Chapter 7 Solution Chemistry

7.1 The Nature of Solutions

Warm Up (p. 364) **and Quick Check** (p. 365)

	Pure Substance	Mixture
Car exhaust		√
Tap water		√ solution
Carbon dioxide	√	
Freshly squeezed orange juice		√
Stainless steel		√ solution
Tea		√ solution
Diamond	√	
Cigarette smoke		√

Practice Problems — Converting Between Units of Solubility (p. 366)

1. $\text{solubility} = 2.4\times10^{-5}\,\frac{\text{mol}}{\text{L}} \times \frac{147.6\text{ g}}{1\text{ mol}} \times \frac{1\text{ L}}{1000\text{ mL}} = 3.5\times10^{-6}\,\frac{\text{g}}{\text{mL}}$

2. $\text{Solubility} = 1.4\times10^{-6}\,\frac{\text{mol}}{\text{L}} \times \frac{462.6\text{ g}}{1\text{ mol}} \times \frac{1\text{ L}}{1000\text{ mL}} = 6.5\times10^{-7}\,\frac{\text{g}}{\text{mL}}$

3. $\text{molar solubility} = \frac{9.3\times10^{-4}\text{ g}}{500\text{ mL}} \times \frac{1\text{ mol}}{143.4\text{ g}} \times \frac{1000\text{ mL}}{\text{L}}$
$= 1.3\times10^{-5}\text{ M}$

4. $\text{mass} = 2.6\times10^{-3}\,\frac{\text{mol}}{\text{L}} \times \frac{413.3\text{ g}}{1\text{ mol}} \times \frac{1\text{ L}}{1000\text{ mL}} \times 250\text{ mL} = 0.27\text{ g}$

Quick Check (p. 367)

1. An anion is a negative ion. A cation is a positive ion.
2. Alkali ions, H^+ and NH_4^+ compounds are always soluble.
3. Nitrate compounds are always soluble.
4. Phosphate, carbonate, and sulphite have low solubility.

Practice Problems — Predicting the Relative Solubility of Salts in Water (p. 368)

1. NaCl	S	6. zinc sulphite	LS
2. $CaCO_3$	LS	7. ammonium hydroxide	S
3. $CuCl_2$	S	8. cesium phosphate	S
4. $Al_2(SO_4)_3$	S	9. copper(I) chloride	LS
5. BaS	S	10. chromium(III) nitrate	S

7.1 Activity (p. 369)

Results and Discussion

1. $NaNO_3$
2. No. At 0°C, $KClO_3$ has the lowest solubility. AT 90°C, $Ce_2(SO_4)_3$ has the lowest solubility.
3. Increases
4. $Ce_2(SO_4)_3$

7.1 Review Questions (p. 370)

1. Homogeneous — is uniform throughout and exists in one phase (e.g., alcohol and water)
Heterogeneous — is not uniform throughout (e.g., oil and vinegar)
Pure substance — contains only one type of particle (atom or molecule) (e.g., gold or water)
Mixture — contains 2 or more components (e.g., salt water)

2. (a) pure substance
(b) mixture - solution
(c) mixture - solution
(d) mixture – not a solution
(e) mixture - solution
(f) cmixture – not a solution
(g) mixture - solution
(h) pure substance

3. A solution is composed of a solute and solvent. The solvent is the substance that makes up the larger part of the solution. If two components can be mixed in any proportions to make a homogeneous mixture, they are miscible.

4. Paint thinner and water are immiscible. You would see two layers of liquid that did not mix.

5. The amount of solute in a specified volume of solution at a particular temperature

6. $\text{solubility} = \frac{2.6 \times 10^{-3}\ \cancel{\text{mol}}}{\cancel{\text{L}}} \times \frac{367\ \text{g}}{1\ \cancel{\text{mol}}} \times \frac{1\ \cancel{\text{L}}}{1000\ \text{mL}} = 9.5 \times 10^{-4}\ \text{g/mL}$

7. $\text{solubility} = \frac{0.0015\ \cancel{\text{g}}}{250\ \cancel{\text{mL}}} \times \frac{1\ \text{mol}}{128.1\ \cancel{\text{g}}} \times \frac{1000\ \cancel{\text{mL}}}{1\ \text{L}} = 4.7 \times 10^{-5}\ \text{M}$

