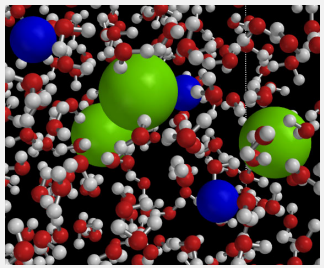
[TP] The molarity of the NaCl aqueous solution shown in the image is approximately ...

17% 1. > 20 M
17% 2. 20 M
17% 3. 2 M
17% 4. 0.2 M
17% 5. 0.02 M
17% 6. < 0.02 M



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# Lecture 19 CH101 A1 (MWF 9:05 am)

Friday, October 19, 2018

For today ...

- Dispersion postscript: Lone pairs versus cloud size
- Dissolving ionic solids
- Solubility guidelines fig 6.28, p 181 (memorize)
- Precipitation reactions
- Concentrations after precipitation

Next lecture: Ionization of molecular solutes; Self-ionization of water; Acid-base reactions: Competition for $H^+$

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## Relative dispersion: lone pairs vs cloud size

| | Boiling point °C | |
|---|---|---|
| $CH_3CH_3$ | −89 | |
| $CH_3CH_2CH_3$ | −42 | Lone pair dispersion predominates |
| $CH_3OCH_3$ | −24 | |

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## Relative dispersion: lone pairs vs cloud size

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| $CH_3CH_2CH_2CH_3$ | −0.5 | Lone pair dispersion predominates |
| $CH_3CH_2OCH_3$ | +7.5 | |

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## Relative dispersion: lone pairs vs cloud size

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| $CH_3CH_3$ | −89 | |
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| $CH_3CH_2OCH_3$ | +7.5 | |
| $CH_3CH_2OCH_2CH_3$ | +34.6 | Cloud (bond pair) dispersion predominates |
| $CH_3CH_2CH_2CH_2CH_3$ | +36 | |





## Relative dispersion: lone pairs vs cloud size

| | Boiling point °C | |
|---|---|---|
| $CH_3CH_3$ | −89 | |
| $CH_3CH_2CH_3$ | −42 | Lone pair dispersion predominates |
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| $CH_3CH_2OCH_2CH_3$ | +34.6 | Cloud (bond pair) dispersion predominates |
| $CH_3CH_2CH_2CH_2CH_3$ | +36 | |
| $CH_3CH_2CH_2CH_2CH_2CH_3$ | +69 | |





## Dissolving ionic salts

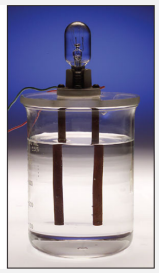
$Na^+(aq)$ and $Cl^-(aq)$ disperse throughout water





## Demonstration: Conductivity of water

Pure water



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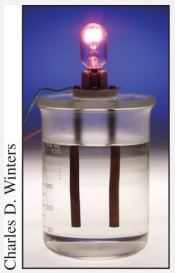
$Na^+(aq) + Cl^-(aq)$



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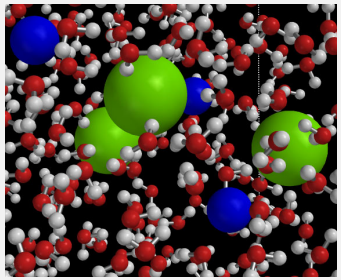
## Dissolving ionic salts

$Na^+(aq)$ and $Cl^-(aq)$ disperse throughout water



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## Representing an NaCl aqueous solution

If 2 mol of NaCl(s) is dissolved in 1 L of water, ...

How many moles of $NaCl(s)$ are present?

How many moles of $NaCl(aq)$ are present?

How many moles of $Na^+(aq)$ are present?

How many moles of $Cl^-(aq)$ are present?

How many moles of $H_2O(l)$ are present?

