

Chemistry 1

Volume 3

Worksheet 2

Calculating Ion Concentrations in Solutions

1. What is the concentration of lithium ions in a 1.45 M solution of Li_3PO_4 ?

2. What is the concentration of NO_3^- in a 0.65 M solution of barium nitrate?

3. When CaCl_2 is dissolved in water, the resulting concentration of Cl^- is 0.15 M. What was the concentration of the original solution?

4. 1.00 L of a 0.25 M solution of CdCl_2 was mixed with 1.00 L of a 0.10 M solution of LiCl . What is the concentration of cadmium, lithium, and chlorine ions in the mixed solution?

5. A solution was obtained by dissolving 1.1 g NaCl and 0.25 g MgCl₂ in 0.50 L of water. What is the concentration of Cl⁻ in the final solution?

6. What is [OH⁻] when 0.66 g NaOH is dissolved in 150 mL water?

7. NaCl and LiCl were dissolved in a solution, and the final $[\text{Cl}^-]$ is 0.15 M. If the original $[\text{NaCl}]$ was 0.10 M, what was the original concentration of LiCl?

8. How many moles of strontium chloride were used to create a 0.15 L solution where $[\text{Cl}^-] = 0.88 \text{ M}$?

9. A chemist wants a final solution of $0.16 \text{ M } [\text{Br}^-]$ with a volume of 0.150 L created from a 0.55 M LiBr solution. What volume of the original solution should be diluted to obtain this concentration?

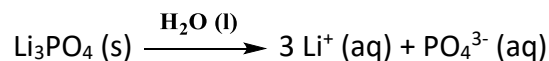
10. **Challenge:** What is the total ion concentration in a solution created by dissolving 0.55 g LiNO_3 in 1.5 L water?

Answer Key

1. What is the concentration of lithium ions in a 1.45 M solution of Li_3PO_4 ?

Step 1:

Write the balanced equation for the dissolution:



Step 2:

For every 1 mole of Li_3PO_4 , 3 moles of Li^+ are formed. Use this as the conversion factor to calculate the Li^+ concentration from the original solution molarity.

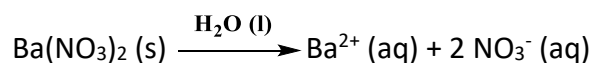
$$\frac{1.45 \text{ mol Li}_3\text{PO}_4}{1 \text{ L}} \left| \frac{3 \text{ mol Li}^+}{1 \text{ mol Li}_3\text{PO}_4} \right| = 4.35 \text{ M Li}^+$$

Correct answer: 4.35 M Li^+

2. What is the concentration of NO_3^- in a 0.65 M solution of barium nitrate?

Step 1:

Write the balanced equation for this process:



Step 2:

Convert moles of $\text{Ba}(\text{NO}_3)_2$ into moles of NO_3^- using the conversion factor of 1 mole of $\text{Ba}(\text{NO}_3)_2$ for every 2 moles NO_3^- .

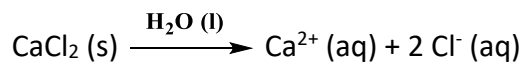
$$\frac{0.65 \text{ mol Ba}(\text{NO}_3)_2}{1 \text{ L}} \left| \frac{2 \text{ mol NO}_3^-}{1 \text{ mol Ba}(\text{NO}_3)_2} \right| = 1.3 \text{ M NO}_3^-$$

Correct answer: 1.3 M NO_3^-

3. When CaCl_2 is dissolved in water, the resulting concentration of Cl^- is 0.15 M. What was the concentration of the original solution?

Step 1:

Write a balanced equation for this process:



Step 2:

Convert $[\text{Cl}^-]$ to $[\text{CaCl}_2]$ using the molar ratio from the equation above.