8. $\text{solubility} = \frac{1.8 \times 10^{-4}\ \cancel{\text{mol}}}{\cancel{\text{L}}} \times \frac{282.8\ \text{g}}{1\ \cancel{\text{mol}}} \times \frac{1\ \cancel{\text{L}}}{1000\ \text{mL}} = 5.1 \times 10^{-5}\ \text{g/mL}$

9. Dissolved in water

10. Many possible answers. For example: FeS, CuS and ZnS

11. Many possible answers. For example: Na_2CO_3, $(NH4)_2CO_3$, K_2CO_3

12. H^+, NH_4^+, Li^+, Na^+ , K^+ , Rb^+ Cs^+ , Fr^+

13. (a) soluble
(b) soluble
(c) soluble
(d) soluble
(e) low solubility
(f) soluble
(g) soluble
(h) soluble

14. $[LiCH_3COO] = \frac{0.53\cancel{\text{g}}}{100\ \cancel{\text{mL}}} \times \frac{1\ \text{mol}}{65.9\ \cancel{\text{g}}} \times \frac{1000\ \cancel{\text{mL}}}{1\text{L}} = 0.080\ \text{M}.$

According to the solubility table, alkali ions are soluble with all anions. Soluble means a solubility of greater than 0.1M. This solution is unsaturated.

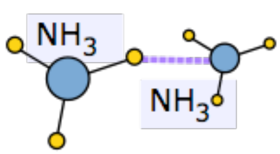
7.2 What Dissolves and What Doesn't — "Like Dissolves Like"

Warm Up (p. 372)

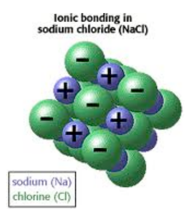
Substance	**Intermolecular Forces Present**
Example: H_2O	hydrogen bonding, dipole-dipole, dispersion forces
I_2	*Dispersion forces*
HF	*hydrogen bonding, dipole-dipole, dispersion forces*
PCl_3	*Dispersion forces*
CH_3CH_2OH	*dipole-dipole, dispersion forces*

Quick Check (p. 374)

1. The NaCl has positive and negative ions, and the water has positive and negative dipoles. The positive sodium ion is attracted to the negative dipole on the oxygen atom of the water molecule. The negative chloride ion is attracted to the positive dipole on the hydrogen atom of the water molecule.
2. Water molecules are attracted to each other by hydrogen bonds. The iodine molecules cannot overcome that attraction between water molecules to get between them.
3. No, NaCl is ionic and oil is non-polar covalent. They are not "like."
4. ammonia NaCl



dipole-dipole force



ionic bonds

Quick Check (p. 376)

1. Yes. Ammonia is polar and so is water. They are "like."
2. No. Ethanol is polar and hexane is non-polar. They are not "like."
3. CH_3OH is more soluble in water. Water is polar so it will be attracted to the polar end on CH_3OH. C_2H_6 is non-polar so is not "like" water.
4. The large non-polar part of octanol is not able to get between water molecules and overcome the attraction that each water molecule has for another water molecule. Larger alcohols are almost insoluble in water.

Quick Check (p. 377)

1. Yes. Iodine is also non-polar covalent. Like dissolves like.
2. Mothballs are non-polar so they will dissolve better in paint thinner which is also non-polar.
3. The solid iodine will dissolve in the paint thinner layer only. It will become pink while the water layer remains clear and colorless.
4. The water molecules are attracted to each other through hydrogen bonds. The CCl_4 molecules are not able to overcome this attraction and get between the water molecules. Water is polar and CCl_4 is non-polar. They are not "like."

7.2 Activity (p. 380)

Results and Discussion

1. Water contains hydrogen bonds and dipole-dipole bonds. Tetrachloroethene is non-polar covalent so only contains dispersion forces.

2. The stain must be polar covalent or ionic.

3. The stain is polar or ionic and tetrachloroethene is non-polar. They are not "like."

4. Because both ionic and polar compounds dissolve in polar covalent solvents.

5. Students' answers will vary.

7.2 Review Questions (p. 381)

1. Solutes that have similar types of intermolecular forces as a solvent will dissolve.

2. Hydrophilic

3. Br_2 is non-polar so is more soluble in CS_2 which is also non-polar. NH_3 is polar so is not "like" Br_2.

4. NH3 is polar just like water. NCl_3 is non-polar so will not dissolve in water.

5. I_2 is non-polar so will not dissolve in polar water. If the water contains I^- ions however, the I_2 reacts to form I_3^- (*aq*) which is ionic. This ion will then be attracted to the positive dipole on the hydrogen atoms on the water molecules.

