4.5 You are presented with three white solids, A, B, and C, which are glucose (a sugar substance), NaOH, and AgBr. Solid A dissolves in water to form a conducting solution. B is not soluble in water. C dissolves in water to form a nonconducting solution. Identify A, B, and C.

AgBr is an ionic solid that is NOT soluble in water. Since A and C dissolve in water, B is AgBr. C dissolves in water but does not conduct a current, so it cannot be ionic. C is glucose. Substance A dissolves in water and is comprised of soluble ions. Substance A is NaOH.

4.7 Which of the following ions will *always* be a spectator ion in a precipitation reaction? Explain briefly.
(a) Cl\(^-\)  NO. Can form ppts with Ag\(^+\), Hg\(^{2+}\) and Pb\(^{2+}\).
(b) NO\(_3\)^-  YES. All nitrates are soluble.
(c) NH\(_4\)^+  YES. All ammoniums are soluble.
(d) S\(^2-\)  NO. Sulfides usually form ppts.
(e) SO\(_4\)^{2-}  NO. Sulfates usually form ppts.

4.19 Using solubility guidelines, predict whether each of the following compounds is soluble or insoluble in water:
(a) NiCl\(_2\)  SOLUBLE  most chlorides are soluble
(b) Ag\(_2\)S  INSOLUBLE  most sulfides not soluble
(c) Cs\(_3\)PO\(_4\)  SOLUBLE  while most phosphates are not soluble, Grp IA Cs\(^+\) is
(d) SrCO\(_3\)  INSOLUBLE  most carbonates not soluble
(e) PbSO\(_4\)  INSOLUBLE  most sulfates soluble, but not with Pb\(^{2+}\)

4.21 Will precipitation occur when the following solutions are mixed? If so, write a balanced chemical equation for the reaction.
(a) Na\(_2\)CO\(_3\) and AgNO\(_3\)  PPT.
\[ Na_2CO_3 (aq) + 2 AgNO_3 (aq) \rightarrow 2 NaNO_3 (aq) + Ag_2CO_3 (s) \]
(b) NaNO\(_3\) and NiSO\(_4\)  NO PPT.
(c) FeSO\(_4\) and Pb(NO\(_3\))\(_2\)  PPT.
\[ FeSO_4 (aq) + Pb(NO_3)_2 (aq) \rightarrow Fe(NO_3)_2 (aq) + PbSO_4 (s) \]
4.24 Write balanced net ionic equations for the reactions that occur in each of the following cases. Identify the spectator ion or ions in each reaction.

(a) \( \text{Cr}_2(\text{SO}_4)_3 \text{(aq)} + (\text{NH}_4)_2\text{CO}_3 \text{(aq)} \rightarrow \)

\text{dissociate compounds into ions}
\[ \text{Cr}^{3+} \text{(aq)} + 3 \text{SO}_4^{2-} \text{(aq)} + 2 \text{NH}_4^+ \text{(aq)} + 2 \text{CO}_3^{2-} \text{(aq)} \]

\text{swap partners and write neutral formulas}
\[ \text{Cr}^{3+} \text{(aq)} + 3 \text{SO}_4^{2-} \text{(aq)} + 2 \text{NH}_4^+ \text{(aq)} + 2 \text{CO}_3^{2-} \text{(aq)} \rightarrow (\text{NH}_4)_2\text{SO}_4 + \text{Cr}_2(\text{CO}_3)_3 \]

\text{balance}
\[ 2 \text{Cr}^{3+} \text{(aq)} + 3 \text{SO}_4^{2-} \text{(aq)} + 6 \text{NH}_4^+ \text{(aq)} + 3 \text{CO}_3^{2-} \text{(aq)} \rightarrow 3 (\text{NH}_4)_2\text{SO}_4 + \text{Cr}_2(\text{CO}_3)_3 \]

\text{check solubility rules}
\[ 2 \text{Cr}^{3+} \text{(aq)} + 3 \text{SO}_4^{2-} \text{(aq)} + 6 \text{NH}_4^+ \text{(aq)} + 3 \text{CO}_3^{2-} \text{(aq)} \rightarrow 3 (\text{NH}_4)_2\text{SO}_4 \text{(aq)} + \text{Cr}_2(\text{CO}_3)_3 \text{(s)} \]

\text{write net ionic to show stable product formation}
\[ 2 \text{Cr}^{3+} \text{(aq)} + 3 \text{CO}_3^{2-} \text{(aq)} \rightarrow \text{Cr}_2(\text{CO}_3)_3 \text{(s)} \]

\text{spectator ions were SO}_4^{2-} \text{(aq)} \text{ and NH}_4^+ \text{(aq)}

(b) \( \text{Ba(NO}_3)_2 \text{(aq)} + \text{K}_2\text{SO}_4 \text{(aq)} \rightarrow \)

