8.1 UNDERSTANDING ACIDS AND BASES

PRACTICE

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Understanding Concepts

1. Ionic compounds when melted will conduct a current (which suggests that they contain charged particles such as ions), while molecular compounds in the liquid state will not (which suggests the absence of charged particles).
2. (a) acidic
   (b) basic
   (c) neutral
   (d) acidic
   (e) neutral
   (f) basic
3. Acids are unlike other molecular compounds in that their aqueous solutions conduct a current, turn blue litmus red, and neutralize bases.
4. According to the Arrhenius theory, litmus colour change in acidic solution is caused by $H+_{(aq)}$ ions, and litmus colour change in basic solution is caused by $OH–_{(aq)}$ ions.
5. Empirically, an acid is a substance that, in solution, will turn blue litmus pink, conduct a current, and neutralize a base. Theoretically, an acid is a substance that will release $H+_{(aq)}$ ions in solution.
6. (a) $NaOH_{(s)} \rightarrow Na^{+}_{(aq)} + OH^{-}_{(aq)}$ (dissociation)

   (b) $HC_2H_3O_{2(l)} \rightarrow H^{+}_{(aq)} + C_2H_3O^{-}_{2(aq)}$ (ionization)

   (c) $H_2SO_{4(l)} \rightarrow H^{+}_{(aq)} + HSO^{-}_{4(aq)}$ (ionization)

   (d) $Ca(OH)_{2(s)} \rightarrow Ca^{2+}_{(aq)} + 2\ OH^{-}_{(aq)}$ (dissociation)

   Note: Acid–base concepts in this text do not address the ionization of polyprotic acids such as sulfuric acid. Single ionization is assumed until later in the student's course of study. (See the example with oxalic acid, $H_2C_2O_{4(aq)}$, shown on page 364.)

Applying Inquiry Skills

7. (a) **Analysis**
   Chemical 1 is the molecular compound, $C_{12}H_{22}O_{11(s)}$, (sucrose) because it dissolves well, to produce a nonconducting, neutral solution.
   Chemical 2 is the ionic compound, $KCl_{(s)}$, because it dissolves well, to produce a conducting, neutral solution.
   Chemical 4 is the ionic hydroxide, $Ba(OH)_{2(s)}$, because it dissolves well, to produce a conducting, basic solution.
   Chemical 7 is the acidic molecular compound benzoic, $HC_7H_5O_{2(s)}$, because it dissolves somewhat, to produce a slightly conducting acidic solution.
   Chemicals 3, 5, and 6 are zinc, calcium phosphate, and paraffin wax. They are not individually identifiable from this evidence. Because none of them dissolve, no observations of the solutions can be made.

   (b) **Evaluation**
   The experimental design could be improved by testing the conductivity of the pure substance (which would identify the metal zinc), and by testing the melting points, which would distinguish ionic calcium phosphate (very high) from molecular paraffin (fairly low).

Making Connections

8. Both acids and bases make good solutions for different types of batteries. Lead–acid and alkaline batteries are the most common examples.
9. Acids (a), (c), (e), and (f) are used for energetic reactions and should be handled with care. Acid (b), carbonic acid, is a weak acid that has low solubility, so it is not dangerous. In fact, it is an ingredient in most soft drinks. Acid (d), acetic acid, is dangerous in pure form, but in vinegar is only about a 5% solution so is not very dangerous because the solution is so dilute.
10. You can be electrocuted anywhere, if current has separate places to enter and to leave your body. If the pure water that you are standing in is part of the circuit, it will be a very poor conductor, and you should be relatively safe. In fact,

dissolved substances (for example, from your boots or feet) would make the water in such a situation a relatively good conductor. It is always best to assume that electricity is dangerous around water!

8.2 pH OF A SOLUTION

PRACTICE

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Understanding Concepts

1. Examples of products with specified pH values include skin creams, soils, shampoos, cat foods, wines, water (in rain, wells, lakes, rivers, aquariums), and waste water outflows.
2. $[H^+_{(aq)}]$ values are:
   (a) 1×10^{-11} mol/L
   (b) 1×10^{-2} mol/L
   (c) 1.0×10^{-4} mol/L
   (d) 1.0×10^{-14} mol/L
3. pH values are:
   (a) 3.0
   (b) 5.0
   (c) 7.00
   (d) 10.00
4. $[H^+_{(aq)}]$ values would have to change from 1×10^{-5} mol/L to 1×10^{-7} mol/L: a ratio of 100:1. The hydrogen ion concentration would have to decrease by a factor of 1/100.
5. Since $\log 1 = 10^0$ exactly, by the definition of logarithms, the pH of a solution with a hydrogen ion concentration of 1 mol/L will be 0.0.
   Note: Since the concentration is given to one significant digit, the pH is reported to one decimal place (one place in the logarithm characteristic).
6. (a) $v_{H^+} = 100\ L$
   $C_{H^+} = 1 \times 10^{-3}$ mol/L
   $$n_{H^+} = 100\ \cancel{L} \times \frac{1 \times 10^{-3}\ \text{mol}}{1\ \cancel{L}}$$
   $$n_{H^+} = 0.1\ \text{mol}$$
   The amount of hydrogen ion present in the wine is 0.1 mol.
   (b) $v_{H^+} = 100\ L$
   pH = 8.00
   $C_{H^+} = 1.0 \times 10^{-8}$ mol/L
   $$n_{H^+} = 100\ \cancel{L} \times \frac{1.0 \times 10^{-8}\ \text{mol}}{1\ \cancel{L}}$$
   $$n_{H^+} = 1.0 \times 10^{-6}\ \text{mol} = 1.0\ \mu\text{mol}$$
   The amount of hydrogen ion present in the seawater is 1.0 mmol.
   (c) $v_{H^+} = 100\ L$
   $C_{H^+} = 10.0$ mmol/L = 0.0100 mol/L
   $$n_{H^+} = 100\ \cancel{L} \times \frac{0.0100\ \text{mol}}{1\ \cancel{L}}$$
   $$n_{H^+} = 1.00\ \text{mol}$$
   The amount of hydrogen ion present in the stomach acid is 1.00 mol.

Reflecting

7. (a) No, setting a zero measured level would have to specify the precision of the zero measurement. A more precise technology may turn an earlier measurement of zero into a non-zero value. Secondly, every chemical is toxic at some concentration. There is no known chemical that needs to be reduced in concentration to zero (whatever that means) in order to become non-toxic.