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## Representing 2 M NaCl aqueous solution

Make a sketch of a 2 M NaCl aqueous solution, representing

waters as chevrons (>)

$Na^+$ ions as +

$Cl^-$ ions as –

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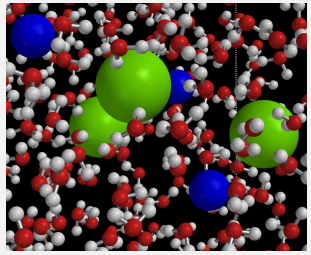
## Estimating molarity



The concentration of water is 55.5 mol/L.

Get molarity from the relative numbers of ions and water molecules.

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[TP] The molarity of the NaCl aqueous solution shown in the image is approximately ...

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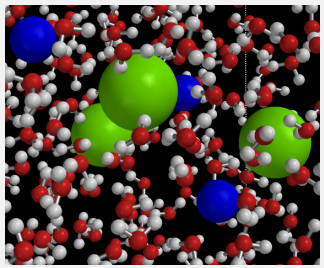

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Solubility guidelines





## Soluble ionic compounds, p181 (memorize!)

| SOLUBLE COMPOUNDS | EXCEPTIONS |
|---|---|
| Almost all salts of $Na^+$, $K^+$, $NH_4^+$ | |
| Salts of nitrate, $NO_3^-$<br>chlorate, $ClO_3^-$<br>perchlorate, $ClO_4^-$<br>acetate, $CH_3CO_2^-$ | |
| Almost all salts of $Cl^-$, $Br^-$, $I^-$ | Halides of $Ag^+$, $Hg_2^{2+}$, $Pb^{2+}$ |
| Compounds containing $F^-$ | Fluorides of $Mg^{2+}$, $Ca^{2+}$, $Sr^{2+}$, $Ba^{2+}$, $Pb^{2+}$ |
| Salts of sulfate, $SO_4^{2-}$ | Sulfates of $Ca^{2+}$, $Sr^{2+}$, $Ba^{2+}$, $Pb^{2+}$ |





## Insoluble ionic compounds, p 181 (memorize!)

| INSOLUBLE COMPOUNDS | EXCEPTIONS |
|---|---|
| Most salts of carbonate, $CO_3^{2-}$<br>phosphate, $PO_4^{3-}$<br>oxalate, $C_2O_4^{2-}$<br>chromate, $CrO_4^{2-}$ | Salts of $NH_4^+$ and the alkali metal cations |
| Most metal sulfides, $S^{2-}$ | |
| Most metal hydroxides and oxides | $Ba(OH)_2$ is soluble |



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## Precipitation reactions

NaCl and $AgNO_3$ are both soluble in water, but AgCl is not.

If aqueous solutions of NaCl and $AgNO_3$, are mixed, the $Ag^+(aq)$ and $Cl^-(aq)$ ions can encounter one another.

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**(b)** Initially the $Ag^+$ ions (silver colour) and $Cl^-$ ions (green) are widely separated.

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## Precipitation reactions

When $Ag^+(aq)$ and $Cl^-(aq)$ ions do encounter one another, they will pair up as a lattice of $AgCl(s)$

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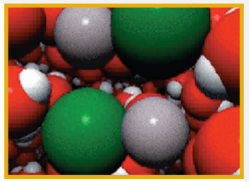

**(c)** $Ag^+$ and $Cl^-$ ions approach and form ion pairs.

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## Precipitation reactions

As more pairs form, they will aggregate so much that solid AgCl settles out of the solution, so that no $AgCl(aq)$ remains in solution.

This process is called precipitation.

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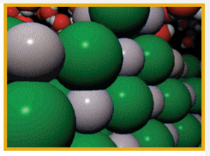

**(d)** As more and more $Ag^+$ and $Cl^-$ ions come together, a precipitate of solid AgCl forms.

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(a)

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[TP] When aqueous solutions of copper(II) chloride and sodium carbonate are combined, ...

