Slide 1

Chloride

What a difference a D makes!

Slide 2

Chloride is not chlorine

Measuring chloride is acquiring information about a very different property of the water.

Chloride is about “salt content”.

Slide 3

Saltiness

The presence of chloride is not lethal to humans, but it is objectionable in water supplies.

Chloride is bad for plants if the concentration is too high… Why?

Slide 4

Osmotic pressure

Does anyone know what osmotic pressure is?

Osmotic pressure is the pressure required to overcome the natural pressure exerted by a solution by virtue of having a concentration.

Slide 5

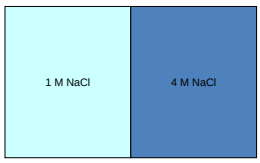
Why is it important?

Consider two solutions separated by a semi-permeable membrane (meaning water can pass through but nothing else) at room temperature (298 K).

On one side of the membrane is a 1 M NaCl solution. On the other side is a 4 M NaCl solution.

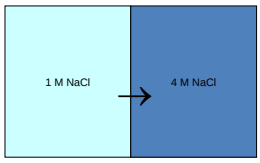
Slide 6

What Happens?



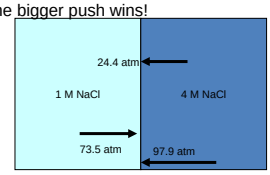
Slide 7

The water moves from the 1 M side to the 4 M side. Why?



Slide 8

Both solutions “push” on the membrane because of their osmotic pressure
The bigger push wins!

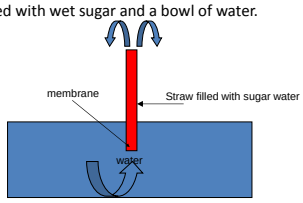


Note the direction of the arrows. Osmotic pressure is pushing AGAINST the solution and is directly proportional to concentration.

Slide 9

Poor Man’s Fountain

You can actually make a fountain out of a straw packed with wet sugar and a bowl of water.



Slide 10

Why is this bad for plants…?

Plants (and animals) are made up of little bags of aqueous solutions. Well, biologists call them "cells" but they really are just little membrane-bound aqueous solutions.

Slide 11

Osmotic pressure

The water flows from the more dilute solution to the more concentrated solution.

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And if you're a plant…???

If the salt concentration in the soil (or water) is too high, water flows out of the plants not into them!!!!!!

Conquering armies used to "salt the fields". Add NaCl to the soil so that nothing would grow in it for years.

Slide 13

Salt is bad, so…

We test for “saltiness” or chloride concentration.

Anybody want to guess how….???

Titration!

Slide 14

Mohr Method – Titration with silver

All titrations require:

1. Reaction
2. Indicator

Slide 15

Mohr Method – Titration with silver

$Ag^{+}_{(aq)} + Cl^{-}_{(aq)} \leftrightarrow AgCl_{(s)}$

$K_{sp} = 3 \times 10^{-10}$

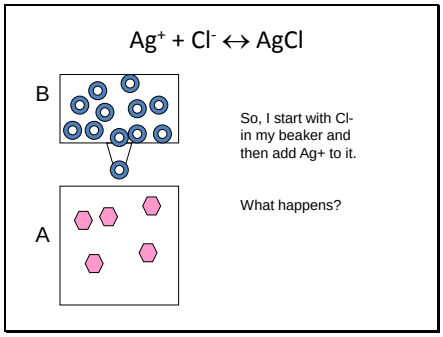
What would you see??

A white solid (AgCl) forms.

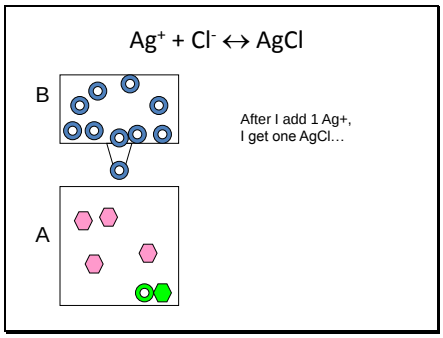
When is your titration done?

When the white solid stops forming.