6. (a) C_3H_6OH – it contains a polar end that is attracted to the polar water molecules
(b) $MgCl_2$ is ionic so will dissolve better in water. Toluene is non-polar.

7. The glycerin and water would mix together but the carbon tetrachloride would remain as a separate layer. The $CuCl_2$ would dissolve into the water/glycerin layer and would color that layer blue.

8. (a) water. Water and ethylene glycol are both polar.
(b) ammonia. Ammonia and ethylene glycol are both polar.
(c) glycerin. Glycerin and ethylene glycol are both polar.

9. (a) CsCl is ionic. Water contains hydrogen bonds, dipole-dipole bonds and dispersion forces.
(b) CH_3OH is polar and contains hydrogen bonds, dipole-dipole forces and dispersion forces. Glycerin is polar and contains hydrogen bonds, dipole-dipole forces and dispersion forces.
(c) N_2 contains only dispersion forces as does C_8H_{18}
(d) Acetone contains dipole-dipole forces and dispersion forces. Ammonia contains hydrogen bonds, dipole-dipole forces and dispersion forces.

7.3 Dissociation Equations and Solution Conductivity

Warm Up (p. 383)

1. For a strong cup of coffee, you would use a large amount of coffee for a given volume of water.
2. To dilute the coffee, you would add more water or milk.
3. No, you have not changed the amount of caffeine in the coffee because you have not added any more coffee. You have simply increased the volume of solution.

Practice Problems — Dilution Calculations (p. 384)

1. $[NaOH] = \frac{0.100 \text{ mol}}{1 \not{L}} \times \frac{0.0500 \not{L}}{0.0800 \text{ L}} = 0.0625 \text{ M}$
2. $[H_2SO_4] = \frac{1.5 \text{ mol}}{1 \not{L}} \times \frac{0.0350 \not{L}}{0.0500 \text{ L}} = 1.1 \text{ M}$
3. $[Ca(NO_3)_2]$ original solution $= \frac{0.025 \not{g}}{0.100 \text{ L}} \times \frac{1 \text{ mol}}{164.1 \not{g}} = 1.1 \text{ M}$

   $[Ca(NO_3)_2]$ diluted solution $= \frac{1.1 \text{ mol}}{1 \not{L}} \times \frac{0.0500 \not{L}}{0.0750 \text{ L}} = 0.73 \text{ M}$
4. $[K_2CrO_4] = \frac{0.40 \text{ mol}}{1 \not{L}} \times \frac{0.0180 \not{L}}{0.0380 \text{ L}} = 0.19 \text{ M}$

Quick Check (p. 385)

1. $Al(NO_3)_3$ (*aq*) → Al^{3+} (*aq*) + 3 NO_3^- (*aq*)

2. $(NH_4)_2SO_4$ (*aq*) → 2 NH_4^+(*aq*) + SO_4^{2-}(*aq*)

3. potassium chromate K_2CrO_4 (*aq*) → 2 K^+(*aq*) + CrO_4^{2-}(*aq*)

4. zinc phosphate $Zn_3(PO_4)_2$ (*aq*) → 3 Zn^{2+}(*aq*) + 2 PO_4^{3-}(*aq*)

Quick Check (p. 386)

1. 3.0 M $Zn(NO_3)_2$: $Zn(NO_3)_2(aq) \rightarrow Zn^{2+}(aq) + 2\,NO_3^-(aq)$

   3.0M 3.0 M 6.0 M

2. 0.50M Na_2CO_3 : $Na_2CO_3(aq) \rightarrow 2\,Na^+(aq) + CO_3^{2-}(aq)$

   0.050M 1.0M 0.50 M

3. 1.5 M ammonium oxalate: $(NH_4)_2C_2O_4(aq) \rightarrow 2\,NH_4^+(aq) + C_2O_4^{2-}(aq)$

   1.5M 3.0 M 6.0 M

4. 3.2×10^{-3} M calcium phosphate : $Ca_3(PO_4)_2(aq) \rightarrow 3\,Ca^{2+}(aq) + 2\,PO_4^{3-}(aq)$