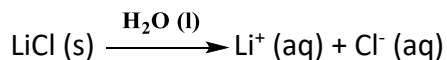
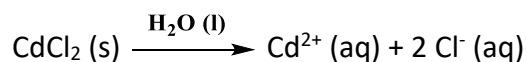
$$\frac{0.15 \text{ mol Cl}^-}{1 \text{ L}} \left| \frac{1 \text{ mol CaCl}_2}{2 \text{ mol Cl}^-} \right| = 0.075 \text{ M CaCl}_2 \text{ solution}$$

Correct answer: 0.075 M CaCl_2 solution

11. 1.00 L of a 0.25 M solution of CdCl_2 was mixed with 1.00 L of a 0.10 M solution of LiCl . What is the concentration of cadmium, lithium, and chlorine ions in the mixed solution?

Step 1:

Write the balanced equations for the dissolution of each of the ionic compounds.



Step 2:

Use the molar ratio of the original ionic compounds to ions to calculate the concentration of the individual ions in their starting solution.

CdCl_2 :

$$\frac{0.25 \text{ mol CdCl}_2}{1 \text{ L}} \left| \frac{1 \text{ mol Cd}^{2+}}{1 \text{ mol CdCl}_2} \right| = 0.25 \text{ M Cd}^{2+}$$

$$\frac{0.25 \text{ mol CdCl}_2}{1 \text{ L}} \left| \frac{2 \text{ mol Cl}^-}{1 \text{ mol CdCl}_2} \right| = 0.50 \text{ M Cl}^-$$

LiCl :

$$\frac{0.10 \text{ mol LiCl}}{1 \text{ L}} \left| \frac{1 \text{ mol Li}^+}{1 \text{ mol LiCl}} \right| = 0.10 \text{ M Li}^+$$

$$\frac{0.10 \text{ mol LiCl}}{1 \text{ L}} \left| \frac{1 \text{ mol Cl}^-}{1 \text{ mol LiCl}} \right| = 0.10 \text{ M Cl}^-$$

Since you have 1.00 L of each solution, the concentration of ions is also the number of moles of each ion:

$$0.25 \text{ M Cd}^{2+} = 0.25 \text{ mol Cd}^{2+}$$

$$0.050 \text{ M Cl}^- = 0.050 \text{ mol Cl}^-$$

$$0.10 \text{ M Li}^+ = 0.10 \text{ mol Li}^+$$

$$0.10 \text{ M Cl}^- = 0.10 \text{ mol Cl}^-$$

Step 3:

Since there are two sources of Cl⁻, add these together to get the total moles of Cl⁻.

$$\text{Cl}^- = 0.10 \text{ mol} + 0.50 \text{ mol} = 0.60 \text{ mol Cl}^-$$

Step 4:

Divide each value of moles by the volume of the new solution (2.00 L).

$$[\text{Cl}^-] = \frac{0.60 \text{ mol}}{2.00 \text{ L}} = 0.30 \text{ M}$$

$$[\text{Cd}^{2+}] = \frac{0.25 \text{ mol}}{2.00 \text{ L}} = 0.13 \text{ M}$$

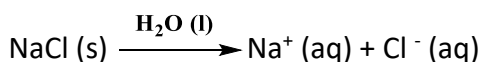
$$[\text{Li}^+] = \frac{0.10 \text{ mol}}{2.00 \text{ L}} = 0.050 \text{ M}$$

Correct answers: [Cl⁻] = 0.30 M; [Cd²⁺] = 0.13 M; [Li⁺] = 0.050 M

4. A solution was obtained by dissolving 1.1 g NaCl and 0.25 g MgCl₂ in 0.50 L of water. What is the concentration of Cl⁻ in the final solution?

Step 1:

Write balanced equations for the processes:





Step 2:

Use the masses and the molar masses of NaCl and MgCl₂ to calculate moles of each and use the molar ratio

$$\frac{1.1 \text{ g NaCl}}{58.44 \text{ g NaCl}} \times \frac{1 \text{ mol NaCl}}{1 \text{ mol NaCl}} = 0.019 \text{ mol NaCl}$$

$$\frac{0.25 \text{ g MgCl}_2}{95.211 \text{ g MgCl}_2} \times \frac{1 \text{ mol MgCl}_2}{1 \text{ mol MgCl}_2} = 0.0026 \text{ mol MgCl}_2$$

Step 3:

Calculate the molarity of the original solutions.

$$\text{Molarity} = \frac{0.019 \text{ mol NaCl}}{0.50 \text{ L}} = 0.038 \text{ M NaCl}$$

$$\text{Molarity} = \frac{0.0026 \text{ mol MgCl}_2}{0.50 \text{ L}} = 0.0052 \text{ M MgCl}_2$$

Step 4:

Use the molar ratio from the balanced equations to calculate [Cl⁻] from each salt.

$$\frac{0.038 \text{ mol NaCl}}{1 \text{ L}} \times \frac{1 \text{ mol Cl}^-}{1 \text{ mol NaCl}} = 0.038 \text{ M Cl}^-$$

$$\frac{0.0052 \text{ mol MgCl}_2}{1 \text{ L}} \times \frac{2 \text{ mol Cl}^-}{1 \text{ mol MgCl}_2} = 0.010 \text{ M Cl}^-$$

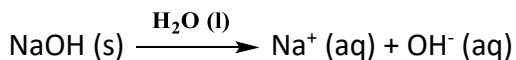
Add these two values together to get the total [Cl⁻] in the final solution.

Correct answer: [Cl⁻] = 0.048 M

5. What is $[\text{OH}^-]$ when 0.66 g NaOH is dissolved in 150 mL water?

Step 1:

The balanced equation for this process is:



Step 2:

Calculate the moles of NaOH using the molar mass of NaOH (39.99 g/mol).

$$\frac{0.66 \text{ g NaOH}}{39.99 \text{ g NaOH}} \times \frac{1 \text{ mol NaOH}}{1 \text{ mol NaOH}} = 0.017 \text{ mol NaOH}$$

Step 3:

Convert 150 mL to L and calculate the molarity of NaOH.

$$\frac{150 \text{ mL}}{1,000 \text{ mL}} \times \frac{1 \text{ L}}{1 \text{ L}} = 0.15 \text{ L}$$

$$\text{Molarity} = \frac{0.017 \text{ mol NaOH}}{0.15 \text{ L}} = 0.11 \text{ M}$$

Step 4:

Convert molarity of NaOH to $[\text{OH}^-]$ using the molar ratio from the balanced equation.

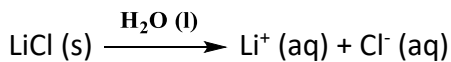
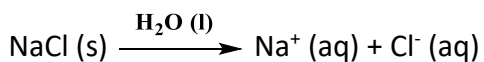
$$\frac{0.11 \text{ mol NaOH}}{1 \text{ L}} \times \frac{1 \text{ mol OH}^-}{1 \text{ mol NaOH}} = 0.11 \text{ M OH}^-$$

Correct answer: $[\text{OH}^-] = 0.11 \text{ M}$

6. NaCl and LiCl were dissolved in a solution, and the final $[\text{Cl}^-]$ is 0.15 M. If the original $[\text{NaCl}]$ was 0.10 M, what was the original concentration of LiCl?

Step 1:

Write out balanced equations for both processes.



Step 2:

Calculate $[\text{Cl}^-]$ from the NaCl using the original molarity of the NaCl solution.

$$\frac{0.10 \text{ mol NaCl}}{1 \text{ L}} \left| \frac{1 \text{ mol Cl}^-}{1 \text{ mol NaCl}} \right| = 0.10 \text{ M Cl}^-$$

Step 3:

Since we know the final concentration of Cl^- and the amount of Cl^- that came from NaCl, we can determine how much of the Cl^- came from LiCl by just subtracting these two numbers.

$$0.15 \text{ M} - 0.10 \text{ M} = 0.05 \text{ M Cl}^-$$

Step 4:

Calculate the molarity of LiCl by using the molarity of Cl^- .

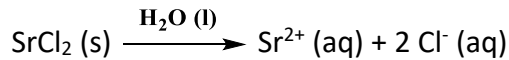
$$\frac{0.05 \text{ mol Cl}^-}{1 \text{ L}} \left| \frac{1 \text{ mol LiCl}}{1 \text{ mol Cl}^-} \right| = 0.05 \text{ M LiCl}$$

Correct answer: 0.05 M LiCl

7. How many moles of strontium chloride were used to create a 0.15 L solution where $[\text{Cl}^-] = 0.88 \text{ M}$?

Step 1:

The balanced equation is:



Step 2:

$$\frac{0.88 \text{ mol Cl}^-}{1 \text{ L}} \quad \left| \quad \frac{1 \text{ mol SrCl}_2}{2 \text{ mol Cl}^-} \quad \right| = 0.44 \text{ M SrCl}_2$$

Step 3:

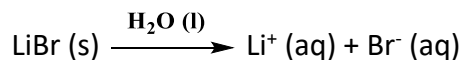
$$0.44 \text{ M SrCl}_2 = \frac{\text{moles SrCl}_2}{0.15 \text{ L}} = 0.066 \text{ moles SrCl}_2$$

Correct answer: 0.066 moles SrCl₂

8. A chemist wants a final solution of 0.16 M [Br⁻] with a volume of 0.150 L created from a 0.55 M LiBr solution. What volume of the original solution should be diluted to obtain this concentration?

Step 1:

Write the balanced equation for this process:



Step 2:

Calculate the moles of LiBr in the final solution. Since moles don't change during a dilution, this is also the moles of LiBr in the original solution.

$$\frac{0.16 \text{ mol Br}^-}{1 \text{ L}} \quad \left| \quad 0.150 \text{ L} \quad \right| \quad \frac{1 \text{ mol LiBr}}{1 \text{ mol Br}^-} \quad \left| \quad = 0.024 \text{ mol LiBr} \right.$$

Step 3:

Calculate the volume using the calculated moles of LiBr and the molarity of the original solution (0.55 M).

$$0.55 \text{ M} = \frac{0.024 \text{ mol LiBr}}{\text{volume}}$$

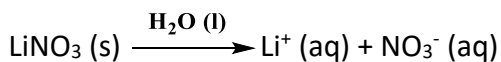
Volume = 0.044 L solution

Correct answer: 0.044 L original LiBr solution.

9. **Challenge:** What is the total ion concentration in a solution created by dissolving 0.55 g LiNO_3 in 1.5 L water?

Step 1:

Write the balanced equation for this process.



Step 2:

Calculate the number of moles LiNO_3 in 0.55 g

$$\frac{0.55 \text{ g LiNO}_3}{68.946 \text{ g LiNO}_3} \times \frac{1 \text{ mol LiNO}_3}{1 \text{ mol LiNO}_3} = 0.0080 \text{ mol LiNO}_3$$

Step 3:

Calculate the molarity of the solution.

$$\text{Molarity} = \frac{0.0080 \text{ mol LiNO}_3}{1.5 \text{ L}} = 0.0053 \text{ M LiNO}_3$$

Step 4:

Use the molar ratio to calculate the concentration of the individual ions in solution.

$$\frac{0.0053 \text{ mol LiNO}_3}{1 \text{ L}} \times \frac{1 \text{ mol Li}^+}{1 \text{ mol LiNO}_3} = 0.0053 \text{ M Li}^+$$

$$\frac{0.0053 \text{ mol LiNO}_3}{1 \text{ L}} \times \frac{1 \text{ mol NO}_3^-}{1 \text{ mol LiNO}_3} = 0.0053 \text{ M NO}_3^-$$

Step 5:

Add $[\text{Li}^+]$ and $[\text{NO}_3^-]$ to get the total ion concentration.

$$\text{Total ion concentration} = 0.0053 \text{ M} + 0.0053 \text{ M} = 0.0106 \text{ M}$$

Correct answer: 0.0106 M