CHAPTER 10 Review

Reflecting on Chapter 10

Summarize this chapter in the format of your choice. Here are a few ideas to use as guidelines:

- Compare the properties of acids and bases.
- Distinguish the two theories for explaining the behaviour and composition of acids and bases.
- Identify conjugate acid-base pairs for selected acid-base reactions.
- Describe strong and weak acids and bases on the basis of their dissociation.
- Explain the significance of the concentration of hydronium ion in describing pH.
- Dilute an acid and describe the effect on its pH.
- Describe and conduct a titration procedure.

Reviewing Key Terms

For each of the following terms, write a sentence that shows your understanding of its meaning.

Arrhenius theory	weak base
hydronium ion	binary acid
Brønsted-Lowry theory	oxoacid
conjugate acid-base pair	pH
conjugate base	neutralization reaction
conjugate acid	salt
strong acid	acid-base indicator
weak acid	titration
strong base	equivalence point
	end-point

Knowledge/Understanding

1. Use the Arrhenius theory and then the Brønsted-Lowry theory to describe the following concepts. If one of the theories does not apply, state that this is the case.
   - **(a)** composition of an acid and a base
   - **(b)** conductivity of an acidic or basic solution
   - **(c)** interaction between an acid and water
   - **(d)** interaction between a base and water
   - **(e)** conjugate acid-base pairs
   - **(f)** strong and weak acids and bases
   - **(g)** the pH of a solution
2. How does diluting an acidic or basic solution affect the pH of the solution?
3. Codeine is a compound that is extracted from opium. It is used for pain relief. The pH of a 0.020 mol/L solution of codeine is 10.26. Is codeine an acid or a base? Is it strong or weak? Explain how you decided.
4. Sodium hydrogen carbonate, $NaHCO_3$ (commonly called sodium bicarbonate, or bicarbonate of soda), is commonly used in baked goods. It dissolves in water to form an alkaline solution.
   - **(a)** Is the pH of $NaHCO_{3(aq)}$ greater or less than 7.00?
   - **(b)** Write the name and formula of an acid and a base that react together to form this compound. Identify each as strong or weak.
5. Aluminum sulfate, $Al_2(SO_4)_3$, is used to help clarify water. In aqueous solution, it is slightly acidic.
   - **(a)** Is the pH of $Al_2(SO_4)_{3(aq)}$ greater or less than 7.00?
   - **(b)** Write the name and formula of an acid and a base that react together to form aluminum sulfate. Identify each as either strong or weak.
6. Sodium hydrogen carbonate can be used to neutralize an acid. The hydrogen carbonate ion is the conjugate base of which acid?
7. Write the net ionic equation for the reaction of aqueous sodium hydroxide with aqueous nitric acid.
8. In different reactions in aqueous solution, the hydrogen carbonate ion can act as an acid or a base. Write the chemical formula of the conjugate acid and the conjugate base of the hydrogen carbonate ion, $HCO_3^-{}_{(aq)}$. Then complete the following equations. State whether the ion is a Brønsted-Lowry acid or a base.
   - **(a)** $HCO_3^-{}_{(aq)} + H_3O^+{}_{(aq)} \rightarrow$
   - **(b)** $HCO_3^-{}_{(aq)} + OH^-{}_{(aq)} \rightarrow$
9. Which of the following are conjugate acid-base pairs? For those pairs that are not conjugates, write the correct conjugate acid or base for each compound or ion.
   - **(a)** HNO_3/OH^-
   - **(b)** NH_4^+/NH_3
   - **(c)** HSO_4^-/SO_4^{2-}
   - **(d)** H_3PO_4/PO_4^{3-}
10. In the laboratory, you have samples of three different acids of equal concentration: a 1.0 mol/L solution of acetic acid, a 1.0 mol/L solution of hydrochloric acid, and a 1.0 mol/L solution of sulfuric acid.
    - **(a)** How would the pH of each acid solution compare? Explain.