   3.2×10^{-3} M 9.6×10^{-3} M 6.4×10^{-3} M

Continued…

Practice Problems — Calculating the Concentrations of Ions in Solution (p. 387)

1. $[HNO_3] = 0.20 \frac{mol}{L} \times \frac{0.0350 L}{0.1100 L} = 0.064 M$

$[Al(NO_3)_3] = 0.15 \frac{mol}{L} \times \frac{0.0750 L}{0.1100 L} = 0.10 M$

$HNO_3(aq) \rightarrow H^+(aq) + NO_3^-(aq)$

0.064M 0.064M 0.064M

$Al(NO_3)_3(aq) \rightarrow Al^{3+}(aq) + 3NO_3^-(aq)$

0.10M 0.10M 0.30M

$[H^+] = 0.064 M$

$[NO_3^-] = 0.064 M + 0.30 M = 0.36 M$

$[Al^{3+}] = 0.10 M$

2. $[H_2SO_4] = 0.85 \frac{mol}{L} \times \frac{0.0226 L}{0.0580 L} = 0.019 M$

$[Na_2SO_4] = 1.3 \frac{mol}{L} \times \frac{0.0354 L}{0.0580 L} = 0.79 M$

$H_2SO_4(aq) \rightarrow 2H^+(aq) + SO_4^{2-}(aq)$

0.019M 0.038M 0.019M

$Na_2SO_4(aq) \rightarrow 2Na^+(aq) + SO_4^{2-}(aq)$

0.79 M 1.6M 0.79M

$[H^+] = 0.038 M$

$[SO_4^{2-}] = 0.019 M + 0.79 M = 0.81 M$

$[Na^+] = 1.6 M$

3. $[K_3PO_4] = 0.10\frac{mol}{L} \times \frac{0.0500L}{0.1000L} = 0.050M$

$[K_2C_2O_4] = 0.20\frac{mol}{L} \times \frac{0.040L}{0.1000L} = 0.080M$

$K_3PO_4(aq) \rightarrow 3K^+(aq) + PO_4^{3-}(aq)$

0.050M 0.15M 0.050M

$K_2C_2O_4(aq) \rightarrow 2K^+(aq) + C_2O_4^{2-}(aq)$

0.080M 0.16M 0.080M

$[K^+] = 0.15M + 0.16M = 0.31M$

$[PO_4^{3-}] = 0.050M$

$[C_2O_4^{2-}] = 0.080M$

4. $[(NH_4)_3PO_4] = 2.3\times10^{-3}\frac{mol}{L} \times \frac{0.1000L}{0.1400L} = 1.6\times10^{-3}M$

$[(NH_4)_2S] = 4.5\times10^{-2}\frac{mol}{L} \times \frac{0.0400L}{0.1400L} = 1.3\times10^{-2}M$

$(NH_4)_3PO_4(aq) \rightarrow 3NH_4^+(aq) + PO_4^{3-}(aq)$

$1.6\times10^{-3}M$ $4.8\times10^{-3}M$ $1.6\times10^{-3}M$

$(NH_4)_2S(aq) \rightarrow 2NH_4^+(aq) + S^{2-}(aq)$

$1.3\times10^{-2}M$ $2.6\times10^{-2}M$ $1.3\times10^{-2}M$

$[NH_4^+] = 4.8\times10^{-3}M + 2.6\times10^{-2}M = 0.031M$

$[PO_4^{3-}] = 1.6\times10^{-3}M$

$[S^{2-}] = 1.3\times10^{-2}M$

Quick Check (p. 389)

1. Ionic Compounds contain a metal ion (or ammonium ion) and a negative ion. An example of anionic compound is NaCl or NH_4NO_3. A molecular compound contains only non-metals.

2. No, sugar is molecular. Ions are required for a solution to conduct electricity.

3. HCl is a strong acid, which means that it will dissociate into ions completely. CH_3COOH is a weak acid so does not dissociate very much into ions.

7.3 Activity (p. 390)
In your diagrams, it should be demonstrated that:

- The dimmest light bulbs will be $C_{12}H_{22}O_{11}$ and C_2H_5OH because they are molecular.
- Only slightly brighter will be NH_3 and CH_3COOH. NH_3 is a weak base so does contain a few ions. CH_3COOH is a weak acid and also contains a few ions.
- The next brightest bulb will be in the HCl. There is a total ion concentration of 1.6M.
- The next brightest bulb will be the NaCl with a total ion concentration of 2.0M.
- The brightest bulb will be in the Na_2CO_3 with a total ion concentration of 2.4M.