0% 1. no precipitate will form
0% 2. $CuCO_3$ will precipitate
0% 3. NaCl will precipitate
0% 4. both $CuCO_3$ and NaCl will precipitate

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[Quiz] Some solid sodium carbonate and solid potassium nitrate are placed together into pure water. After thorough stirring and allowing things to settle, …

0% 1. $NaNO_3(s)$ will have precipitated
0% 2. $K_2CO_3(s)$ will have precipitated
0% 3. Neither $Na_2CO_3$ and nor $KNO_3$ will dissolve, and so will have settled as solids to the bottom of the solution
0% 4. Everything will dissolve, no precipitate will form, and so the solution will be clear





Concentrations before and after precipitation





## A comprehensive example

You are given 150 mL of a 0.20 M aqueous solution of ammonium carbonate and 150 mL of 0.40 M aqueous solution of barium iodide. These solutions are mixed and a precipitate forms.

Write the net-ionic equation for this process.

What are the spectator ions for this process?

What is the limiting reactant?





## A comprehensive example

You are given 150 mL of a 0.20 M aqueous solution of ammonium carbonate and 150 mL of 0.40 M aqueous solution of barium iodide.

$$(NH_4)_2CO_3(s) \rightarrow 2\ NH_4^+(aq) + CO_3^{2-}(aq)$$
$$BaI_2(s) \rightarrow Ba^{2+}(aq) + 2\ I^-(aq)$$

| $NH_4^+(aq)$ | $Ba^{2+}(aq)$ | $CO_3^{2-}(aq)$ | $I^-(aq)$ |
|---|---|---|---|
| | | | |



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## A comprehensive example

You are given 150 mL of a 0.20 M aqueous solution of ammonium carbonate and 150 mL of 0.40 M aqueous solution of barium iodide.

$$(NH_4)_2CO_3(s) \rightarrow 2\ NH_4^+(aq) + CO_3^{2-}(aq)$$
$$BaI_2(s) \rightarrow Ba^{2+}(aq) + 2\ I^-(aq)$$

| $NH_4^+(aq)$ | $Ba^{2+}(aq)$ | $CO_3^{2-}(aq)$ | $I^-(aq)$ |
|---|---|---|---|
| $2 \times 0.20\ M \times 0.150\ L$ $= 0.060\ mol$ | $0.40\ M \times 0.150\ L$ $= 0.060\ mol$ | $0.20\ M \times 0.150\ L$ $= 0.030\ mol$ | $2 \times 0.40\ M \times 0.150\ L$ $= 0.120\ mol$ |



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[Quiz] You are given 150 mL of a 0.20 M aqueous solution of ammonium carbonate and 150 mL of 0.40 M aqueous solution of barium iodide. These solutions are mixed and a precipitate forms. The limiting reagent is ....

17% 1. $BaI_2(s)$
17% 2. $(NH_4)_2CO_3(s)$
17% 3. $NH_4^+(aq)$
17% 4. $Ba^{2+}(aq)$
17% 5. $CO_3^{2-}(aq)$
17% 6. $I^-(aq)$



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## A comprehensive example

You are given 150 mL of a 0.20 M aqueous solution of ammonium carbonate and 150 mL of 0.40 M aqueous solution of barium iodide.

These solutions are mixed and a precipitate forms

$$(NH_4)_2CO_3(s) \rightarrow 2\ NH_4^+(aq) + CO_3^{2-}(aq)$$
$$BaI_2(s) \rightarrow Ba^{2+}(aq) + 2\ I^-(aq)$$
$$Ba^{2+}(aq) + CO_3^{2-}(aq) \rightarrow BaCO_3(s)$$

| | $Ba^{2+}(aq)$ | $CO_3^{2-}(aq)$ | $BaCO_3(s)$ |
|---|---|---|---|
| start | 0.060 mol | 0.030 mol | 0 |
| change | | | |
| end | | | |



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## A comprehensive example

You are given 150 mL of a 0.20 M aqueous solution of ammonium carbonate and 150 mL of 0.40 M aqueous solution of barium iodide. These solutions are mixed and a precipitate forms.

