Legal

For legislation: Both the Canadian and the American governments have passed legislation to reduce the discharge of sulfur and nitrogen oxides.

Against legislation: Passing laws will not solve the problem but only create difficulties for companies.

Ecological

For legislation: Sulfuric and sulfurous acids cause considerable damage when they fall to Earth in the form of acid deposition. Some environmental groups claimed that 14 000 Canadian lakes have been damaged by acid deposition. Acid deposition is also suspected as one of the causes of forest decline, particularly in forests at high altitudes and colder latitudes.

Against legislation: Some researchers report that acid deposition painted on seedlings in soil with inadequate nutrients actually has a beneficial effect on growth.

Scientific

For legislation: Empirical work indicates that the main causes of acid deposition in North America are sulfur dioxide, SO_2, and nitrogen oxides, NO_x. In the atmosphere, SO_2 reacts with water to produce sulfurous acid, $H_2SO_{3(aq)}$.

Against legislation: A 1988 U.S. federal task force maintained that damage to human health, crops, and forests by acid deposition is yet to be proven.

(c) and (d) (Answers will vary widely.)

PRACTICE

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Making Connections

1. Many medications require that the **hospital pharmacist** has a thorough knowledge of acids and base chemistry. For example, there are several antacid medications for treating peptic ulcer. Some pain relievers are weak acids that potentially can irritate the stomach of patients. The blood must be maintained within a very narrow pH range for the body to function properly. The pharmacist must be aware of the effects of medication on blood pH.

   The **quality-control chemist** must ensure that product specifications are maintained during the manufacturing process. For example, samples of shampoo are checked regularly during a manufacturing process to ensure that their pH falls within required limits. Many pain relievers are weak acids. The amount of acid in a given tablet can be determined by conducting an acid–base titration to ensure that the tablet contains the required amount.

   The **inorganic laboratory analyst** could design and test specific procedures for handling industrial chemicals and processes. For example, coiled steel is often "pickled" or cleaned using a dip tank of sulfuric acid. The strength of the acid bath needs to be monitored regularly to ensure it can clean the steel effectively. Once the acid has been depleted, the analyst must oversee the proper treatment and disposal of the sludge remaining in a dip tank.

   The **environmental chemist** monitors the testing of samples taken from specific sites. Acids and bases are commonly used in the preparation of samples for analysis. Sometimes the chemist is required to determine the specific concentration of an acid or base spill in the environment and perhaps monitor its cleanup. Knowledge of acid–base properties will help the chemist to determine the best way for containing and treating the spill.

2. (a) The only university in Ontario that has an undergraduate program specifically designed to train analytical chemists is York University.
   (b) At the time of publication of this text, the undergraduate tuition for York University was $915 per full course.
   (c) A variety of scholarships and bursaries is available. Consult the York web site for further details.

CHAPTER 8 LAB ACTIVITIES

ACTIVITY 8.1.1 DETERMINING THE pH OF COMMON SUBSTANCES

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(a) acids: vinegar, soft drinks, shampoo, orange juice, milk
neutral: tap water, milk
basic: antacid, household ammonia, liquid soap

(b) Based on the evidence gathered in this activity, the pH of many foods is generally less than 7 (acidic) and the pH of cleaning solutions is generally greater than 7 (basic). These generalizations are based upon a limited number of foods and cleaners tested.

(c) Litmus paper only provides a quick, inexpensive test to classify substances as being acidic, basic, or neutral. Wide-range pH test paper is useful when comparing the acidity of a wide range of substances. The advantage of the pH meter over test paper is that it can provide specific pH readings, useful when comparing solutions that have similar pH values, indistinguishable by the wide-range pH test paper.
(d) Calibration to a specific pH is necessary to ensure that the initial reading of the meter is correct.

INVESTIGATION 8.3.1 THE pH OF SALT SOLUTIONS

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Prediction

(a) According to the concept of hydrolysis, the pH of the salts tested in order from lowest to highest is:

1. $NaHSO_{4(aq)}$ pH = 1.50
2. $Fe(SO)_{4(aq)}$ pH > 1.76
3. $FeCl_{3(aq)}$ pH = 1.91
4. $Al_2(SO_4)_{3(aq)}$ pH > 2.85
5. $AlCl_{3(aq)}$ pH = 3.00
6. $CuSO_{4(aq)}$ pH > 4.50
7. $NH_4Cl_{(aq)}$ pH = 5.12
8. $NaCl_{(aq)}$ pH = 7.00
9. $(NH_4)_2SO_{4(aq)}$ pH < 7.50
10. $K_2SO_{4(aq)}$ pH = 7.50
11. $(NH_4)_2OOCCOO_{(aq)}$ pH < 8.63
12. $NH_4CH_3COO_{(aq)}$ pH < 8.87
13. $NaHCO_{3(aq)}$ pH < 9.68
14. $(NH_4)_2CO_{3(aq)}$ pH < 11.66
15. $Na_2CO_{3(aq)}$ pH = 11.66
16. $Na_3PO_{4(aq)}$ pH = 12.69

The reasoning behind the above prediction is provided in the examples below.

For $NaHSO_{4(aq)}$, $HSO_{4(aq)}^-$ is amphoteric but $HSO_{4(aq)}^-$ is a weaker base than water. Therefore, a calculation involving $HSO_{4(aq)}^-$ being only an acid is justified.

$$[H^+_{(aq)}] = \sqrt{K_a\,[HSO^+_{4(aq)}]}$$

$$= \sqrt{\frac{1.0 \times 10^{-2}\ \text{mol}}{1\ \text{L}} \times \frac{0.10\ \text{mol}}{1\ \text{L}}}$$

$$[H^+_{(aq)}] = 3.1 \times 10^{-2}\ \text{mol}$$

$$pH = -\log[H^+_{(aq)}]$$

$$= -\log(3.1 \times 10^{-2}\ \text{mol})$$

$$pH = 1.50$$

Procedure

(b)

1. Dip a strip of pH paper into the 1.0 mol/L solution for a controlled period of time.
2. Observe and record the pH.
3. Repeat steps 1 and 2 for each of the salt solutions.
4. Dispose of all solutions into the sink and flush with plenty of water.