There is much controversy concerning whether chrysotile should be banned outright from further use and whether or not existing asbestos insulation in buildings should be removed. Many experts feel that existing asbestos should be left in place unless it becomes damaged enough that there is a chance that its fibers will become airborne. Indeed, its removal can increase dramatically the levels of airborne asbestos in a building unless extraordinary precautions are taken.

One scientist has stated: "Removing asbestos is like waking up a pit bull terrier by poking a stick in its ear. We should let sleeping dogs lie."

Some environmentalists, however, feel that existing asbestos is a ticking time bomb—that it should be removed as soon as possible, as one can never predict when building insulation will be damaged.

Most of the initial concern about asbestos was related to **crocidolite,** *blue asbestos*, and **amosite,** *brown asbestos*. Evidence implicating crocidolite in causing cancer in humans was already well established several decades ago. It is a material with thin, straight, and relatively short fibers that more readily penetrate lung passages, and it is a more potent carcinogen than the white form. Crocidolite and amosite are mined in South Africa and Australia and were not used much in North America, but were used in many areas of Europe, including the United Kingdom.

More than 50 countries, including the European Union and Australia, have now banned *all* forms of asbestos. Some environmentalists and physicians worry that, although workers in developed countries wear masks and overalls and handle white asbestos properly to greatly minimize their exposure to it, these practices are not common yet in developing countries, in some of which it is still used in construction. Canada, among other countries, has resisted efforts by agencies of the United Nations to place chrysotile on the list of most hazardous substances, even though there is strong evidence that it causes cancer.

Review Questions 10–15 are based on the material in the preceding section.

Review Questions

1. Discuss the relationship between atmospheric particulates and haze.

2. What is *acid rain*? What two acids predominate in it? Explain why the predominant acid in acid rain differs in eastern and western North America.

3. What is the difference between *dry* and *wet deposition*?

4. Using chemical equations, explain how acid rain is neutralized by limestone that is present in soil. Describe ways in which humans have tried to neutralize acidified lakes.

5. Explain what is meant by the expression *critical load*.

6. Describe the effects of acid precipitation upon (a) dissolved levels of aluminum, (b) fish populations, and (c) trees.

7. Explain the difference between soot-and-sulfur-dioxide smog and photochemical smog in terms of the chemicals involved and the health effects they cause.

8. What is the difference in meaning between *absorbed* and *adsorbed* when they refer to particulates?

9. List four important reasons why coarse particles usually are of less danger to human health than are fine particles.

10. What are the main sources of formaldehyde in indoor air? What are its effects? What are the characteristics of *sick building syndrome*?

11. What is meant by the phrase *air toxic*? What are the main exposure routes to; and effects on health of, benzene? What chemicals can be used to replace benzene?

12. What are the main sources of nitrogen dioxide and of carbon monoxide in indoor air?

13. Why is smoke from cooking stoves an important health problem in many developing countries?

14. What are some of the constituents of tobacco smoke? What is meant by *tar* in the smoke?

15. What are the three forms of asbestos called? Why is asbestos of environmental concern?

Additional Problems

1. A sample of acidic precipitation is found to have a pH of 4.2. Upon analysis, it is found to have a total sulfur concentration of 0.000010 M. Calculate the concentration of nitric acid in the sample, and from the ratio of nitric to total acid, decide whether the air sample probably originated in eastern or in western North America.

2. If the pH of rainfall in upstate New York is found to be 4.0, and if the acidity is half due to nitric acid and half to the two hydrogen ions released by sulfuric acid, calculate the masses of the primary pollutants nitric oxide and sulfur dioxide that are required to acidify 1 liter of such rain.

3. The pH in a lake of size 3.0 km × 8.0 km and an average depth of 100 m is found to be 4.5. Calculate the mass of calcium carbonate that must be added to the lake water in order to raise its pH to 6.0.

4. The pH of a sample of rain is found to be 4.0. Calculate the percentage of HSO_4^- that is ionized in this sample, given that the acid dissociation constant for the second stage of ionization of H_2SO_4 is 1.2×10^{-2} mol L^{-1}. Repeat the calculation for a pH of 3.0. Is the trend shown by these calculations consistent with qualitative predictions made according to Le Châtelier's principle (which states that the position of equilibrium shifts so as to minimize the effect of any stress)? [*Hint:* Write the expression for the acid dissociation constant for the weak acid in terms of the concentrations of the reactants and products, and use the stoichiometry of the balanced equation to reduce the number of unknowns to one.]

5. Calculate the mass of fine particles inhaled by an adult each year, assuming that he/she inhales about 350 L of air per hour and that the average $PM_{2.5}$ index of this air is 10 μg m^{-3}. Assuming that each particle has a diameter of about 1 μm, and that the density of the particles is about 0.5 g mL^{-1}, calculate the total surface area of this annual load of particles. [*Hint:* The surface area of a spherical particle is equal to $4\pi r^2$, where r is its radius.]

6. The detection threshold of formaldehyde by humans is about 100 ppb. Would a typical human be able to detect formaldehyde at a concentration of 250 μg m^{-3} if the air temperature was 23°C and the pressure 1.00 atm?

7. What mass of formaldehyde gas must be released from building materials, carpets, etc. in order to produce a concentration of 0.50 ppm of the gas in a room having dimensions of 4 m × 5 m × 2 m?