Write the net-ionic equation for this process.

What are the spectator ions for this process?

What is the limiting reactant?

How many moles of the solid precipitate are formed?

After precipitation, what are the molarities (M) of each ion remaining in solution?



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## A comprehensive example

You are given 150 mL of a 0.20 M aqueous solution of ammonium carbonate and 150 mL of 0.40 M aqueous solution of barium iodide.

These solutions are mixed and a precipitate forms

$$(NH_4)_2CO_3(s) \rightarrow 2\ NH_4^+(aq) + CO_3^{2-}(aq)$$
$$BaI_2(s) \rightarrow Ba^{2+}(aq) + 2\ I^-(aq)$$
$$Ba^{2+}(aq) + CO_3^{2-}(aq) \rightarrow BaCO_3(s)$$

| | $Ba^{2+}(aq)$ | $CO_3^{2-}(aq)$ | $BaCO_3(s)$ |
|---|---|---|---|
| start | 0.060 mol | 0.030 mol | 0 |
| change | | | |
| end | | | |





## A comprehensive example

You are given 150 mL of a 0.20 M aqueous solution of ammonium carbonate and 150 mL of 0.40 M aqueous solution of barium iodide.

These solutions are mixed and a precipitate forms

$$(NH_4)_2CO_3(s) \rightarrow 2\ NH_4^+(aq) + CO_3^{2-}(aq)$$
$$BaI_2(s) \rightarrow Ba^{2+}(aq) + 2\ I^-(aq)$$
$$Ba^{2+}(aq) + CO_3^{2-}(aq) \rightarrow BaCO_3(s)$$

| | $Ba^{2+}(aq)$ | $CO_3^{2-}(aq)$ | $BaCO_3(s)$ |
|---|---|---|---|
| start | 0.060 mol | 0.030 mol | 0 |
| change | −0.030 mol | −0.030 mol | +0.030 mol |
| end | 0.030 mol | 0 | 0.030 mol |





## A comprehensive example

You are given 150 mL of a 0.20 M aqueous solution of ammonium carbonate and 150 mL of 0.40 M aqueous solution of barium iodide. These solutions are mixed and a precipitate forms.

Write the net-ionic equation for this process.

What are the spectator ions for this process?

What is the limiting reactant?

How many moles of the solid precipitate are formed?

After precipitation, what are the molarities (M) of each ion in solution?

Is the final solution electrically neutral?





[TP] You are given 150 mL of a 0.20 M aqueous solution of ammonium carbonate and 150 mL of 0.40 M aqueous solution of barium iodide. These solutions are mixed and a precipitate forms. After the precipitation, the solution ...

25% 1. will be positively charged (excess total positive charge)
25% 2. will be electrically neutral (equal total positive and negative charge)
25% 3. will be negatively charged (excess total negative charge)
25% 4. More information needed

| | $Ba^{2+}(aq)$ | $CO_3^{2-}(aq)$ | $BaCO_3(s)$ |
|---|---|---|---|
| start | 0.060 mol | 0.030 mol | 0 |
| change | −0.030 mol | −0.030 mol | +0.030 mol |
| end | 0.030 mol | 0 | 0.030 mol |



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## A comprehensive example

You are given 150 mL of a 0.20 M aqueous solution of ammonium carbonate and 150 mL of 0.40 M aqueous solution of barium iodide.

These solutions are mixed and a precipitate forms. After the precipitation, the total electrical charge due to the ions remaining in solution is 0.

| | Moles of ions | Moles of charge |
|---|---|---|
| $NH_4^+(aq)$ | 0.060 | 0.060 "+" |
| $I^-(aq)$ | 0.120 | 0.120 "−" |
| $Ba^{2+}(aq)$ | 0.030 | 0.060 "+" |
| Total | | 0 |

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