(b) If samples of each acid were used in separate titration experiments with 0.50 mol/L sodium hydroxide solution, how would the volume of acid required for neutralization compare? State your reasoning.

11. Write balanced chemical equations for the following reactions:
(a) calcium oxide with hydrochloric acid
(b) magnesium with sulfuric acid
(c) sodium carbonate with nitric acid

12. Domestic bleach is typically a 5% solution of sodium hypochlorite, $NaOCl_{(aq)}$. It is made by bubbling chlorine gas through a solution of sodium hydroxide.
(a) Write a balanced chemical equation showing the reaction that takes place.
(b) In aqueous solution, the hypochlorite ion combines with $H^+_{(aq)}$ present in water to form hypochlorous acid. Write the equation for this reaction. Is the hypochlorite ion acting as an acid or a base?

13. In this chapter, you are told that $[H_3O^+]$ in pure water is 1.0×10^{-7} mol/L at 25°C. Thus, two out of every one billion water molecules have dissociated. Check these data by answering the following questions.
(a) What is the mass (in g) of 1.0 L of water?
(b) Calculate the amount (in mol) of water in 1.0 L. This is the concentration of water in mol/L.
(c) Divide the concentration of hydronium ions by the concentration of water. Your answer should be about 2 ppb.

Inquiry

14. 80.0 mL of 4.00 mol/L, H_2SO_4 are diluted to 400.0 mL by adding water. What is the molar concentration of the sulfuric acid after dilution?

15. In a titration experiment, 25.0 mL of an aqueous solution of sodium hydroxide was required to neutralize 50.0 mL of 0.010 mol/L hydrochloric acid. What is the molar concentration of the sodium hydroxide solution?

16. A burette delivers 20 drops of solution per 1.0 mL. What amount (mol) of $H^+_{(aq)}$ is present in one drop of a 0.20 mol/L HCl solution?

17. How is a 1.0 mol/L solution of hydrochloric acid different from a 1.0 mol/L solution of acetic acid? Suppose that you added a strip of magnesium metal to each acid. Would you observe any differences in the reactions? Explain your answer so that grade 9 students could understand it.

Communication

18. Commercial processors of potatoes remove the skin by using a 10-20% by mass solution of sodium hydroxide. The potatoes are soaked in the solution for a few minutes at 60-70°C, after which the peel can be sprayed off using fresh water. You work in the laboratory at a large food processor and must analyse a batch of sodium hydroxide solution. You pipette 25.00 mL of $NaOH_{(aq)}$, and find it has a mass of 25.75 g. Then you titrate the basic solution against 1.986 mol/L HCI, and find it requires 30.21 mL of acid to reach an end point.
(a) Inform your supervisor what the molar concentration of the sodium hydroxide is.
(b) The mass percent of NaOH present must be a minimum of 10% for the solution to be used. Advise your supervisor whether or not the solution can be used to process more potatoes, and explain your reasoning.

19. Ammonia is an important base, used to make fertilizers, nylon, and nitric acid. The manufacture of ammonia depends on a process discovered by Fritz Haber (1868-1934). After gathering information from print or electronic resources, write an obituary for Haber. Describe his accomplishments and the effect on society of plentiful supplies of ammonia.

Making Connections

20. Limestone, chalk, and marble are all forms of calcium carbonate. Limestone rock can be used to build roads, but it is a very important basic compound used in large quantities by chemical industries. For example, limestone is used directly to make concrete and cement. It is also used in the manufacture of glass and in agriculture. Limestone is often processed to make quicklime, CaO, and hydrated lime (calcium hydroxide), $Ca(OH)_2$.

(a) Research the uses of quicklime and hydrated lime. Investigate one of these uses further.

(b) Design a poster illustrating the use you decided to research. Your poster should be both informative and visually interesting. Include a bibliography showing the resources you found useful.

21. On several occasions during the past few years, you have studied the environmental issue of acid rain. Now that you have further developed your understanding of acids and bases in this chapter, reflect on your earlier understandings.

