



Qualitative Analysis

Qualitative - definitions of solubility

Solubility rules

Identifying ions

Balancing ionic equations

Complex ions

Balancing complex ion equations



Qualitative?

- We can analyse chemicals in two main ways:
 - Quantitative – an analysis using quantities like volume, mass or amount
 - Qualitative – an analysis using qualities such as colour change, smell or precipitation (cloudiness)
- The purpose of this form of qualitative analysis is to identify the presence of certain ions in a solution



Solubility

- When you add a chemical to water it could do two things:
 - It could dissolve and the water will turn see through (transparent) - this is a soluble substance
 - It might just sit there and not dissolve - it is insoluble
- If an insoluble substance is made in water the liquid will turn cloudy, this is called precipitation. A precipitate will settle over time and the solid will form a layer on the bottom of the test-tube

A ball-and-stick molecular model showing a complex organic or inorganic structure with various colored spheres (red, black, grey, blue) representing atoms, connected by sticks representing bonds. The model is positioned in the top-left corner of the slide.

Solubility Rules - Intro

- Ions come in two forms:
 - Anions - negatively charged ions
 - Cations - positively charged ions
- Every ionic substance is made from a cation and an anion
- Certain ions easily dissolve, others tend to be insoluble. They all follow certain rules
- We can use these rules in order to predict what ions are present in an 'unknown' solution



Solubility Rules - Details

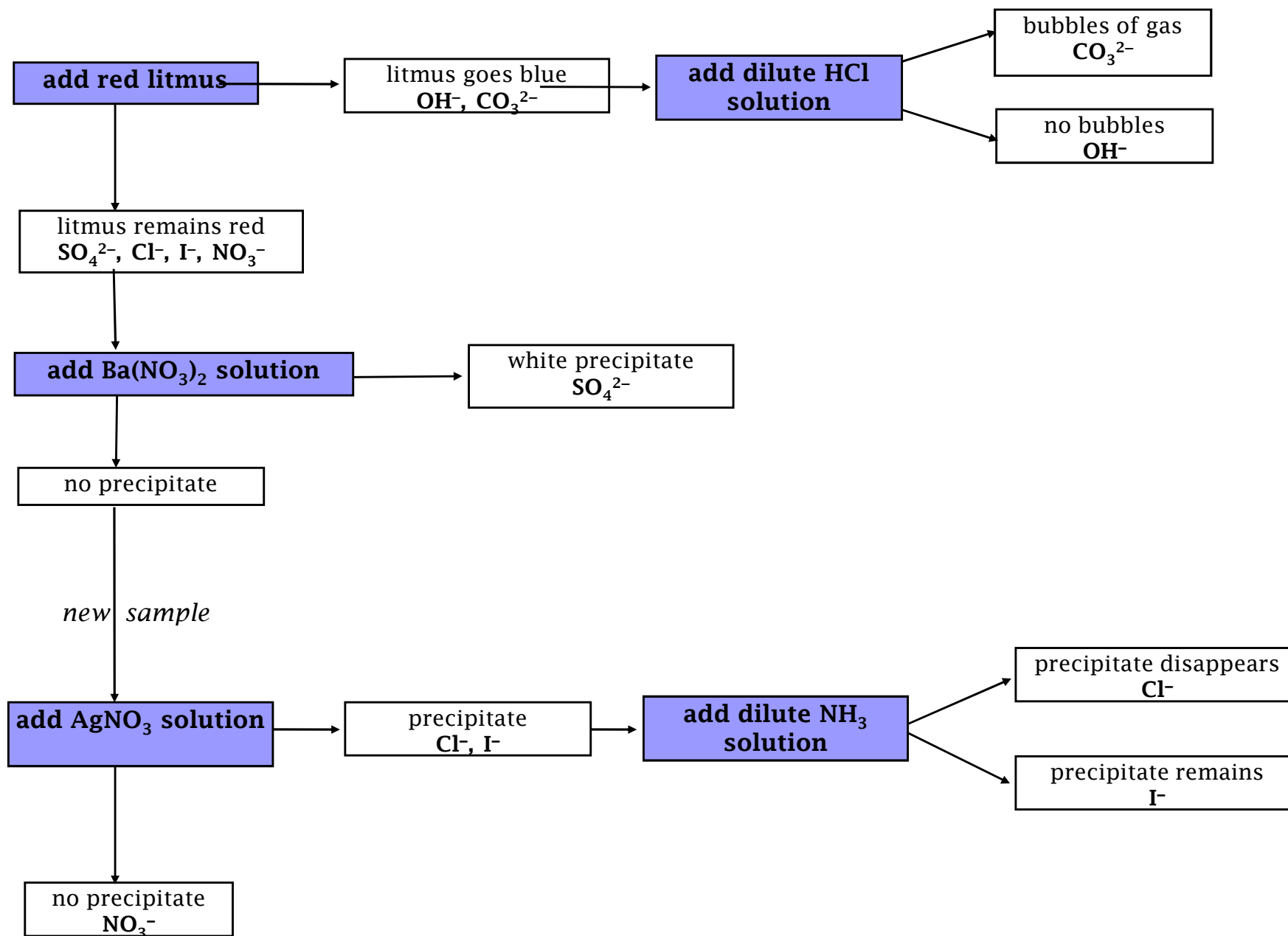
- These are the general rules:
 - All Group 1 and ammonium (NH_4^+) ions are soluble
 - All nitrates are soluble
 - All chlorides are soluble (except for Ag and Pb)
 - All sulphates are soluble (except for Ba and Pb)
 - All carbonates are insoluble (except for Group 1 and NH_4^+)
 - All hydroxides are insoluble (except for Group 1, NH_4^+ and Ba)