Results and Discussion

1. Ionic = HCl, NaOH and Na_2CO_3. Covalent = $C_{12}H_{22}O_{11}$, C_2H_5OH, CH_3COOH, and NH_3 .

2.
$HCl(aq) \rightarrow H^+(aq) + Cl^-(aq)$
0.8 M 0.8 M 0.8 M
$NaCl(aq) \rightarrow Na^+(aq) + Cl^-(aq)$
1.0 M 1.0 M 1.0 M
$Na_2CO_3(aq) \rightarrow 2\,Na^+(aq) + CO_3^{2-}(aq)$
0.8 M 1.6 M 0.8 M

3. In HCl: [ions] = 1.6M
In NaCl: [ions] = 2.0M
In Na_2CO_3 : [ions] = 2.4M

4. Na_2CO_3 > NaCl > HCl > CH_3COOH = NH_3 > $C_{12}H_{22}O_{11}$ = C_2H_5OH

5. A good electrical conductor is one that contains ions. The higher the concentration of ions in solution, the greater its conductivity will be.

Continued…

7.3 Review Questions (p. 391)

1\. a) $[HCl] = 0.55\,\frac{mol}{L} \times \frac{0.175\,L}{0.200\,L} = 0.48\,M$

b) $[Na_2Cr_2O_7] = 0.035\,\frac{mol}{L} \times \frac{0.0450\,L}{0.1000\,L} = 0.016\,M$

c) $[NaOH] = 2.0\,\frac{mol}{L} \times \frac{0.1000\,L}{0.0750\,L} = 2.7\,M$

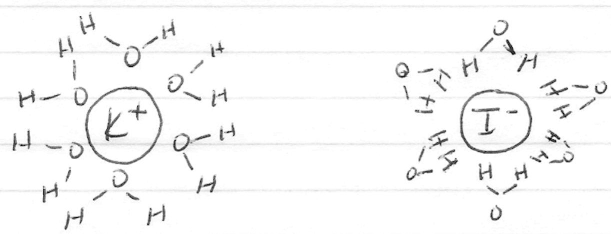
2\. mol HCl required $= 2.5\,\frac{mol}{L} \times 0.2500\,L = 0.625$ mol HCl

volume stock solution $= 0.625$ mol HCl $\times \frac{1\,L}{6.0\,mol} = 0.10\,L$

3\. When a solute dissolves in a solvent, the solvent molecules surround the solute particles. If the solvent is water, it is called hydration. If the solvent molecules are not water, it is called solvation.

4\. A water molecule is polar. The oxygen atom on a water molecule has a negative dipole because the electrons in the bonds are more attracted to the oxygen atom. The negative dipole on the oxygen is attracted to the positive charge on the cation.

5\.