\text{Ba}^{2+} \text{(aq)} + \text{SO}_4^{2-} \text{(aq)} \rightarrow \text{BaSO}_4 \text{(s)}

\text{spectator ions were NO}_3^- \text{ and K}^+

(c) \( \text{Fe(NO}_3)_2 \text{(aq)} + \text{KOH} \text{(aq)} \rightarrow \)

\text{Fe}^{2+} \text{(aq)} + 2 \text{OH}^- \text{(aq)} \rightarrow \text{Fe(OH)}_2 \text{(s)}

\text{spectator ions were NO}_3^- \text{ and K}^+

4.39 Complete and balance the following molecular equations, and then write the net ionic equation for each:

(a) \( \text{HBr} \text{(aq)} + \text{Ca(OH)}_2 \text{(aq)} \rightarrow \)

\[ 2 \text{HBr} \text{(aq)} + \text{Ca(OH)}_2 \text{(aq)} \rightarrow \text{CaBr}_2 \text{(aq)} + 2 \text{H}_2\text{O} \text{(l)} \]

\text{NET} \quad \text{H}^+ \text{(aq)} + \text{OH}^- \text{(aq)} \rightarrow \text{H}_2\text{O (l)}

(b) \( \text{Cu(OH)}_2 \text{(s)} + \text{HClO}_4 \text{(aq)} \rightarrow \)

\[ \text{Cu(OH)}_2 \text{(s)} + 2 \text{HClO}_4 \text{(aq)} \rightarrow \text{Cu(ClO}_4)_2 \text{(aq)} + 2 \text{H}_2\text{O} \text{(l)} \]

\text{NET} \quad \text{H}^+ \text{(aq)} + \text{OH}^- \text{(aq)} \rightarrow \text{H}_2\text{O (l)} \quad \text{(USE LOWEST RATIO)}
(c) \(\text{Al(OH)}_3 (s) + \text{HNO}_3 (aq) \rightarrow \text{Al(OH)}_3 (s) + 3 \text{HNO}_3 (aq) \rightarrow \text{Al(NO}_3)_3 (aq) + 3 \text{H}_2\text{O} (l)\)  
\[ \text{NET } \text{H}^+(aq) + \text{OH}^-(aq) \rightarrow \text{H}_2\text{O} (l) \]

4.43 Write a balanced molecular equation and a net ionic equation for the reaction that occurs when
(a) solid \(\text{CaCO}_3\) reacts with an aqueous solution of nitric acid

\[\text{CaCO}_3 (s) + 2 \text{HNO}_3 (aq) \rightarrow \text{Ca(NO}_3)_2 (aq) + \text{H}_2\text{O} (l) + \text{CO}_2 (g)\]

acceptable answer for NET IONIC is…

\[\text{NET } \text{CO}_3^{2-}(aq) + 2 \text{H}^+(aq) \rightarrow \text{H}_2\text{O} (l) + \text{CO}_2 (g) \text{ (STABLE PRODUCTS)}\]

[officially \(2\text{H}^+(aq) + \text{CaCO}_3 (s) \rightarrow \text{H}_2\text{O} (l) + \text{CO}_2 (g) + \text{Ca}^{2+}(aq)\) since not all aqueous]

(b) solid iron(II) sulfide reacts with an aqueous solution of hydrobromic acid

\[\text{FeS} (s) + \text{HBr} (aq) \rightarrow \text{FeBr}_2 (aq) + \text{H}_2\text{S} (g)\]

acceptable answer for NET IONIC is…

\[\text{S}^{2-}(aq) + 2 \text{H}^+(aq) \rightarrow \text{H}_2\text{S} (g)\]

[officially \(2\text{H}^+(aq) + \text{FeS} (s) \rightarrow \text{H}_2\text{S} (g) + \text{Fe}^{2+}(aq)\) since not all aqueous]

4.45 Define oxidation and reduction in terms of
(a) electron transfer  
OXIDATION IS LOSS of e^-
REDUCTION IS GAIN of e^-  "OIL RIG"

(b) oxidation numbers
OXIDATION IS INCREASE IN OX #
REDUCTION IS DECREASE IN OX #

4.49 Determine the oxidation number for the indicated element in each of the following substances:
(a) \(\text{S} \text{ in } \text{SO}_2 \quad \text{S} = +4\)
(b) \(\text{C} \text{ in } \text{COCl}_2 \text{ (note: NOT Co) } \quad \text{C} = +4 \text{ (assign O, then Cl, then C)}\)
(c) \(\text{Mn} \text{ in } \text{MnO}_4^- \quad \text{Mn} = +7 \text{ (take charge of ion into account)}\)
(d) \(\text{Br} \text{ in } \text{HBrO} \quad \text{Br} = +1 \text{ (assign O, then Br)}\)

4.51 Which element is oxidized and which is reduced in the following reactions?
(a) \(\text{N}_2 (g) + 3 \text{H}_2 (g) \rightarrow 2 \text{NH}_3 (g)\)
assign OX #'s first
\[
\begin{array}{c|c|c}
\text{N}_2 & \text{0} & 0 \\
\text{H}_2 & -3 & +1 \\
\end{array}
\]

\[\text{N}_2 (g) + 3 \text{H}_2 (g) \rightarrow 2 \text{NH}_3 (g) \quad \text{ignore coefficients for this application}\]

\(\text{H} \text{ atom (0 to +1) oxidized}\)
\(\text{N} \text{ atom (0 to -3) reduced}\)
(b) $3 \text{Fe(NO}_3\text{)}_2 \text{(aq)} + 2 \text{Al (s)} \rightarrow 3 \text{Fe (s)} + 2 \text{Al(NO}_3\text{)}_3 \text{(aq)}$

\[
\begin{array}{cccc}
+2 & +5 & -2 & 0 \\
+3 & +5 & -2 & 0 \\
\end{array}
\]

$3 \text{Fe(NO}_3\text{)}_2 \text{(aq)} + 2 \text{Al (s)} \rightarrow 3 \text{Fe (s)} + 2 \text{Al(NO}_3\text{)}_3 \text{(aq)}$

**Al atom** (0 to +3) oxidized
**Fe atom** (+2 to 0) reduced

**ADDITIONAL EXERCISE #2**
Examine the following reactions and identify whether or not a REDOX (oxidation-reduction) reaction has occurred.

If REDOX has occurred, report the following:
- the atom oxidized
- the atom reduced
- the oxidizing agent
- the reducing agent

\[
\begin{array}{cccc}
+4 & -1 & 0 & +2 -1 & 0 \\
\end{array}
\]

A) $\text{SiCl}_4 + 2 \text{Mg} \rightarrow 2 \text{MgCl}_2 + \text{Si}$

**Mg atom** (0 to +2) oxidized, Mg is reducing agent
**Si atom** (+4 to 0) reduced, $\text{SiCl}_4$ is oxidizing agent

\[
\begin{array}{cccc}
+4 & -1 & +1 -2 & +1 -1 & +4 -2 \\
\end{array}
\]

B) $\text{SiCl}_4 + 2 \text{H}_2\text{O} \rightarrow 4 \text{HCl} + \text{SiO}_2$

**NO REDOX**

**ADDITIONAL EXERCISE #3**
Use the Activity Series (Table 4.5) to predict the outcome (if any) of each of the following reactions:

**ANY METAL ON LIST CAN BE OXIDIZED BY THE IONS OF AN ELEMENT BELOW IT.**

a) $\text{Cr (s)} + 3 \text{AgNO}_3 \rightarrow \text{Cr(NO}_3\text{)}_3 \text{(aq)} + \text{Ag (s)}$ because Ag ion is below Cr on list

b) $\text{Fe (s)} + \text{Mn}^{+2} \rightarrow \text{NR}$ because Mn ion is above Fe on list

4.61 (a) Calculate the molarity of a solution that contains 0.0250 mol $\text{NH}_4\text{Cl}$ in exactly 500. mL of solution.

\[
\text{M} = \frac{\text{mol solute}}{\text{L sol'n}} = 0.0250 \text{ mol} / 0.500 \text{ L} = 0.0500 \text{ mol/L or } \text{M (Did you convert mL to L?)}
\]

(b) How many moles of $\text{HNO}_3$ are present in 50.0 mL of a 2.50 M solution of nitric acid?

\[
\text{convert mL} \text{ to } \text{L while maintaining SF} = \frac{50.0 \text{ mL}}{1 \text{ L}} \times \frac{1000 \text{ mL}}{1 \text{ L}} = 0.0500 \text{ L}
\]

\[
\text{M} = \frac{\text{mol solute}}{\text{L sol'n}} \text{ rearrange to } \text{mol solute} = \text{M} \times \text{L} = 2.50 \text{ M} (0.0500 \text{ L});
\]

\[
\text{convert } \text{M} \text{ to its units of mol/L; L cancels ANSWER: 0.125 mol}
\]
(c) How many milliliters of 1.50 M KOH solution are needed to provide 0.275 mol of KOH?

\[ M = \frac{\text{mol solute}}{\text{L sol'n}} \text{ so rearrange to } L = \frac{\text{mol solute}}{M} \]

\[ L = \frac{0.275 \text{ mol}}{(1.50 \text{ mol/L})} = 0.183 \text{ L; convert to 183 mL} \]

4.67 Calculate (b) the molar concentration of a solution containing 14.75 g of Ca(NO\(_3\))\(_2\) in 1.375 L

\[ M = \frac{\text{mol solute}}{\text{L sol'n}} \text{ convert grams to moles} \]

\[ \begin{align*}
\text{Ca} & \times 40.08 = 40.08 \\
\text{N} & \times 14.01 = 28.02 \\
\text{O} & \times 16.00 = 96.00 \\
\text{sum} & = 164.10 \text{ g/mol} \\
\end{align*} \]

\[ \frac{(14.75 \text{ g}) \times (1 \text{ mol Ca(NO}_3\text{)}_2) / 164.10 \text{ g}}{1.375 \text{ L}} = 0.065370 = 0.06537 \text{ mol/L (4 SF)} \]

4.69 (a) Which will have the highest concentration of potassium ion: 0.20 M KCl, 0.15 M K\(_2\)CrO\(_4\), or 0.080 M K\(_3\)PO\(_4\)?

Beware of dissociation!

<table>
<thead>
<tr>
<th>Solution</th>
<th>Molar Concentration</th>
<th>K(^+) Concentration</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.20 M KCl</td>
<td>1 X 0.20 mol/L = 0.20 M K(^+)</td>
<td>0.20 M K(^+)</td>
</tr>
<tr>
<td>0.15 M K(_2)CrO(_4)</td>
<td>2 X 0.15 mol/L = 0.30 M K(^+)</td>
<td>0.30 M K(^+)</td>
</tr>
<tr>
<td>0.080 M K(_3)PO(_4)</td>
<td>3 X 0.080 mol/L = 0.24 M K(^+)</td>
<td>0.24 M K(^+)</td>
</tr>
</tbody>
</table>

0.15 M K\(_2\)CrO\(_4\) has the highest potassium ion concentration

4.73 (a) You have a stock solution of 14.8 M NH\(_3\). How many milliliters of this solution should you dilute to make 1000.0 mL of 0.250 M NH\(_3\)?

\[ C_iV_i = C_fV_f \]

\[ C_i = 14.8 \text{ M} \]

\[ V_f = 1000.0 \text{ mL} \]

\[ C_f = 0.250 \text{ M} \]

SOLVE THE ALGEBRA! \[ V_i = \frac{C_fV_f}{C_i} \]

\[ V_i = \frac{(0.250 \text{ M}) (1000.0 \text{ mL})}{14.8 \text{ M}} = 16.891 \text{ mL} = 16.9 \text{ mL (3 SF)} \]

Check work: You have more volume and lesser concentration at end.
4.81 (a) What volume of 0.115 M HClO₄ solution is needed to neutralize 50.00 mL of 0.0875 M NaOH?

Start your calculation by writing a balanced chemical equation:

\[ 1 \text{ NaOH} + 1 \text{ HClO}_4 \rightarrow \text{H}_2\text{O} + \text{NaClO}_4 \]

Start the math with the item you know the most about (both volume and molarity here). Don’t forget to convert mL to L so you can use molarity concepts. FOLLOW THE LABELS! RELATE MOLES OF ACID TO MOLES OF BASE.

\[
50.00 \text{ mL (1 L / 1000 mL)} = 0.05000 \text{ L} \\
0.05000 \text{ L NaOH} \frac{(0.0875 \text{ mol NaOH})}{(1 \text{ L NaOH})} \frac{(1 \text{ mol HClO}_4)}{(1 \text{ mol NaOH})} = 0.115 \text{ mol HClO}_4 \\
= 0.0380 \text{ L or 38.0 mL}
\]

(b) What volume of 0.128 M HCl is needed to neutralize 2.87 g of Mg(OH)₂?

BEWARE! "DIBASIC" COMPOUND!

Start your calculation by writing a balanced chemical equation:

\[ 1 \text{ Mg(OH)}_2 + 2 \text{ HCl} \rightarrow 2\text{H}_2\text{O} + \text{MgCl}_2 \]

You will be converting grams to moles of Mg(OH)₂:

\[
\begin{align*}
\text{Mg} & \quad 1 \times 24.31 = 24.31 \\
\text{O} & \quad 2 \times 16.00 = 32.00 \\
\text{H} & \quad 2 \times 1.01 = 2.02 \\
\text{sum} & \quad 58.33 \text{ g/mol}
\end{align*}
\]

\[
2.87 \text{ g Mg(OH)}_2 \frac{(1 \text{ mol Mg(OH)}_2)}{(58.33 \text{ g Mg(OH)}_2)} \frac{(2 \text{ mol HCl})}{(1 \text{ mol Mg(OH)}_2)} \frac{(1 \text{ L HCl})}{(0.128 \text{ mol HCl})} = 0.76879 \text{ L} = 0.769 \text{ L or 769 mL (3 SF)}
\]