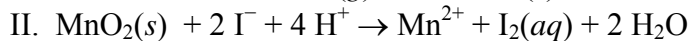
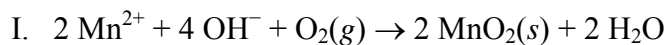
Compound	Percent by weight of Element Q	Molecular Weight
X	64.8%	?
Y	73.0%	104.
Z	59.3%	64.0

- The vapor density of compound X at  $27^\circ\text{C}$  and 750. mm Hg was determined to be 3.53 grams per liter. Calculate the molecular weight of compound X.
- Determine the mass of element Q contained in 1.00 mole of each of the three compounds.
- Calculate the most probable value of the atomic weight of element Q.
- 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  $\text{CO}_2$  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.

- The hydrocarbon burns completely, producing 7.2 grams of water and 7.2 liters of  $\text{CO}_2$  at standard conditions. What is the empirical formula of the hydrocarbon?
- Calculate the mass in grams of  $\text{O}_2$  required for the complete combustion of the sample of the hydrocarbon described in (a).
- The hydrocarbon dissolves readily in  $\text{CHCl}_3$ . The freezing point of a solution prepared by mixing 100. grams of  $\text{CHCl}_3$  and 0.600 gram of the hydrocarbon is  $-64.0^\circ\text{C}$ . The molal freezing-point depression constant of  $\text{CHCl}_3$  is  $4.68^\circ\text{C/molal}$  and its normal freezing point is  $-63.5^\circ\text{C}$ . Calculate the molecular weight of the hydrocarbon.
- What is the molecular formula of the hydrocarbon?

**1993**

The amount of oxygen,  $\text{O}_2$ , dissolved in water can be determined by titration. First,  $\text{MnSO}_4$  and  $\text{NaOH}$  are added to a sample of water to convert all of the dissolved  $\text{O}_2$  to  $\text{MnO}_2$ , as shown in equation I above. Then  $\text{H}_2\text{SO}_4$  and  $\text{KI}$  are added and the reaction represented by equation II proceeds. Finally, the  $\text{I}_2$  that is formed is titrated with standard sodium thiosulfate,  $\text{Na}_2\text{S}_2\text{O}_3$ , according to equation III.

- According to the equation above, how many moles of  $\text{S}_2\text{O}_3^{2-}$  are required for analyzing 1.00 mole of  $\text{O}_2$  dissolved in water?
- A student found that a 50.0-milliliter sample of water required 4.86 milliliters of 0.0112-molar  $\text{Na}_2\text{S}_2\text{O}_3$  to reach the equivalence point. Calculate the number of moles of  $\text{O}_2$  dissolved in this sample.
- How would the results in (b) be affected if some  $\text{I}_2$  were lost before the  $\text{S}_2\text{O}_3^{2-}$  was added? Explain.
- What volume of dry  $\text{O}_2$  measured at  $25^\circ\text{C}$  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.)
- 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**

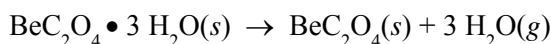
An unknown compound contains only the three elements C, H, and O. A pure sample of the compound is analyzed and found to be 65.60 percent C and 9.44 percent H by mass.

- Determine the empirical formula of the compound.
- 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  $40.0 \text{ kg}\cdot\text{K}\cdot\text{mol}^{-1}$ .)
- When 1.570 grams of the compound is vaporized at  $300^\circ\text{C}$  and 1.00 atmosphere, the gas occupies a volume of 577 milliliters. What is the molar mass of the compound based on this result?
- 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  $\text{BeC}_2\text{O}_4(s)$  and its hydrate.

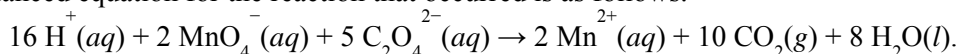
- (a) Calculate the mass percent of carbon in the hydrated form of the solid that has the formula  $\text{BeC}_2\text{O}_4 \cdot 3 \text{H}_2\text{O}$
- (b) When heated to  $220.^\circ\text{C}$ ,  $\text{BeC}_2\text{O}_4 \cdot 3 \text{H}_2\text{O}(s)$  dehydrates completely as represented below.



If 3.21 g of  $\text{BeC}_2\text{O}_4 \cdot 3 \text{H}_2\text{O}(s)$  is heated to  $220.^\circ\text{C}$ , calculate

- (i) the mass of  $\text{BeC}_2\text{O}_4(s)$  formed, and,
- (ii) the volume of the  $\text{H}_2\text{O}(g)$  released, measured at  $220.^\circ\text{C}$  and 735 mm Hg.
- (c) A 0.345 g sample of anhydrous  $\text{BeC}_2\text{O}_4$ , 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  $\text{KMnO}_4(aq)$ .

The balanced equation for the reaction that occurred is as follows.



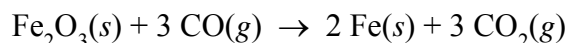
The volume of 0.0150 M  $\text{KMnO}_4(aq)$  required to reach the equivalence point was 17.80 mL.

- (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.
- $\text{MnO}_4^-(aq)$
  - $\text{C}_2\text{O}_4^{2-}(aq)$
- (iii) Calculate the total number of moles of  $\text{C}_2\text{O}_4^{2-}(aq)$  that were present in the 100. mL of prepared solution.
- (iv) Calculate the mass percent of  $\text{BeC}_2\text{O}_4(s)$  in the impure 0.345 g sample.

**2003B**

Answer the following questions that relate to chemical reactions.

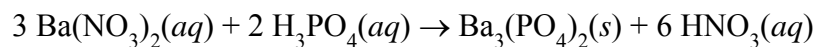
- (a) Iron(III) oxide can be reduced with carbon monoxide according to the following equation.



A 16.2 L sample of  $\text{CO}(g)$  at 1.50 atm and  $200.^\circ\text{C}$  is combined with 15.39 g of  $\text{Fe}_2\text{O}_3(s)$ .

- (i) How many moles of  $\text{CO}(g)$  are available for the reaction?
- (ii) What is the limiting reactant for the reaction? Justify your answer with calculations.
- (iii) How many moles of  $\text{Fe}(s)$  are formed in the reaction?

- (b) In a reaction vessel, 0.600 mol of  $\text{Ba}(\text{NO}_3)_2(s)$  and 0.300 mol of  $\text{H}_3\text{PO}_4(aq)$  are combined with deionized water to a final volume of 2.00 L. The reaction represented below occurs.



- (i) Calculate the mass of  $\text{Ba}_3(\text{PO}_4)_2(s)$  formed.
- (ii) Calculate the pH of the resulting solution.
- (iii) What is the concentration, in  $\text{mol L}^{-1}$ , of the nitrate ion,  $\text{NO}_3^-(aq)$ , after the reaction reaches completion?