6. a) $FeCl_3(aq) \rightarrow Fe^{3+}(aq) + 3Cl^-(aq)$

b) $MnHPO_4(aq) \rightarrow Mn^{2+}(aq) + HPO_4^{2-}(aq)$

c) $Zn(SCN)_2(aq) \rightarrow Zn^{2+}(aq) + 2\,SCN^-(aq)$

d) $Al_2(Cr_2O_7)_3(aq) \rightarrow 2Al^{3+}(aq) + 3\,Cr_2O_7^{2-}(aq)$

e) $Ag_2C_2O_4(aq) \rightarrow 2Ag^+(aq) + C_2O_4^{2-}(aq)$

f) $Fe_2(SO_3)_3(aq) \rightarrow 2\,Fe^{3+}(aq) + 3\,SO_3^{2-}(aq)$

g) $CrCrO_4(aq) \rightarrow Cr^{2+}(aq) + CrO_4^{2-}(aq)$

h) $NH_4HC_2O_4(aq) \rightarrow NH_4^+(aq) + HC_2O_4^-(aq)$

7. Total moles HCl $= \left(0.60\frac{mol}{L} \times 0.2500L\right) + \left(1.0\frac{mol}{L} \times 0.3000L\right)$

$= 0.45\ mol$

$[HCl] = \frac{0.45\ mol}{0.5500L} = 0.82M$

8. a) $CuCl_2(aq) \rightarrow Cu^{2+}(aq) + 2Cl^-(aq)$

0.20M 0.20M 0.40M

b) $Li_2C_2O_4(aq) \rightarrow 2\,Li^+(aq) + C_2O_4^{2-}(aq)$

1.5M 3.0M 1.5M

c) $HNO_3(aq) \rightarrow H^+(aq) + NO_3^-(aq)$

6.0M 6.0M 6.0M

d) $Mg(MnO_4)_2(aq) \rightarrow Mg^{2+}(aq) + 2MnO_4^-(aq)$

$1.4\times10^{-3}M$ $1.4\times10^{-3}M$ $2.8\times10^{-3}M$

9. $(NH_4)_2CrO_4(aq) \rightarrow 2NH_4^+(aq) + CrO_4^{2-}(aq)$

0.60M <u>0.30M</u>

10. NO_3^- ions move to the positive electrode. K^+ ions move to the negative electrode. This is a good electrolyte because it contains ions.

11. Strong acids dissociate completely to form ions.

HCl, HBr, HI, HNO_3, H_2SO_4, $HClO_4$

12. Place the conductivity apparatus in each solution. The HNO_3 solution will be a good conductor because it is ionic. The $C_{12}H_{22}O_{11}$ solution will be a poor conductor because it is molecular.

13. a) good b) non-electrolyte c) weak
d) good e) non-electrolyte f) weak

14. Disagree. You can have a sugar solution of high concentration (molecular) that will not conduct electricity. Good conductors are ionic.

7.4 An Introduction to Titrations

Warm Up (p. 393)

1. $1\ H_2SO_4(aq) + 2\ NaOH(aq) \rightarrow 2\ H_2O(l) + 1\ Na_2SO_4(aq)$
2. $3\ HBr(aq) + Al(OH)_3\ (aq) \rightarrow AlBr_3\ (aq) + 3\ H_2O(l)$
3. $2\ NH_4OH + H_2SO_4 \rightarrow (NH_4)_2SO_4 + 2\ H_2O\ (l)$
4. Acid = H_2CO_3 and base = KOH

Practice Problems — Simple Titration Calculations (p. 394)

1. moles NaOH = $\frac{0.30\text{ mol}}{1\ \cancel{\text{L}}} \times 0.01562\ \cancel{\text{L}} = 4.69 \times 10^{-3}$ mol NaOH

   moles HCl = $4.69 \times 10^{-3}\ \cancel{\text{mol NaOH}} \times \frac{1\text{ mol HCl}}{1\ \cancel{\text{mol NaOH}}} = 4.69 \times 10^{-3}$ mol HCl

   [HCl] = $\frac{4.69 \times 10^{-3}\text{ mol HCl}}{0.02500\text{ L}} = 0.19$ M

2. moles H_2SO_4 = $\frac{0.20\text{ mol}}{1\ \cancel{\text{L}}} \times 0.02425\ \cancel{\text{L}} = 4.85 \times 10^{-3}$ mol H_2SO_4

   moles NaOH= $4.85 \times 10^{-3}\ \cancel{\text{mol } H_2SO_4} \times \frac{2\text{ mol NaOH}}{1\ \cancel{\text{mol } H_2SO_4}} = 9.70 \times 10^{-3}$ mol NaOH

   [NaOH] = $\frac{9.70 \times 10^{-3}\text{ mol NaOH}}{0.01000\text{ L}} = 0.97$ M

3. moles $Sr(OH)_2 = \frac{0.015 \text{ mol}}{1 \cancel{L}} \times 0.02268 \cancel{L} = 3.40 \times 10^{-4}$ mol $Sr(OH)_2$

moles $HNO_3 = 3.40 \times 10^{-4} \cancel{\text{mol } Sr(OH)_2} \times \frac{2 \text{ mol NaOH}}{1 \cancel{\text{mol } Sr(OH)_2}} = 6.80 \times 10^{-4}$ mol HNO_3

$[HNO_3] = \frac{6.80 \times 10^{-4} \text{ mol } HNO_3}{0.00500 \text{ L}} = 0.14$ M

