

Aqueous Solutions & Reactions

Reading: Ch 4 section 4 - 7 Homework: Chapter 4: 49*, 53, 55, 57, 63, 67, 69*, 71*, 73, 75*

* = 'important' homework question

Concentration of Solutions

Discussion: When you finish this class chances are good you'll head out to a local bar for a well deserved 'adult beverage'. Assuming the bar you visit is running a special where you can buy a pint of beer *or* a pint of wine for the same price, which do you choose and why?

Answer:



Concentration = Molarity* (**M**) = number moles of *solute* per Liter of *solution*

* The Molarity (mol/L conc.) is most often printed on lab reagent solution bottles, e.g. 9.0 M H₂SO₄ (aq)

i.e. $\text{Molarity} = \frac{\text{Moles Solute}}{\text{Liters Solution}}$ Units: mol/L or just **M**

Where:

SOLUTION = **SOLUTE** + **SOLVENT**

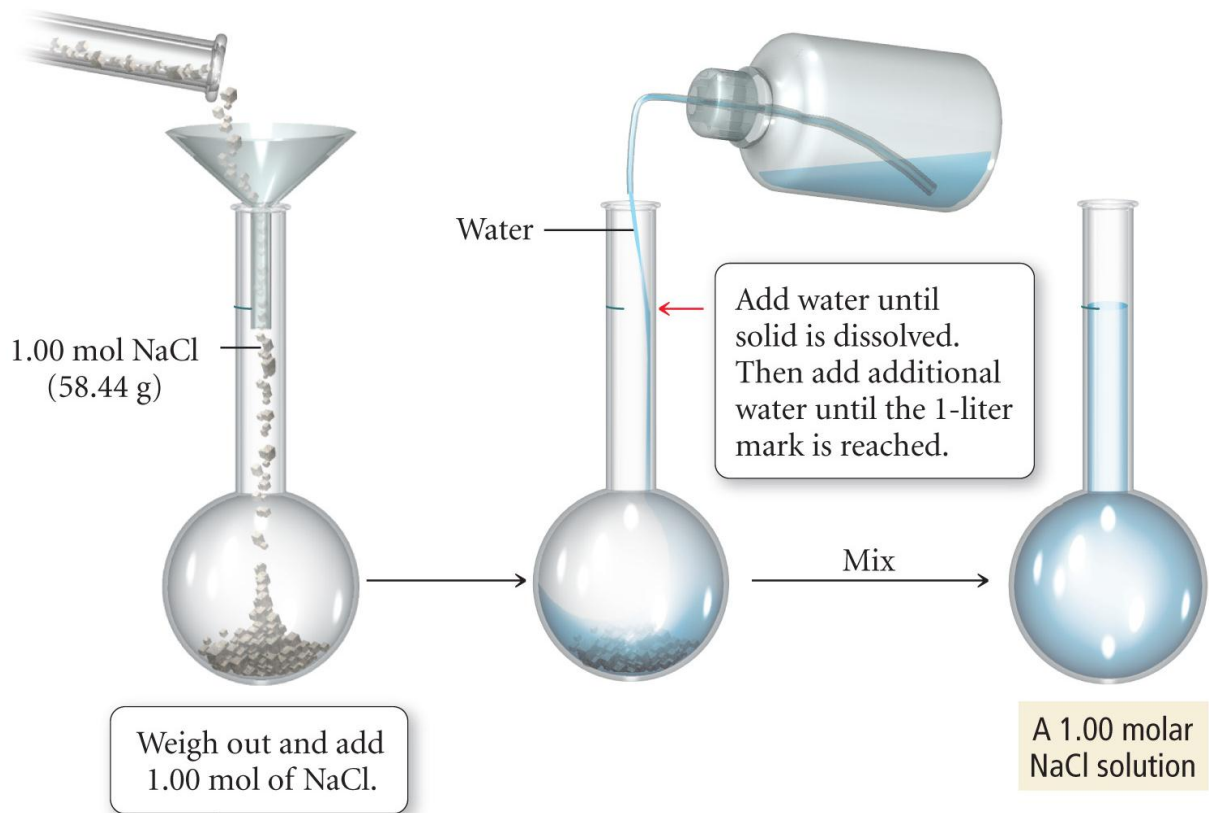
Example:

PEPSI =

Task: Think up one more example illustrating the components of a solution.

Stock Solutions: It is often necessary to make up a stock solution (a solution of known concentration) in lab for use within an experimental procedure – you will do this with your titration labs.