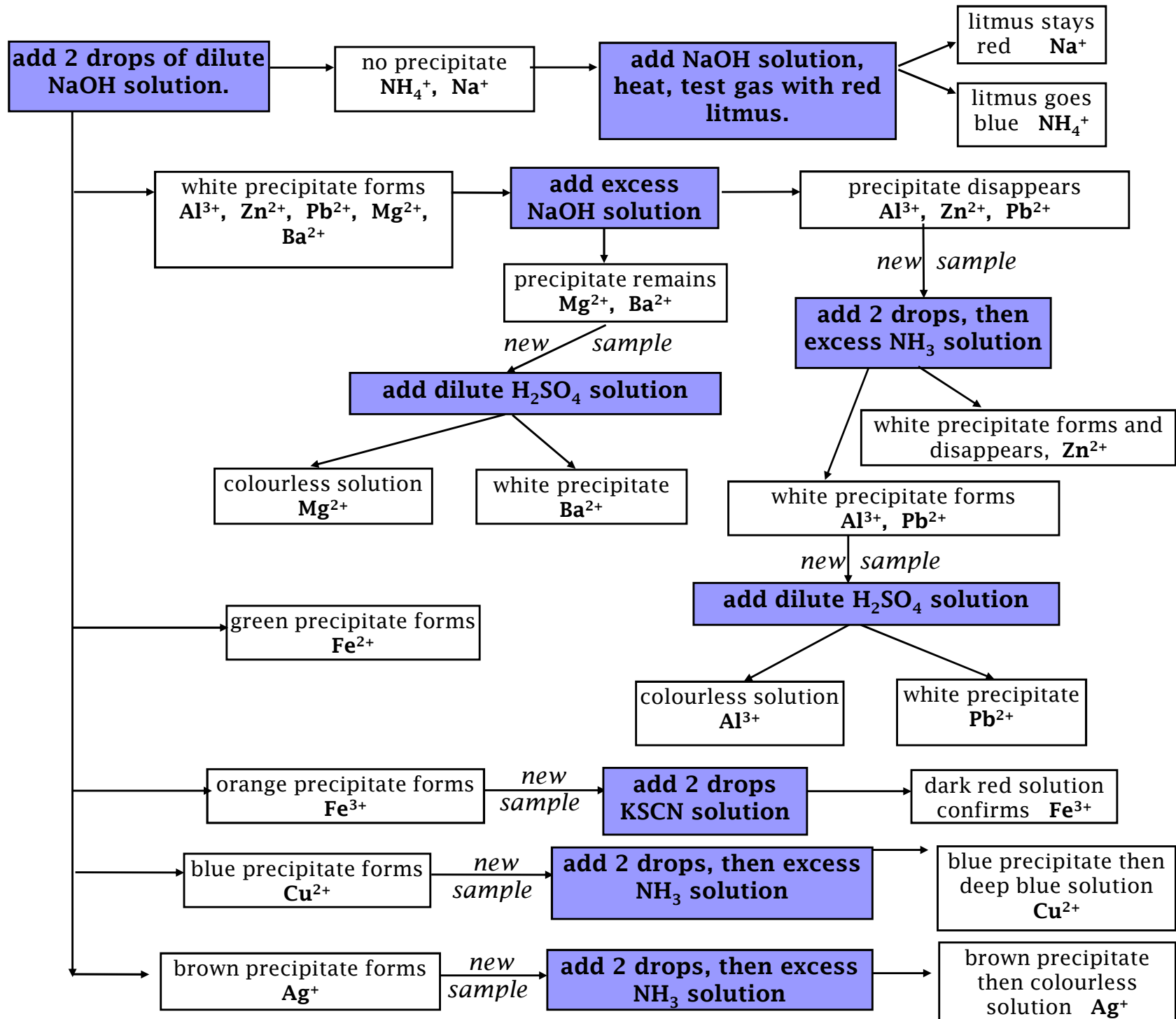
Identifying Ions

- We could use these rules to work out if hydroxides or chlorides are present in a solution. (What is one difference between the two ions?)
- To make life easier we could use a flow chart that shows the order that we need to do tests in order to eliminate possible ions
- These two flow charts divide all ions into two groups – anions and cations. Once we have identified one of the ions in a solution we need to identify the other

Identifying Anions: CO_3^{2-} , Cl^- , I^- , SO_4^{2-} , NO_3^- , OH^-



Identifying Cations: NH_4^+ , Na^+ , Mg^{2+} , Ag^+ , Fe^{2+} , Fe^{3+} , Cu^{2+} , Al^{3+} , Pb^{2+} , Zn^{2+} , Ba^{2+}



Identifying Anions I

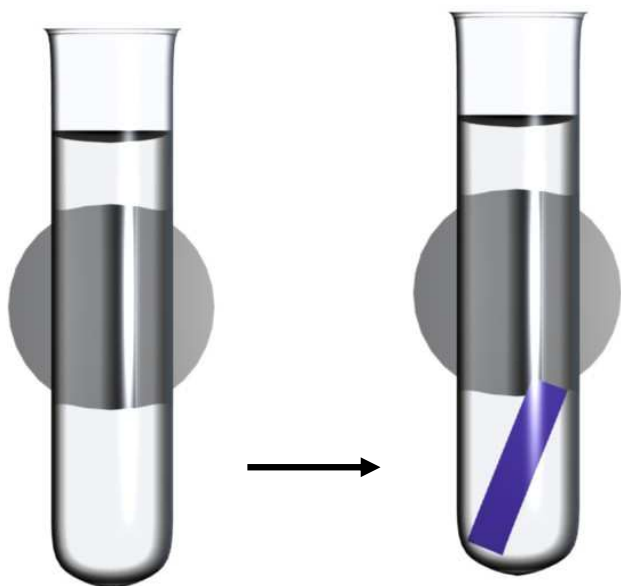
- Use the anion flowchart to identify the anion used below:

The diagram illustrates a series of chemical tests performed on a sample in test tubes:

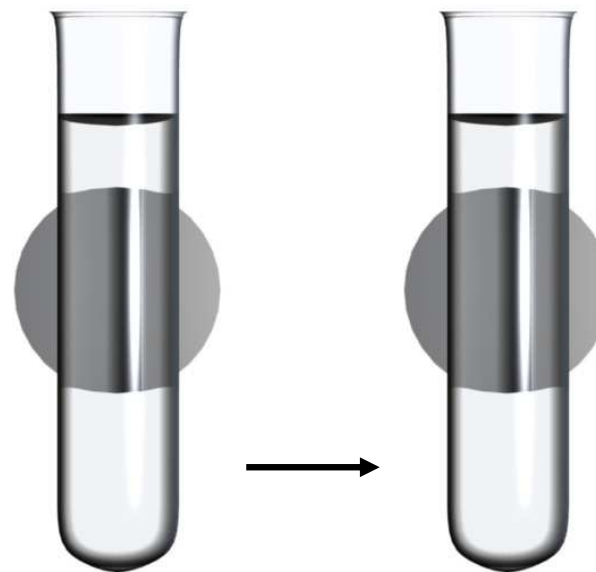
- Test 1:** A test tube containing a clear liquid. An arrow points to a second test tube where the liquid has turned red. Below this step is a blue box labeled "Add red litmus".
- Test 2:** A test tube containing red liquid. An arrow points to a second test tube where the liquid has turned colorless. Below this step is a blue box labeled "Add $\text{Ba}(\text{NO}_3)_2$ ".
- Test 3:** A test tube containing colorless liquid. An arrow points to a second test tube where the liquid has turned white. Below this step is a blue box labeled "Add AgNO_3 ".
- Test 4:** A test tube containing white precipitate. An arrow points to a second test tube where the precipitate has dissolved. Below this step is a blue box labeled "Add NH_3 ".