4. moles NaOH $= \frac{0.12 \text{ mol}}{1 \cancel{L}} \times 0.01000 \cancel{L} = 1.2 \times 10^{-3}$ mol NaOH

mol $H_2C_2O_4 = 1.2 \times 10^{-3} \cancel{\text{mol NaOH}} \times \frac{1 \text{ mol } H_2C_2O_4}{2 \cancel{\text{mol NaOH}}} = 6.0 \times 10^{-4}$ mol

volume $H_2C_2O_4 = 6.0 \times 10^{-4} \cancel{\text{mol } H_2C_2O_4} \times \frac{1 \text{ L}}{0.50 \cancel{\text{mol } H_2C_2O_4}} = 1.2 \times 10^{-3}$ L

Quick Check (p. 396)

1. A pipette is used to deliver a specific volume of solution. The solution is suctioned up into the pipette. A burette is used to gradually add a volume of solution. It has a valve that dispenses solution.
2. Usually the standardized solution
3. The Erlenmeyer flask
4. Moles of H^+ and moles of OH^-

7.4 Activity (p. 397)

Results and Discussion

1. $CH_3COOH + NaOH \rightarrow NaCH_3COO + H_2O$
2. Colourless
3. When a small amount of NaOH is added, it is neutralized by the CH_3COOH. There is an excess of CH_3COOH so the indicator remains colourless.
4. 12.30 mL – 0.50 mL = 11.80 mL
5. At the endpoint, the indicator changes colour because the CH_3COOH has been completely neutralized by the added NaOH and there is now an excess of NaOH in the flask.
6. Trial #1: 12.31 mL – 0.50 mL = 11.81 mL
   Trial #2: 23.75 mL – 12.31 mL = 11.44 mL
   Trial #3: 35.22 mL – 23.70 mL = 11.52 mL
   Average volume NaOH = (11.44 mL + 11.52 mL) / 2 = 11.48 mL
7. moles NaOH $= \frac{0.15 \text{ mol}}{1 \cancel{L}} \times 0.01148 \cancel{L} = 1.72 \times 10^{-3}$ mol NaOH
8. moles $CH_3COOH = 1.72 \times 10^{-3} \cancel{\text{mol NaOH}} \times \frac{1 \text{ mol } CH_3COOH}{1 \cancel{\text{mol NaOH}}} = 1.72 \times 10^{-3}$ mol
9. $[CH_3COOH] = \frac{1.72 \times 10^{-3} \text{ mol } CH_3COOH}{0.0100 \text{ L}} = 0.17$ M

7.4 Review Questions (p. 399)

1. Acid begins with H or ends in –COOH. Examples: HCl and CH_3COOH. A base contains hydroxide. Example: NaOH

2. (a) $HI + LiOH \rightarrow LiI + H_2O$
   (b) $Ca(OH)_2 + 2\ HNO_3 \rightarrow Ca(NO_3)_2 + 2\ H_2O$
   (c) $CH_3COOH + NH_4OH \rightarrow NH_4CH_3COO + H_2O$
   (d) $H_2SO_4 + 2\ KOH \rightarrow K_2SO_4 + 2\ H_2O$

3. The solution will be pink at the beginning of the titration because the Erlenmeyer contains the base NaOH. At the endpoint, the solution will be colourless when all of the NaOH has been neutralized.

4.Standardized: a solution whose concentration is known.
Equivalence point: the point in the titration where moles H+ = moles OH-.
Endpoint: the point in the titration where the indicator changes colour.

5.

Molarity of $Sr(OH)_2$ = 0.050 M	**Trial #1**	**Trial #2**	**Trial #3**
Initial burette reading (mL)	0.00	16.05	32.93
Final burette reading (mL)	16.05	32.93	49.68
Volume of $Sr(OH)_2$ added (mL)	16.05	16.88	16.75
Average volume $Sr(OH)_2$ (mL)	16.82		

$$\text{moles } Sr(OH)_2 = \frac{0.050\text{ mol}}{1\ \cancel{L}} \times 0.01682\ \cancel{L} = 8.41 \times 10^{-4}\text{ mol } Sr(OH)_2$$

$$\text{moles HCl} = 8.41 \times 10^{-4}\ \cancel{\text{mol } Sr(OH)_2} \times \frac{2\text{ mol HCl}}{1\ \cancel{\text{mol } Sr(OH)_2}} = 1.68 \times 10^{-3}\text{ mol HCl}$$

$$[HCl] = \frac{1.68 \times 10^{-3}\text{ mol HCl}}{0.01000\text{ L}} = 0.17\text{M}$$