Walkthrough: Preparing a 1.0 M NaCl (aq) stock solution:



Notes

Question and Demo: What is the concentration of a solution made by dissolving 2.845 g of sugar ($C_6H_{12}O_6$) in water and making the final volume up to 150 mL?



Remember that Moles Solute, Solution Concentration and Solution Volume are all related. Sketch a 'pyramid' to help you solve concentration problems for solutions.

Question: What mass of NaCl is contained within 0.50 L of a 6.0 M NaCl(aq) solution?



Since $CV = \text{moles}$ for any solution, concentration (C) and solution volume (V) terms can also be used in 'slides and ladders' problems featuring solutions.

Example: What volume (in mL) of 2.0 M HCl is needed to completely react with a 5.5 gram stick of chalk ($\text{CaCO}_3(\text{s})$)? What volume of $\text{CO}_2(\text{g})$ would be recovered, assuming a 100% yield? Hint: You have seen this reaction before.

Dilutions



Question: When you dilute something with water (for example your morning coffee) do you change the number of moles of solute (caffeine) dissolved?

Answer:

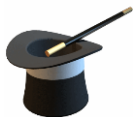


Since the number of moles of *solute* in a *solution* is not altered by adding more *solvent* (by dilution) then:

Moles solute (before dilution) = **Moles solute** (after dilution)

Now, since moles is a constant and moles = CV, then:

$$C_{(\text{before})} V_{(\text{before})} = C_{(\text{after})} V_{(\text{after})}$$



Use the $C_{(\text{before})} V_{(\text{before})} = C_{(\text{after})} V_{(\text{after})}$ relationship to find the concentration of a solution that has been diluted

Example Question: A laboratory procedure requires you to prepare 100 mL of 2.0 M HCl solution from an 18.0 M stock solution of this acid. Describe how this would be achieved.

Recap: The Importance of the mole



Most of the equations we have met in this handout feature # moles as a variable. **Thus, moles can in many ways be considered the chemists' link between macro and micro scale quantities.**

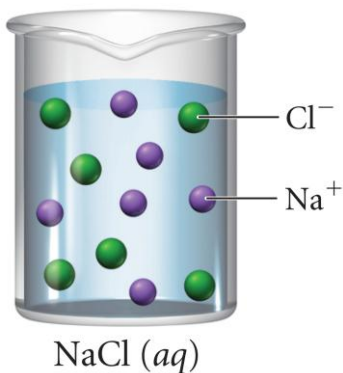
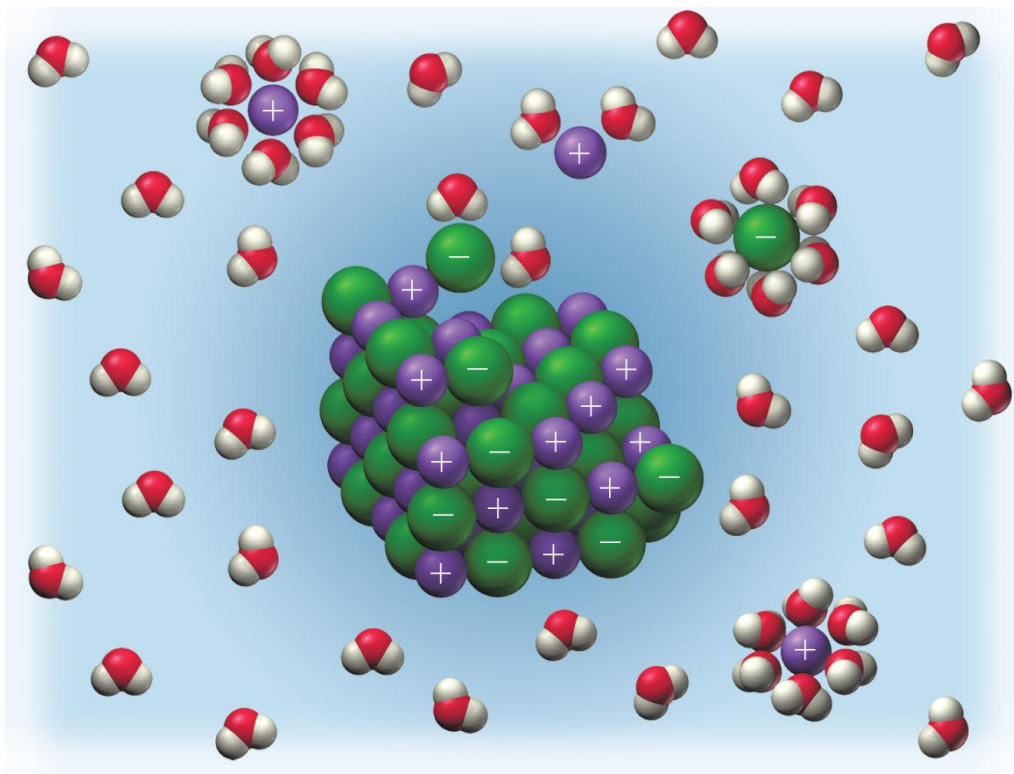


Task: Write down as many equations you can featuring the mole. Use this information to construct a 'spider' (flow) chart illustrating how all these conversions 'go through' moles.