Identifying Anions II

- Use the anion flowchart to identify the anion used below:



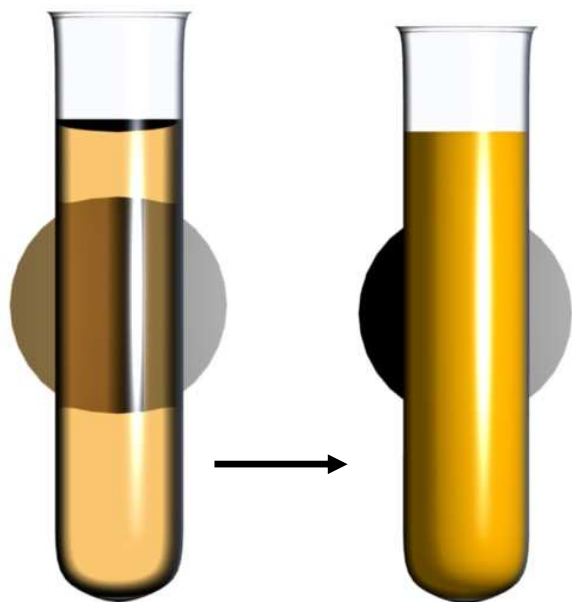
Add red
litmus



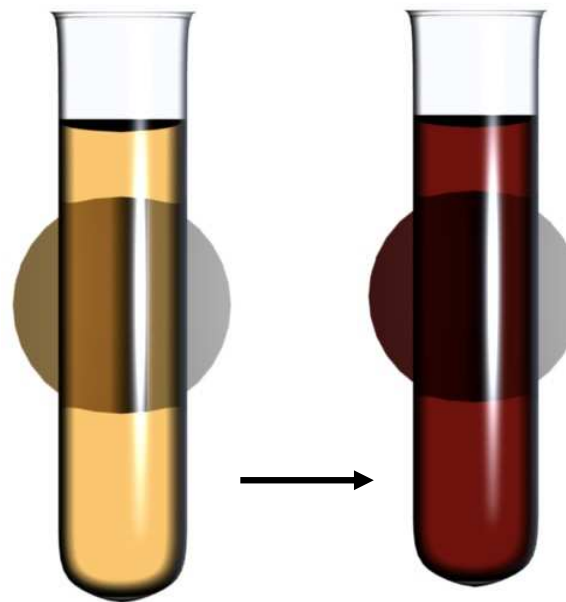
Add HCl

Identifying Cations I

- Use the cation flowchart to identify the cation used below:



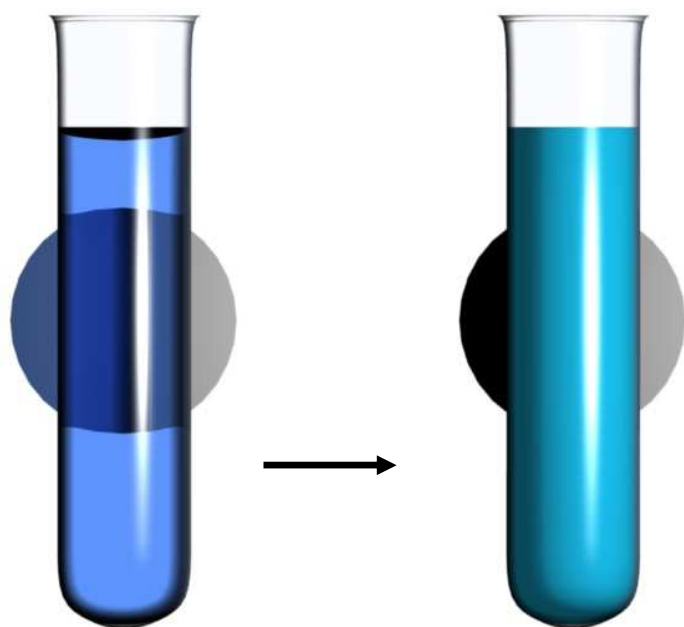
Add NaOH



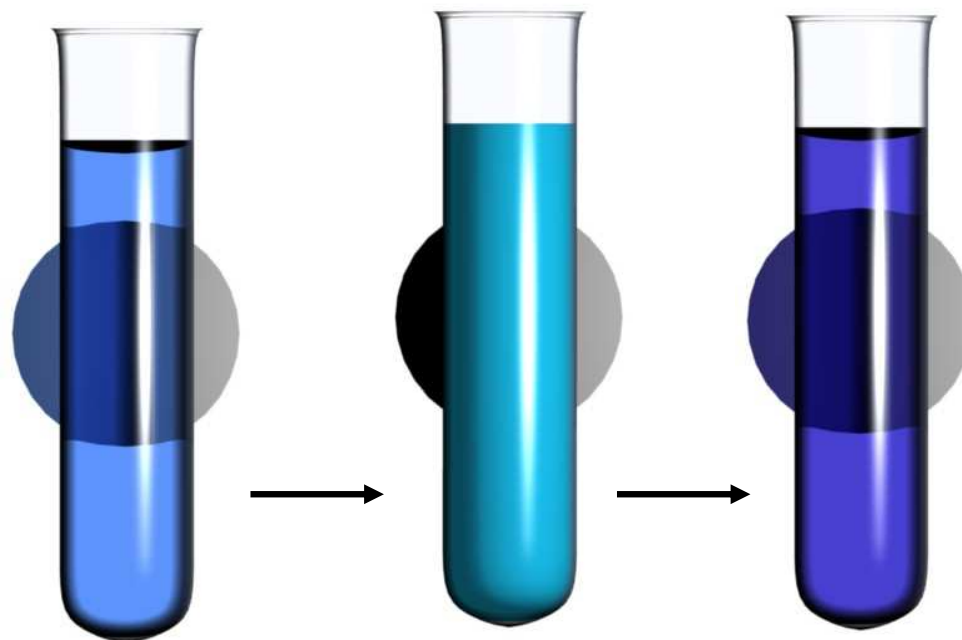
Add KSCN

Identifying Cations II

- Use the cation flowchart to identify the cation used below:



Add NaOH

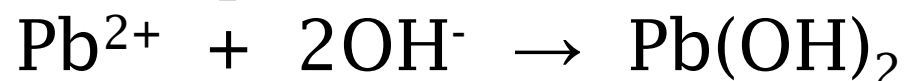


Add NH_3

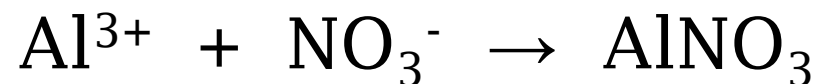


Balancing Equations

- In the assessment you will have to show balanced equations for the precipitation reactions. A precipitation reaction is one that produces a cloudy liquid because of the presence of a solid in the liquid.
- In other words two ions will join together to form a solid. For example:



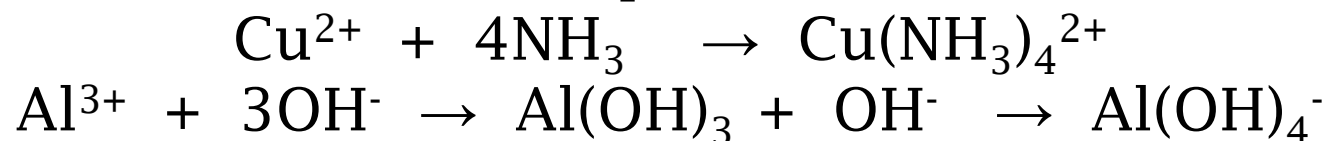
- All of the charges of the ion can be found on your flow chart but you have to put them together and balance the equation properly.
- How do I fix this?





Complex Ions

- You may have noticed that in some occasions we had a precipitate (a solid) then we added excess (more) chemicals to it. Occasionally the precipitate ended up disappearing - this indicates that the solid has turned back into an ion, a **complex ion**.
- A complex ion is a metal ion that has got extra negative chemicals (*ligands*) stuck to it. Instead of balancing out the charge it ends up retaining it's charge and turns into an ion again. Here are some examples:



- The hardest part about complex ions is that you have to remember how many ligands are stuck to it...



Balancing Complex Ion Equations

- With previous ionic equations all we had to do was to make sure that the ions charges matched.
- Unfortunately with complex ions we work backwards:
 1. Memorise how many ligands match up with the metal ion
e.g. Al^{3+} has 4 OH^- ions
 2. Write that down as your product: $\rightarrow \text{Al}(\text{OH})_4^-$
 3. Now write down the reactants: $\text{Al}^{3+} + 4\text{OH}^-$
- You may be thinking, “Oh no! I have to remember a whole heap of numbers and ligands.” Well, yes you do **BUT** it is not as bad as it seems.
- On the next page we will investigate trends with the complex ions that you will need to memorise...