(a) List two facts about acid rain that you now understand in a more comprehensive way. Explain what is different between your previous and your current understanding in each case.

(b) Identify three questions that your teacher could assign as a research project on acid rain. The emphasis of the research must be on how an understanding of chemistry can contribute clarifying the questions and possible solutions involved in this issue. Develop a rubric that would be used to assess any student who is assigned this research project.

22. Research the use of hypochlorous acid in the management of swimming pools and write a report on your findings. Include a discussion on the importance of controlling pool water.

Answers to Practice Problems and Short Answers to Section Review Questions

Practice Problems: **1.** HCN/CN^- and H_2O/H_3O^+ **2.** H_2O/OH^- and CH_3COO^-/CH_3COOH **3.** as an acid: $HS^-_{(aq)} + H_2O_{(\ell)} \leftrightarrow S^{2-}_{(aq)} + H_3O^+_{(aq)}$; as a base: $HS^-_{(aq)} + H_2O_{(\ell)} \leftrightarrow H_2S_{(aq)} + OH^-_{(aq)}$ **4.(a)** HBr; bromate; Br^- **(b)** hydrogen sulfide, HS^-; sulfide, S_2^- **5.(a)** nitric acid, HNO_3; nitrate, NO_3^- **(b)** nitrous acid, HNO_2; nitrite, NO_2^- **(c)** hyponitrous acid, HNO; hyponitrite, NO^- **(d)** phosphoric acid, H_3PO_4; dihydrogen phosphate, $H_2PO_4^-$, hydrogen phosphate, HPO_4^{2-}, phosphate, PO_4^{3-} **(e)** phosphorous acid, H_3PO_3; dihydrogen phosphite, $H_2PO_3^-$, hydrogen phosphite, HPO_3^{2-}, phosphite, PO_3^{3-} **(f)** periodic acid, HIO_4; periodate, IO_4^- **6.(a)** 2.57 **(b)** 7.138 **(c)** 4.01 **(d)** 11.082 **7.** pH = 2.30; acidic **8.** 3.54; acidic **9.(a)** 2.20 **(b)** 9.181; basic **10.** 0.210 mol/L **11.** 31.5 mL **12.(a)** 22.5 mL **(b)** 24.7 mL **(c)** 4.8 mL **13.(a)** 0.0992 mol/L **(b)** 0.269 mol/L **(c)** 0.552 mol/L

Section Review: **10.1:** **1.(a)** B and D **(b)** A (C, although unintended, would also be correct) **(c)** A, B, D **(d)** no **(e)** litmus test, for example **5.(a)** H_2O **(b)** HCO_3^- **6.(a)** NO_3^- **(b)** SO_4^{2-} **7.** c and d **8.** a and b **9.(a)** $HF_{(aq)} + H_2O_{(l)} \rightarrow H_3O^+_{(aq)} + F^-_{(aq)}$ **(b)** HF/F^-; H_2O/H_3O^+ **10.(a)** $H_2PO_4^-/HPO_4^{2-}$ and CO_3^{2-}/HCO_3^- **(b)** $HCOOH/HCOO^-$ and CN^-/HCN **(c)** $H_2PO_4^-/HPO_4^{2-}$ and OH^-/H_2O **10.2:** **3.** weak **4.** potassium permanganate; permanganic acid, $HMnO_4$ **5.(a)** sulfuric acid, H_2SO_4 **(b)** hydrofluoric acid, HF **(c)** hydrosulfuric acid, H_2S **(d)** bromous acid, HBr_2 **7.** egg white, camembert cheese, beets, yogurt, sauerkraut **8.(a)** 7.4 **(b)** 1.4 **9.** 2.90 **10.** 1.0 mol/L; concentrations greater than this give negative pH values, but this gives no advantage over the actual concentration of H_3O^+ **10.3:** **1.** acid + base = salt + water **4.** 0.304 mol/L **5.** 0.107 mol/L