6. moles H_2CO_3 = 0.20 mol × 0.02500 L = 0.0050 mol H_2CO_3

$$\text{moles NaOH} = 0.0050\ \cancel{\text{mol } H_2CO_3} \times \frac{2\text{ mol NaOH}}{1\ \cancel{\text{mol } H_2CO_3}} = 0.010\text{ mol NaOH}$$

$$\text{volume NaOH} = 0.010\ \cancel{\text{mol NaOH}} \times \frac{1\text{ L}}{0.50\ \cancel{\text{mol NaOH}}} = 0.020\text{ L NaOH}$$

7. $$\text{moles NaOH} = \frac{0.50\text{ mol}}{1\ \cancel{L}} \times 0.01820\ \cancel{L} = 9.1 \times 10^{-3}\text{ mol NaOH}$$

$$\text{moles } CH_3COOH = 9.1 \times 10^{-3}\ \cancel{\text{mol NaOH}} \times \frac{1\text{ mol HCl}}{1\ \cancel{\text{mol NaOH}}} = 9.1 \times 10^{-3}\text{ mol } CH_3COOH$$

$$[HCl] = \frac{9.1 \times 10^{-3}\text{ mol } CH_3COOH}{0.01000\text{ L}} = 0.19\text{ M}$$

8. $[H_2C_2O_4] = \frac{0.18\,g}{0.25000\,L} \times \frac{1\,mol}{126\,g} = 5.7\times10^{-3}\,M$

$mol\ H_2C_2O_4 = 5.7\times10^{-3}\,\frac{mol}{L} \times 0.02500\,L = 1.4\times10^{-4}\,mol\ H_2C_2O_4$

$mol\ NaOH = 1.4\times10^{-4}\,mol\ H_2C_2O_4 \times \frac{2\,mol\ NaOH}{1\,mol\ H_2C_2O_4} = 2.9\times10^{-4}\,mol\ NaOH$

$[NaOH] = \frac{2.9\times10^{-4}\,mol}{0.01525\,L} = 1.9\times10^{-2}\,M\ NaOH$

9. $mol\ NaOH = 0.10\,\frac{mol}{L} \times 0.01830\,L = 1.83\times10^{-3}\,mol\ NaOH$

$mol\ C_9H_8O_4 = 1.83\times10^{-3}\,mol\ NaOH \times \frac{1\,mol\ C_9H_8O_4}{1\,mol\ NaOH}$

$= 1.83\times10^{-3}\,mol\ C_9H_8O_4$

$mass\ C_9H_8O_4 = 1.83\times10^{-3}\,mol\ C_9H_8O_4 \times \frac{180\,g}{1\,mol\ C_9H_8O_4}$

$= 0.329\,g$

$\%\ mass = \frac{0.329\,g}{0.50\,g} \times 100\% = 66\%$

10. $mol\ HCl = 0.10\,\frac{mol}{L} \times 0.00725\,L = 7.25\times10^{-4}\,mol\ HCl$

$mol\ Ca(OH)_2 = 7.25\times10^{-4}\,mol\ HCl \times \frac{1\,mol\ Ca(OH)_2}{2\,mol\ HCl}$

$= 3.63\times10^{-4}\,mol\ Ca(OH)_2$

$mass\ Ca(OH)_2 = 3.63\times10^{-4}\,mol\ Ca(OH)_2 \times \frac{74.1\,g}{1\,mol\ Ca(OH)_2}$

$= 0.027\,g$

11. Volume NaOH added:

trial #1: 15.25 mL trial #2: 15.22 mL trial #3: 15.40 mL

$average\ volume = \frac{(15.25 + 15.22)}{2} = 15.24\,mL\ NaOH$

$mol\ NaOH = 0.100\,\frac{mol}{L} \times 0.01524\,L = 1.52\times10^{-3}\,mol\ NaOH$

$mol\ HA = 1.52\times10^{-3}\,mol\ NaOH \times \frac{1\,mol\ HA}{1\,mol\ NaOH} = 1.52\times10^{-3}\,mol\ HA$

$molar\ mass = \frac{0.1915\,g\ HA}{1.52\times10^{-3}\,mol\ HA} = 126\,g/mol$