Complex Ion Trends

$\text{Cu}(\text{H}_2\text{O})_6^{2+}$	$\text{Zn}(\text{OH})_4^{2-}$
$\text{Zn}(\text{H}_2\text{O})_6^{2+}$	$\text{Zn}(\text{NH}_3)_4^{2+}$
$\text{Al}(\text{H}_2\text{O})_6^{3+}$	$\text{Cu}(\text{NH}_3)_4^{2+}$
$\text{Al}(\text{OH})_4^-$	$\text{Ag}(\text{NH}_3)_2^+$
$\text{Pb}(\text{OH})_4^{2-}$	FeSCN^{2+}

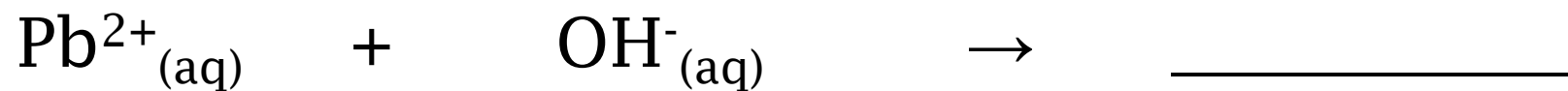
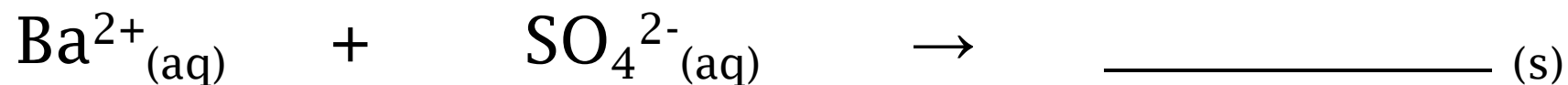
Trends:

1. All complex ions containing water have SIX ligands
2. The rest have FOUR ligands (except Silver (2) and Iron (1))



Balancing Exercises - Precipitation

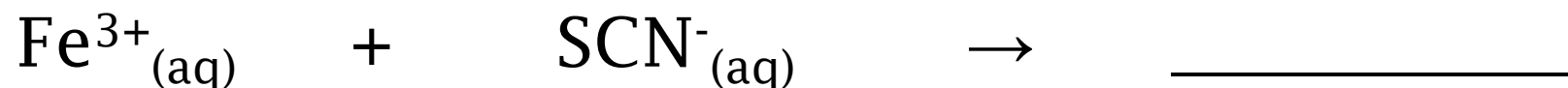
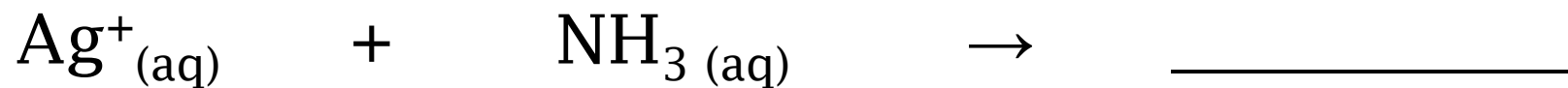
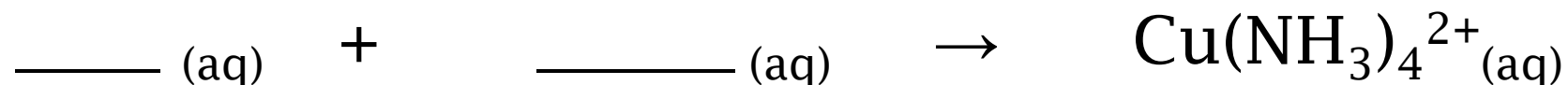
- Precipitates:





Balancing Exercises – Complex Ions

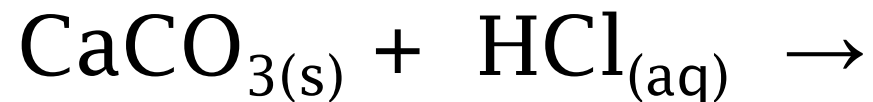
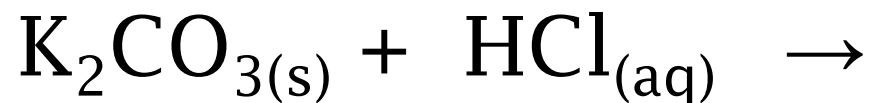
- Complex Ions:





Balancing Exercises - Acid Reactions

● Acids + Carbonates:





Balancing Exercises – Extras

- Create balanced equations for the formation of:

