Calculations for Solutions Worksheet and Key

1) 23.5g of NaCl is dissolved in enough water to make .683 L of solution.
   a) What is the molarity (M) of the solution?

   b) How many moles of NaCl are contained in 0.0100 L of the above NaCl solution?

   c) What volume (L) of this NaCl solution would contain 0.200 moles of NaCl?

2) 12.5g of glucose (C₆H₁₂O₆) is dissolved in enough water to make 750.0 mL of solution.
   a) What is the molarity (M) of the solution?

   b) How many moles of glucose are contained in 237 mL of the above glucose solution?

   c) What volume (L) of this glucose solution would contain 0.079 moles of glucose?
3) 45.7 g of magnesium chloride (MgCl₂) is dissolved in 2.40 kg of water.

   a) What is the molality (m) of the solution?

   b) How many moles of MgCl₂ are contained in 1.76 kg of solvent?

   c) How many kg of solvent would contain 0.0150 moles of MgCl₂?

4) 114.5 g of KCl is dissolved in enough water to make 3.6 L of solution.

   a) How many osmoles are in one mole of KCl when it dissolves?

   b) What is the osmolarity of the solution?

   c) How many osmoles are contained in 1.00 L of the above potassium chloride solution?

   d) How many liters (L) of this potassium chloride solution would contain 0.350 osmoles?
5) 7.58 g of 2-propanol (C₃H₈O) is added to enough water to make 1.50 L of solution.

   a) How many osmoles are in one mole of 2-propanol when it dissolves?

   b) What is the osmolarity of the solution?

   c) How many osmoles are contained in 25.00 mL of the above 2-propanol solution?

   d) How many liters (L) of this 2-propanol solution would contain 0.00575 osmoles?

6) 46.0 g of barium nitrate is dissolved in 2.60 kg of water.

   a) How many osmoles are in one mole of barium nitrate when it dissolves?

   b) What is the osmolality of the solution?

7) A glucose (C₆H₁₂O₆) solution is prepared by adding 5.00 grams of glucose to enough water to make 200.0 mL of solution.

   a) What is the %(w/v) of the solution?

   b) What volume (mL) of this solution would contain 0.0735 grams of glucose?

   c) How many grams of glucose would be present in 185 mL of this solution?
8) 234.5 g of KCl is dissolved in enough water to make 3.6 L of solution.
   
   a) How many **equivalents of potassium (K⁺)** are in **one mole** of KCl when it dissolves?  
   *(note: you are concerned with the Eq from K⁺ **only**, do not include Eq from Cl⁻)*
   
   b) What is the concentration of **potassium** in (Eq/L)?
   
   c) How many **equivalents (Eq)** of K⁺ are contained in 0.700 L of the above potassium chloride solution?
   
   d) How many liters (L) of this potassium chloride solution would contain 0.050 **equivalents Eq of K⁺**?

9) 0.250 g of aluminum sulfate is dissolved in enough water to make 150 mL of solution.
   
   a) How many **equivalents of sulfate ion (SO₄²⁻)** are in **one mole** of aluminum sulfate when it dissolves?  
   *(note: you are concerned with the Eq from SO₄²⁻ **only**, do not include Eq from Al⁺)*
   
   b) What is the concentration of **sulfate** in (Eq/L)?
   
   c) How many **equivalents (Eq)** of SO₄²⁻ are contained in 0.0280 L of the above aluminum sulfate solution?
   
   d) How many liters (L) of this aluminum sulfate solution would contain 0.0025 **equivalents Eq of SO₄²⁻**?
### Molarity calculations (fill-in all the boxes)

<table>
<thead>
<tr>
<th>solute</th>
<th>moles of solute</th>
<th>grams of solute</th>
<th>volume of solution</th>
<th>Concentration (Molarity, M=mole/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NaCl</td>
<td>3.00 moles</td>
<td></td>
<td>0.500 L</td>
<td></td>
</tr>
<tr>
<td>NaCl</td>
<td></td>
<td>13.5 g</td>
<td>0.150 L</td>
<td></td>
</tr>
<tr>
<td>NaCl</td>
<td>0.375 moles</td>
<td></td>
<td></td>
<td>1.00 M</td>
</tr>
<tr>
<td>NaCl</td>
<td></td>
<td>0.059 g</td>
<td></td>
<td>0.30 M</td>
</tr>
<tr>
<td>KNO₃</td>
<td>1.57 moles</td>
<td></td>
<td></td>
<td>0.770 M</td>
</tr>
<tr>
<td>KNO₃</td>
<td></td>
<td>1.98 g</td>
<td></td>
<td>2.00 M</td>
</tr>
<tr>
<td>KNO₃</td>
<td></td>
<td></td>
<td>0.288 L</td>
<td>0.197 M</td>
</tr>
</tbody>
</table>