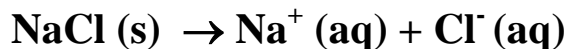
Properties of Solutions: Electrolytes



An *electrolytic solution* is formed when an ionic compound (such as NaCl) dissolves in water to form a solution containing solvated (*dissociated and mobile*) ions. Alternatively, an *electrolyte* is simply a *dissociated* ion dissolved in water. (see below and slide)



Example: When table salt is dissolved in water it undergoes dissociation to make aqueous Na⁺ and Cl⁻ ions (this is what happens when you dissolve table salt make pasta!):



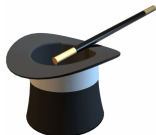
Note: This information is most often further abbreviated, i.e.: NaCl (aq) \equiv Na⁺ (aq) + Cl⁻ (aq)

This is true for *all* electrolytic solutions. Recall that the state symbol (aq) means ‘aqueous’ or with water – it means the *solute* has formed a *solution* by dissolving in a *solvent* (water).

Aqueous Reactions in which a solid product (precipitate, ppt.) forms

Worked example: Write *balanced*, *complete* and *net* ionic equations for the reaction of silver nitrate and sodium chloride solutions.

The Balanced ionic equation



This is the balanced, ionic double replacement ('swapping partners') reaction you are already familiar with.

Balanced:

Question: How do we know which one of the products formed (AgCl or NaNO₃) is the solid recovered from the reaction?



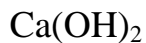
Whether or not an ionic material is soluble in water is known. This data appears in the solubility chart.

⇒ Determine if the product(s) are soluble via the chart and include the appropriate state symbol(s) in the balanced equation. ALWAYS INCLUDE STATE SYMBOLS IN ALL YOUR BALANCED, COMPLETE AND NET EQUATIONS

Solubility chart (will be supplied)

Soluble Compounds			Insoluble Compounds		
		Exceptions			Exceptions
Compounds containing	NO ₃ ⁻	None	CO ₃ ²⁻		NH ₄ ⁺ & group IA cations
	Cl ⁻	Ag ⁺ , Hg ²⁺ , Pb ²⁺	PO ₄ ³⁻		NH ₄ ⁺ & group IA cations
	Br ⁻	Ag ⁺ , Hg ²⁺ , Pb ²⁺	OH ⁻		group IA cations Ca ²⁺ , Sr ²⁺ , Ba ²⁺ & NH ₄ ⁺
	I ⁻	Ag ⁺ , Hg ²⁺ , Pb ²⁺			
	SO ₄ ²⁻	Ba ²⁺ , Hg ²⁺ , Pb ²⁺			

Task: State whether the following ionic materials are soluble or insoluble in water:



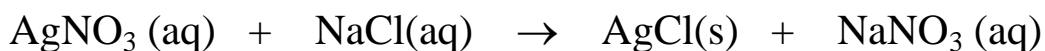
The Complete ionic equation



Recall that the state symbol (aq) means that the ions of an ionic compound are SEPARATED (dissociated) and, therefore, MOBILE when dissolved in water.

A complete ionic equation shows each type of ion dissolved in solution. Consider it to be a 'longhand' version of the balanced equation.

Balanced:



Complete:

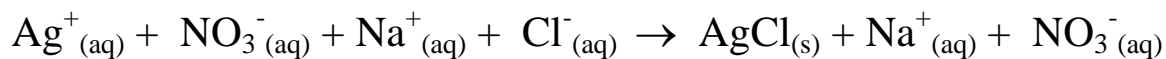


Solids (s), liquids (l) and gases (g) are NOT in the (aq), state so do not appear as individual (dissociated) ions in the complete ionic equation.

The Net ionic equation

Question: What can be done ‘algebraically’ with the complete ionic equation?

