# Do now:

Will a precipitate form when 0.50 g of $Ca(NO_3)$ is added to a 100mL solution that contains 0.320 mol.L$^{-1}$ of sulfate ions?

$K_s$ $(CaSO_4)$ = 2.00 x 10$^{-5}$
$M(Ca(NO_3)_2)$ = 164 g.mol$^{-1}$
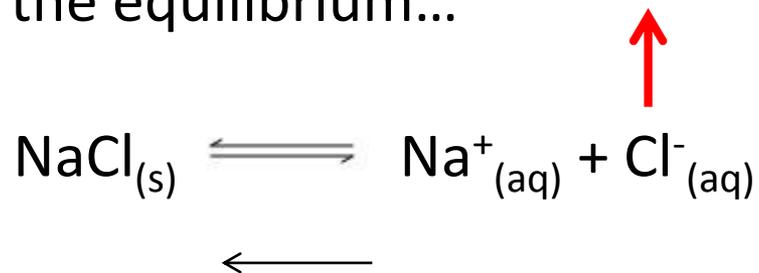
What is the maximum mass of $Ca(NO_3)$ that could be added for no precipitate to form?

# Common ion effect

Addition of a common ion decreases the solubility of the sparingly soluble salt.

The key is to look at the equilibrium…

$$NaCl_{(s)} \rightleftharpoons Na^+_{(aq)} + Cl^-_{(aq)}$$

Addition of product (the common ion) increases its concentration, shifting the equilibrium to the left.

# Complex ions

Formation of a complex ion increases the solubility of the sparingly soluble salt.

The key is to look at the equilibrium…

$$AgNO_{3(s)} \rightleftharpoons Ag^+_{(aq)} + NO_3^-_{(aq)}$$

Removal of product (the complex ion) decreases its concentration, shifting the equilibrium to the right.

Complex ions
Usually with $NH_3$ or $OH^-$ solution
$[Ag(NH_3)_2]^+$, $[Cu(NH_3)_4]^{2+}$, $[Zn(NH_3)_4]^{2+}$
$[Al(OH)_4]^-$, $[Zn(OH)_4]^{2-}$, $[Pb(OH)_4]^{2-}$

# 2013 Exam Q 2 (c)

In an experiment, a saturated solution was made by dissolving $1.44 \times 10^{-3}$ g of $Ag_2CrO_4$ in water, and making it up to a volume of 50.0 mL.

$M(Ag_2CrO_4) = 332$ g $mol^{-1}$

(c) In another experiment, 0.0100 g of $Ag_2CrO_4$ in beaker A was made up to a volume of 50.0 mL with water. In beaker B, 0.0100 g of $Ag_2CrO_4$ was made up to a volume of 50.0 mL with 0.100 mol $L^{-1}$ ammonia solution.

$K_s(Ag_2CrO_4) = 2.61 \times 10^{-12}$



0.0100 g
$Ag_2CrO_4$

0.0100 g
$Ag_2CrO_4$

50 mL

50 mL

water

ammonia
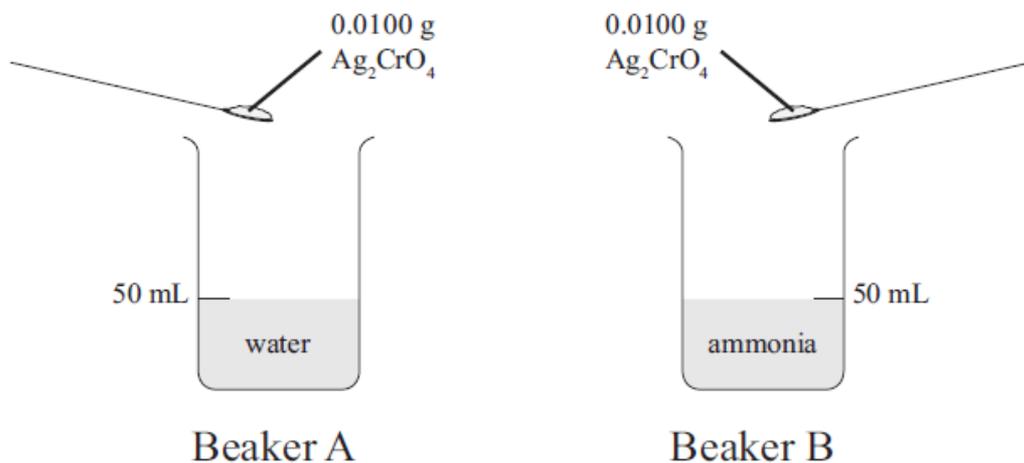
Beaker A

Beaker B

Compare and contrast the solubility of $Ag_2CrO_4$ in beaker A and beaker B.

No calculations are necessary.

# 2013 Exam Q 2 (c)

**For A:**

- Recognises that more dissolves in B.
- Recognises that a complex ion forms.

**For M:**

- Recognises that more dissolves in beaker B with link to an equation.
- Recognises that in ammonia a silver complex ion will form.

**For E:**

- Links equilibrium of silver chromate with silver & ammonium complex ion removal and hence more dissolves.
- Recognises $0.0100 \, g > 1.44 \times 10^{-3}$, therefore solid $Ag_2CrO_4$ is present.
- Correct equation of formation of complex ion.

Dissolving 0.0100g of silver chromate in 50 mL water will result in solid being present, as the required amount to make a saturated solution is $1.44 \times 10^{-3}$ g in 50 mL, so any more than this will form a solid.

If the same mass is added to 50 mL of ammonia, more will dissolve and less solid will be present due to the formation of a complex ion. The $Ag_2CrO_4$ will dissociate completely and form an equilibrium.

$$Ag_2CrO_4 \rightleftharpoons 2Ag^+ + CrO_4^{2-}$$

$$Ag^+ + 2NH_3 \rightleftharpoons [Ag(NH_3)_2]^+$$
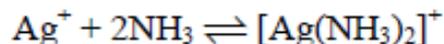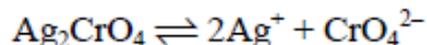
The silver ion will then react further with $NH_3$, removing it from the above equilibrium. Thus, more $Ag_2CrO_4$ will dissolve to re-establish equilibrium.

\* However in beaker B, the solubility of $Ag_2CrO_4$ will be significantly greater. In beaker B, the $Ag^+$ that is in solution will form the complex ion $[Ag(NH_3)_2^+]$ due to the presence of excess $NH_3$:

$$Ag^+_{(aq)} + 2NH_{3(aq)} \rightarrow [Ag(NH_3)_2^+]_{(aq)}$$
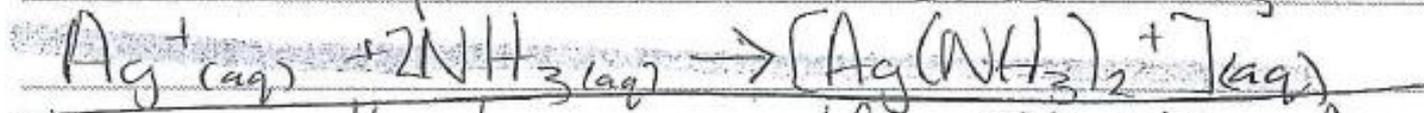
This will decrease the $[Ag^+]$. As a result the solubility equilibrium (①) will favour the foward reaction to increase the $[Ag^+]$ in the solution. Obviously this results in more $Ag_2CrO_4$ dissolving and solubility increasing. Hence the solubility of $Ag_2CrO_4$ is significantly greater in Beaker B ~~(HAGA 1A~~ (with excess $-0.100 mol L^{-1} - NH_3$) than in beaker A (with water).)

# 2014 Exam Q2 c

(c) The solubility of zinc hydroxide, $Zn(OH)_2$, can be altered by changes in pH. Some changes in pH may lead to the formation of complex ions, such as the zincate ion, $[Zn(OH)_4]^{2-}$.

Use equilibrium principles to explain why the solubility of zinc hydroxide increases when the pH is less than 4 or greater than 10.
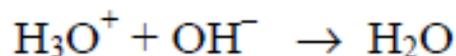
*No calculations are necessary.*
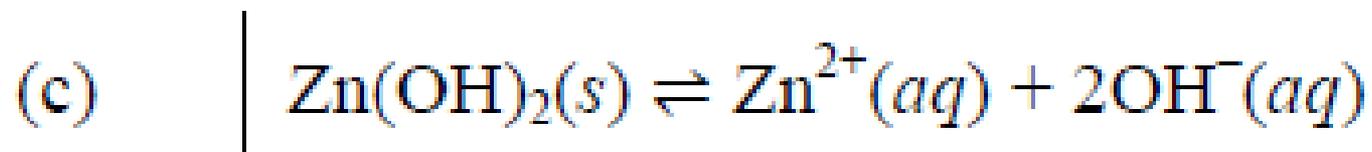
(c) $$Zn(OH)_2(s) \rightleftharpoons Zn^{2+}(aq) + 2OH^-(aq)$$

When pH is less than 4 / low, $[OH^-]$ is decreased due to the reaction with $H_3O^+$ to form water,

$$H_3O^+ + OH^- \rightarrow H_2O$$
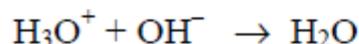
so equilibrium shifts to the right to produce more $[OH^-]$, therefore more $Zn(OH)_2$ will dissolve.

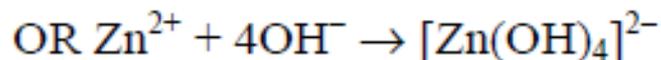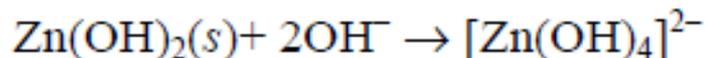# 2014 Exam Q2 c

When pH is less than 4 / low, $[OH^-]$ is decreased due to the reaction with $H_3O^+$ to form water,

$$H_3O^+ + OH^- \rightarrow H_2O$$

so equilibrium shifts to the right to produce more $[OH^-]$, therefore more $Zn(OH)_2$ will dissolve.

When pH is greater than 10 / high, then more $OH^-$ is available and the complex ion (zincate ion) will form.

$$Zn(OH)_2(s) + 2OH^- \rightarrow [Zn(OH)_4]^{2-}$$

$$OR \; Zn^{2+} + 4OH^- \rightarrow [Zn(OH)_4]^{2-}$$

This decrease in $[Zn^{2+}]$ causes the position of equilibrium to shift further to the right, therefore more $Zn(OH)_2$ dissolves.