### Osmolarity calculations

<table>
<thead>
<tr>
<th>solute</th>
<th>moles of solute</th>
<th>osmoles of solute</th>
<th>grams of solute</th>
<th>volume of solution</th>
<th>Concentration (Osmolar = osmole/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>KCl</td>
<td>2.40 moles</td>
<td></td>
<td></td>
<td>0.600 L</td>
<td></td>
</tr>
<tr>
<td>KCl</td>
<td></td>
<td>1.5 g</td>
<td></td>
<td>0.750 L</td>
<td></td>
</tr>
<tr>
<td>KCl</td>
<td>0.050 moles</td>
<td></td>
<td></td>
<td></td>
<td>1.00 osmolar</td>
</tr>
<tr>
<td>KCl</td>
<td></td>
<td>0.892 g</td>
<td></td>
<td></td>
<td>0.150 osmolar</td>
</tr>
<tr>
<td>glucose C₆H₁₂O₆</td>
<td>1.50 moles</td>
<td></td>
<td></td>
<td>0.600 L</td>
<td>1.22 osmolar</td>
</tr>
<tr>
<td>glucose C₆H₁₂O₆</td>
<td></td>
<td>1.17 g</td>
<td></td>
<td>0.375 L</td>
<td>0.0100 osmolar</td>
</tr>
<tr>
<td>glucose C₆H₁₂O₆</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.0750 osmolar</td>
</tr>
</tbody>
</table>
1) 23.5g of NaCl is dissolved in enough water to make .683 L of solution.
   a) What is the molarity \((M)\) of the solution?

   Molar mass of NaCl = 58.44 g/mole

   Moles of NaCl:
   \[
   \frac{23.5 \text{ g NaCl}}{58.44 \text{ g NaCl}} = \frac{0.402 \text{ moles NaCl}}{0.683 \text{ L of solution}}
   \]

   Molarity \(= \frac{\text{moles}}{\text{liter solution}} = \frac{0.402 \text{ moles NaCl}}{0.683 \text{ L of solution}} = 0.589 \text{ M NaCl}\)

   b) How many moles of NaCl are contained in 0.0100 L of the above NaCl solution?

   \[
   \frac{0.0100 \text{ L solution}}{0.589 \text{ moles NaCl}} = 0.00589 \text{ mole NaCl}
   \]

   • Note: The concentration gives us the relationship between the amount of solute and the amount of
     solution....we use the concentration as a conversion factor!!!!!

   c) What volume \((L)\) of this NaCl solution would contain 0.200 moles of NaCl?

   \[
   \frac{0.200 \text{ moles of NaCl}}{0.589 \text{ moles NaCl}} = 0.340 \text{ L of solution}
   \]

2) 12.5g of glucose \((C_6H_{12}O_6)\) is dissolved in enough water to make 750.0 mL of solution.
   a) What is the molarity \((M)\) of the solution?

   Molar mass of glucose = 180.18 g/mole

   Moles of glucose:
   \[
   \frac{12.5 \text{ g glucose}}{180.18 \text{ g glucose}} = \frac{0.0694 \text{ moles glucose}}{0.7500 \text{ L of solution}}
   \]

   Molarity \(= \frac{\text{moles}}{\text{liter solution}} = \frac{0.0694 \text{ moles glucose}}{0.7500 \text{ L of solution}} = 0.0925 \text{ M glucose}\)

   b) How many moles of glucose are contained in 237 mL of the above glucose solution?

   \[
   \frac{0.237 \text{ L solution}}{0.0925 \text{ moles glucose}} = 0.219 \text{ mole glucose}
   \]
c) What volume (L) of this glucose solution would contain 0.079 moles of glucose?

\[
\begin{array}{ccc}
0.079 \text{ moles glucose} & | & \text{L of solution} & | & = 0.85 \text{ L of solution} \\
0.0925 \text{ moles glucose} & & & & \\
\end{array}
\]

3) 45.7 g of magnesium chloride (\(\text{MgCl}_2\)) is dissolved in 2.40 kg of water.

a) What is the molality (\(m\)) of the solution?

Molar mass of \(\text{MgCl}_2\) = 95.21 g/mole

Moles of \(\text{MgCl}_2\):

\[
\frac{45.7 \text{ g} \text{MgCl}_2}{95.21 \text{ g} \text{MgCl}_2} = 0.480 \text{ moles MgCl}_2
\]

Molality = \(\frac{\text{moles}}{\text{kg of solvent}}\) = \(\frac{0.480 \text{ moles MgCl}_2}{2.40 \text{ kg of solvent}} = 0.200 \text{ mol MgCl}_2 / \text{kg} = 0.200 \text{ } m \text{MgCl}_2\)

b) How many moles of \(\text{MgCl}_2\) are contained in 1.76 kg of solvent?

\[
\begin{array}{ccc}
\text{Concentration of the solution} & & \\
\text{1.76 kg solvent} & | & 0.200 \text{ moles MgCl}_2 & | & = 0.352 \text{ moles MgCl}_2 \\
\text{1 kg of solvent} & & & & \\
\end{array}
\]

c) How many kg of solvent would contain 0.0150 moles of \(\text{MgCl}_2\)?

\[
\begin{array}{ccc}
\text{Concentration of the solution} & & \\
0.0150 \text{ moles MgCl}_2 & | & 0.200 \text{ moles MgCl}_2 & | & = 0.0750 \text{ kg of solvent} \\
1 \text{ kg of solvent} & & & & \\
\end{array}
\]

4) 114.5 g of KCl is dissolved in enough water to make 3.6 L of solution.

a) How many osmoles are in one mole of KCl when it dissolves?

\(\text{one mole of KCl} = 2 \text{ osmoles}\)

- This relationship can be used as a conversion factor to convert between moles and osmoles:

\[
\begin{align*}
\text{2 osmoles} & \quad \text{or} \quad \frac{1 \text{ mole KCl}}{2 \text{ osmoles}} \\
\end{align*}
\]
b) What is the osmolarity of the solution?

- First get the moles of KCl then convert to osmoles:
  Molar mass of KCl = 74.55 g/mole
  
  Osmoles in solution:
  
  \[
  \frac{114.5 \text{ g KCl}}{74.55 \text{ g KCl}} \times 1 \text{ mole KCl} = 2 \text{ osmoles}
  \]

  Osmolarity = \(\frac{\text{osmoles}}{\text{L of solution}}\) = \(\frac{3.072 \text{ osmoles}}{3.6 \text{ L of solution}}\) = 0.85 osmoles /L solution = \textbf{0.85 osmolar}


c) How many osmoles are contained in 1.00 L of the above potassium chloride solution?

\[
\frac{1.00 \text{ L solution}}{0.85 \text{ osmoles}} = \frac{0.85 \text{ osmoles}}{1 \text{ L of solution}}
\]

As in the case of molarity (M) and molality (m), the concentration (osmolarity this time) gives us the relationship between the amount of solute and the amount of solution...we use the concentration as a conversion factor!!!!

d) How many liters (L) of this potassium chloride solution would contain 0.350 osmoles?

\[
\frac{0.350 \text{ osmoles}}{0.85 \text{ osmoles}} = \frac{0.41 \text{ L of solution}}{1 \text{ L of solution}}
\]

5) 7.58 g of 2-propanol (C₃H₈O) is added to enough water to make 1.50 L of solution.

a) How many osmoles are in one mole of 2-propanol when it dissolves?

one mole of 2-propanol = one osmole (2-propanol does not dissociate into ions)

b) What is the osmolarity of the solution?

Molar mass of 2-propanol = 60.11 g/mole

Osmoles in solution:

\[
\frac{7.58 \text{ g 2-propanol}}{60.11 \text{ g 2-propanol}} \times 1 \text{ mole 2-propanol} = 1 \text{ osmole}
\]

Osmolarity = \(\frac{\text{osmoles}}{\text{L of solution}}\) = \(\frac{0.126 \text{ osmoles}}{1.50 \text{ L of solution}}\) = 0.0840 osmoles /L solution = \textbf{0.0840 osmolar}
c) How many osmoles are contained in 25.00 mL of the above 2-propanol solution?

$$\frac{0.02500 \ \text{L of solution}}{0.0840 \ \text{osmoles}} = 0.00210 \ \text{osmoles}$$

d) How many liters (L) of this 2-propanol solution would contain 0.00575 osmoles?

$$\frac{0.00575 \ \text{osmoles}}{0.0840 \ \text{osmoles}} = 0.0685 \ \text{L of solution}$$

6) 46.0 g of barium nitrate is dissolved in 2.60 kg of water.

a) How many osmoles are in one mole of barium nitrate when it dissolves?

one mole of Ba(NO$_3$)$_2$ = 3 osmoles
- Ba(NO$_3$)$_2$ dissociates into 3 particles, one Ba$^{2+}$ ion and 2 nitrate ions
- This relationship can be used as a conversion factor to convert between moles and osmoles:

$$\left( \frac{3 \ \text{osmoles}}{1 \ \text{mole Ba(NO$_3$)$_2$}} \right) \ \text{or} \ \left( \frac{1 \ \text{mole Ba(NO$_3$)$_2$}}{3 \ \text{osmoles}} \right)$$

b) What is the osmolality of the solution?

Molar mass of Ba(NO$_3$)$_2$ = 261.35 g/mole
- Osmoles in solution:

$$\frac{46.0 \ \text{g Ba(NO$_3$)$_2$}}{261.35 \ \text{g Ba(NO$_3$)$_2$}} \cdot \frac{1 \ \text{mole Ba(NO$_3$)$_2$}}{1 \ \text{mole Ba(NO$_3$)$_2$}} \cdot \frac{3 \ \text{osmoles}}{1 \ \text{mole Ba(NO$_3$)$_2$}} = 0.528 \ \text{osmoles Ba(NO$_3$)$_2$}$$

Osmolality = $$\frac{0.528 \ \text{osmoles}}{2.60 \ \text{kg of solvent}} = 0.203 \ \text{osmoles/kg}$$

= 0.203 osmolal

7) A glucose (C$_6$H$_{12}$O$_6$) solution is prepared by adding 5.00 grams of glucose to enough water to make 200.0 ml of solution.

a) What is the % (w/v) of the solution?

$$\%(\text{w/v}) = \left( \frac{\text{g solute}}{\text{mL of solution}} \right) \times 100 = \left( \frac{5.00 \ \text{g glucose}}{200.0 \ \text{mL}} \right) \times 100\% = 2.50 \% (\text{w/v})$$
b) What volume (mL) of this solution would contain 0.0735 grams of glucose?
   - Use the concentration as a conversion factor!

\[
\frac{0.0735 \text{ g glucose}}{2.50 \text{ g glucose}} = \frac{100. \text{ mL}}{2.50 \text{ mL}} = \frac{2.94 \text{ mL of solution}}{100. \text{ mL}}
\]

Note: 2.50 % (w/v) means there are 2.50 g in 100 mL of solution = your conversion factor.

c) How many grams of glucose would be present in 185 mL of this solution?
   - Use the concentration as a conversion factor!

\[
\frac{185 \text{ mL of solution}}{100. \text{ mL of solution}} = \frac{2.50 \text{ g glucose}}{100. \text{ mL of solution}} = \frac{4.63 \text{ g glucose}}{100. \text{ mL of solution}}
\]

8) 234.5 g of KCl is dissolved in enough water to make 3.6 L of solution.

a) How many **equivalents of potassium (K^+)** are in one mole of KCl when it dissolves?
   - **One mole of KCl = 1 Eq K^+ (recall that an equivalent is a mole of charge)**
   - This relationship can be used as a conversion factor to convert between moles and equivalents:

\[
\left( \frac{1 \text{ Eq K}^+}{1 \text{ mole KCl}} \right) \text{ or } \left( \frac{1 \text{ mole KCl}}{1 \text{ Eq K}^+} \right)
\]

b) What is the concentration from potassium in (Eq K^+/L)?
   - First get the moles of KCl then convert **equivalents (Eq)**:
   - Molar mass of KCl = 74.55 g/mole
   
   \[
   \begin{array}{ccc}
   234.5 \text{ g KCl} & \rightarrow & 1 \text{ mole KCl} \\
   74.55 \text{ g KCl} & \rightarrow & 1 \text{ mole KCl} \\
   \end{array}
   \]
   
   \[
   \frac{1 \text{ Eq K}^+}{1 \text{ mole KCl}} = 3.146 \text{ Eq K}^+ \]
   
   \[
   \left( \frac{\# \text{ Eq K}^+}{\text{L of solution}} \right) = \left( \frac{3.146 \text{ Eq K}^+}{3.6 \text{ L of solution}} \right) = 0.87 \text{ Eq K}^+/L \text{ solution}
   \]
c) How many _equivalents Eq of K⁺_ are contained in 0.700 L of the above potassium chloride solution?

- As in the case of molarity (M), the concentration (Eq/L this time) gives us the relationship between the _amount of solute_ and the _amount of solution_. We use the _concentration_ as a conversion factor!

\[
\begin{array}{c|c|c}
0.700 \text{ L solution} & 0.87 \text{ Eq K}^+ & = 0.61 \text{ Eq K}^+
\end{array}
\]

**Concentration of potassium ions in solution**

\[
\begin{array}{c|c}
0.050 \text{ Eq K}^+ & 1 \text{ L of solution}
\end{array}
\]

\[
\begin{array}{c}
0.87 \text{ Eq K}^+
\end{array}
\]

= 0.057 L of solution

\[
0.250 \text{ g of aluminum sulfate is dissolved in enough water to make 150 mL of solution.}
\]

\[
\begin{array}{c}
a) \text{ How many _equivalents of sulfate ion (SO}_4^{2-}\text{)_ are in one mole of aluminum sulfate when it dissolves?}
\end{array}
\]

\[
\text{one mole of Al}_2(\text{SO}_4)_3 = 6 \text{ Eq SO}_4^{2-} \quad \text{(recall that an equivalent is a mole of charge/mole of compound)}
\]

- 3 moles sulfate ions x (2 moles of charge/1 mole sulfate ions) = 6 Eq

\[
\begin{array}{c}
\text{This relationship can be used as a _conversion factor_ to convert between moles and equivalents:}
\end{array}
\]

\[
\begin{array}{c}
\left(\frac{6 \text{ Eq SO}_4^{2-}}{1 \text{ mole Al}_2(\text{SO}_4)_3}\right) \quad \text{or} \quad \left(\frac{1 \text{ mole Al}_2(\text{SO}_4)_3}{6 \text{ Eq SO}_4^{2-}}\right)
\end{array}
\]

\[
\begin{array}{c}
b) \text{ What is the concentration of sulfate in (Eq/L)?}
\end{array}
\]

\[
\text{First get the moles of Al}_2(\text{SO}_4)_3\text{ then convert _equivalents (Eq):}
\]

\[
\text{Molar mass of Al}_2(\text{SO}_4)_3 = 342.17 \text{ g/mole}
\]

\[
\text{Equivalents (Eq) in solution :}
\]

\[
\begin{array}{c|c|c}
0.250 \text{ g Al}_2(\text{SO}_4)_3 & 1 \text{ mole Al}_2(\text{SO}_4)_3 & 6 \text{ Eq SO}_4^{2-}\n\end{array}
\]

\[
\begin{array}{c|c|c}
342.17 \text{ g Al}_2(\text{SO}_4)_3 & 1 \text{ mole Al}_2(\text{SO}_4)_3 & 1 \text{ mole Al}_2(\text{SO}_4)_3
\end{array}
\]

\[
\left(\frac{0.00438 \text{ Eq SO}_4^{2-}}{0.15 \text{ L of solution}}\right) = 0.029 \text{ Eq SO}_4^{2-}/\text{L solution}
\]
c) How many equivalents (Eq) of $SO_4^{2-}$ are contained in 0.0280 L of the above aluminum sulfate solution?