Complete:



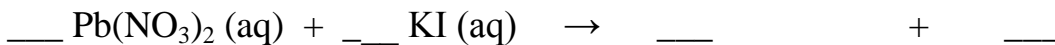
Net:



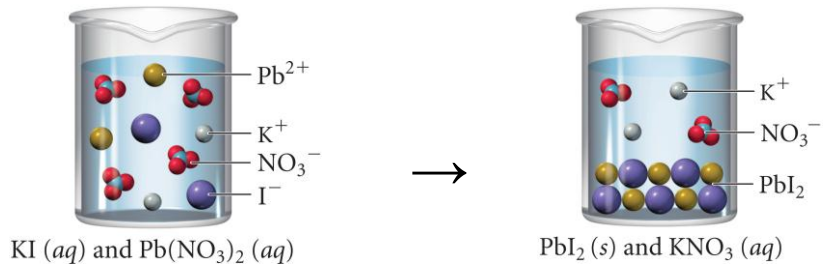
‘Cancel’ ions (spectator ions) common to both sides in the Complete ionic equation to give the Net ionic equation. This is ‘where the action is’ in any ionic reaction.

Walkthrough Example: Balanced, complete and net ionic equations for the reaction of potassium iodide and lead (II) nitrate solutions:

Balanced

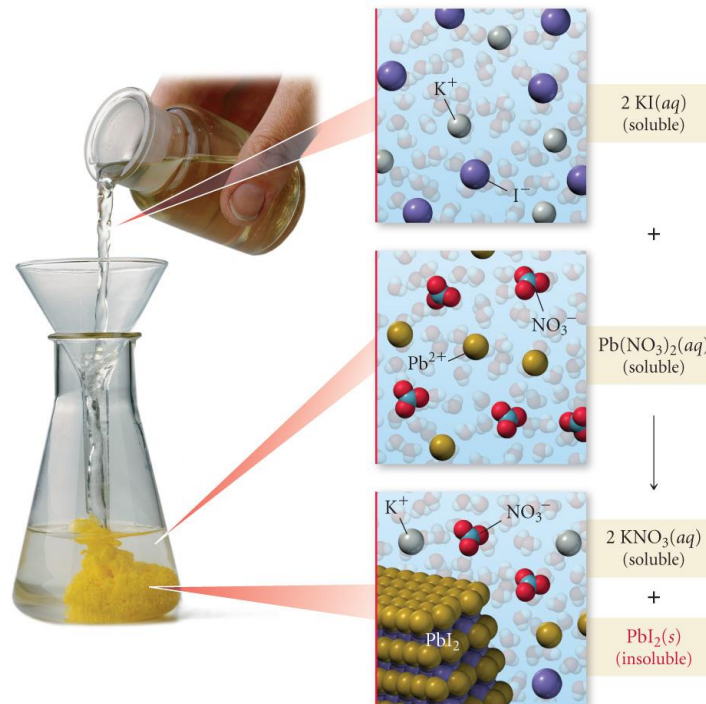


Complete



Net

Summary



Group Task: Write balanced, complete and net ionic equations for the following reactions:

1. Silver nitrate solution mixed with calcium hydroxide solution
2. Barium nitrate solution mixed with sulfuric acid solution
3. Calcium chloride solution mixed with sodium phosphate solution (lab)



"Equations and Solubility"

Try the following question (taken from the second practice midterm).

Write *balanced*, *complete* and *net ionic* equations illustrating the reaction between aqueous solutions of silver nitrate and sodium phosphate. *Include all state symbols.*

Balanced chemical equation:

Complete ionic equation:

Net ionic equation:

List the names and formulas of five insoluble ionic compounds containing the hydroxide ion.

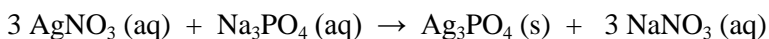


"Equations and Solubility"

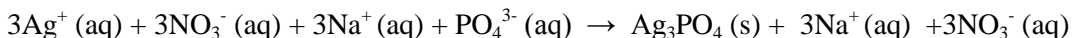
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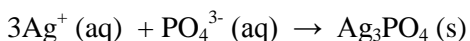
Balanced chemical equation:



Complete ionic equation:



Net ionic equation:



List the names and formulas of five insoluble ionic compounds containing the hydroxide ion.

Any except with group 1A, Ca^{2+} , Sr^{2+} , Ba^{2+} and NH_4^+

eg: Silver (I) hydroxide AgOH , Copper (I) Hydroxide CuOH , Magnesium hydroxide $\text{Mg}(\text{OH})_2$, Iron (II) hydroxide $\text{Fe}(\text{OH})_2$, Lead (II) hydroxide $\text{Pb}(\text{OH})_2$