- As in the case of molarity (M), the concentration (Eq/L in this case) gives us the relationship between the amount of solute and the amount of solution....we use the concentration as a conversion factor!!!!

\[
\begin{array}{c|c}
\text{Concentration of sulfate ions in solution} & \\
0.0280 \text{ L solution} & 0.029 \text{ Eq } SO_4^{2-} \\
\hline
\text{L of solution} & 0.00081 \text{ Eq } SO_4^{2-}
\end{array}
\]

d) How many liters (L) of this aluminum sulfate solution would contain 0.0025 equivalents Eq of $SO_4^{2-}$?

\[
\begin{array}{c|c|c}
0.0025 \text{ Eq } SO_4^{2-} & 1 \text{ L of solution} & = 0.086 \text{ L of solution} \\
\hline
0.029 \text{ Eq } SO_4^{2-} &
\end{array}
\]
### Molarity calculations (fill-in all the boxes)

<table>
<thead>
<tr>
<th>solute</th>
<th>moles of solute</th>
<th>grams of solute</th>
<th>volume of solution</th>
<th>Concentration (Molarity, M=mole/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NaCl</td>
<td>3.00 moles</td>
<td>175 g</td>
<td>0.500 L</td>
<td>6.00 M</td>
</tr>
<tr>
<td>NaCl</td>
<td>.231 moles</td>
<td>13.5 g</td>
<td>.150 L</td>
<td>1.54 M</td>
</tr>
<tr>
<td>NaCl</td>
<td>.375 moles</td>
<td>21.9 g</td>
<td>.375 L</td>
<td>1.00 M</td>
</tr>
<tr>
<td>NaCl</td>
<td>.0010 moles</td>
<td>.059 g</td>
<td>.0033 L</td>
<td>0.30 M</td>
</tr>
<tr>
<td>KNO₃</td>
<td>1.57 moles</td>
<td>159 g</td>
<td>2.04 L</td>
<td>.770 M</td>
</tr>
<tr>
<td>KNO₃</td>
<td>.0196 moles</td>
<td>1.98 g</td>
<td>.00980 L</td>
<td>2.00 M</td>
</tr>
<tr>
<td>KNO₃</td>
<td>.0567 moles</td>
<td>5.73 g</td>
<td>.288 L</td>
<td>.197 M</td>
</tr>
</tbody>
</table>

### Osmolarity calculations

<table>
<thead>
<tr>
<th>solute</th>
<th>moles of solute</th>
<th>osmoles of solute</th>
<th>grams of solute</th>
<th>volume of solution</th>
<th>Concentration (Osmolar = Osmole/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>KCl</td>
<td>2.40 moles</td>
<td>4.80 osmoles</td>
<td>179 g</td>
<td>0.600 L</td>
<td>8.00 osmolar</td>
</tr>
<tr>
<td>KCl</td>
<td>0.020 moles</td>
<td>0.040 osmoles</td>
<td>1.5 g</td>
<td>0.750 L</td>
<td>0.053 osmolar</td>
</tr>
<tr>
<td>KCl</td>
<td>.050 moles</td>
<td>0.10 osmoles</td>
<td>3.7 g</td>
<td>0.10 L</td>
<td>1.00 osmolar</td>
</tr>
<tr>
<td>KCl</td>
<td>0.0120 moles</td>
<td>0.0240 osmoles</td>
<td>0.892 g</td>
<td>0.160 L</td>
<td>0.150 osmolar</td>
</tr>
<tr>
<td>glucose C₆H₁₂O₆</td>
<td>1.50 moles</td>
<td>1.50 osmoles</td>
<td>270. g</td>
<td>1.23 L</td>
<td>1.22 osmolar</td>
</tr>
<tr>
<td>glucose C₆H₁₂O₆</td>
<td>0.00649 moles</td>
<td>0.00649 osmoles</td>
<td>1.17 g</td>
<td>.649 L</td>
<td>0.0100 osmolar</td>
</tr>
<tr>
<td>glucose C₆H₁₂O₆</td>
<td>0.0281 moles</td>
<td>0.0281 osmoles</td>
<td>5.06 g</td>
<td>0.375 L</td>
<td>0.0750 osmolar</td>
</tr>
</tbody>
</table>