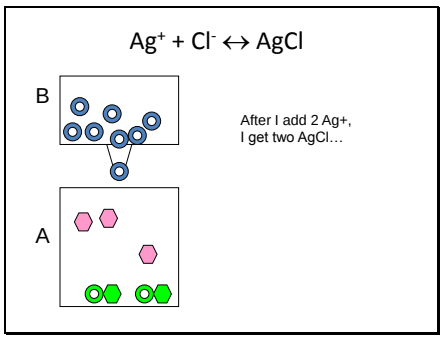
Slide 16



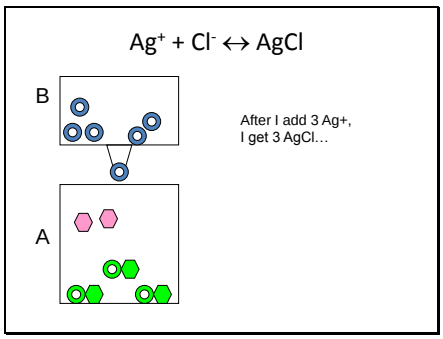
Slide 17



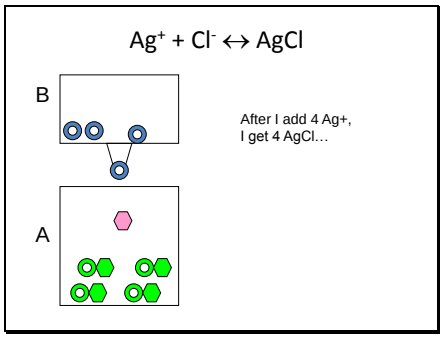
Slide 18



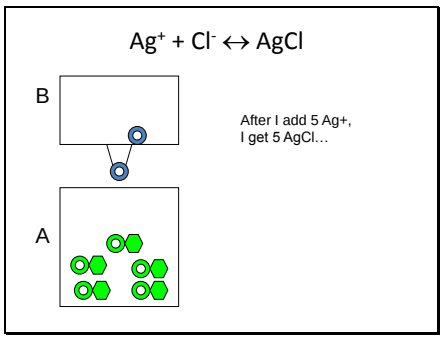
Slide 19



Slide 20



Slide 21



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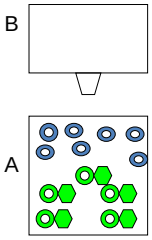
$Ag^+ + Cl^- \leftrightarrow AgCl$



After I add 1,000,000 Ag+, I get 5 AgCl.

As soon as I made the 5 AgCl, I stopped making any new AgCl – that would be my endpoint!

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How would you know it's stopped?

Hard to tell. So we use a second reaction as an indicator. (Much like with the chlorine analysis.)

$2\ Ag^+_{(aq)} + CrO_4^{2-}{}_{(aq)} \leftrightarrow Ag_2CrO_{4\,(s)}$

$K_{sp} = 5 \times 10^{-12}$

Silver chromate is a red-brown solid

Slide 24

So you add a little chromate!

$Ag^+_{(aq)} + Cl^-_{(aq)} \leftrightarrow AgCl_{(s)}$

$K_{sp} = 3 \times 10^{-10}$

$2\ Ag^+_{(aq)} + CrO_4^{2-}{}_{(aq)} \leftrightarrow Ag_2CrO_{4\,(s)}$

$K_{sp} = 5 \times 10^{-12}$

Since the K is smaller and the $[CrO_4^{2-}]$ is small – the second reaction won't happen until the first one is done!

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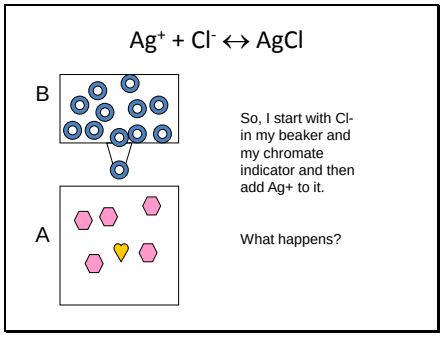
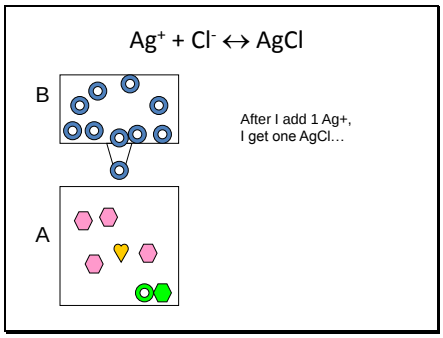
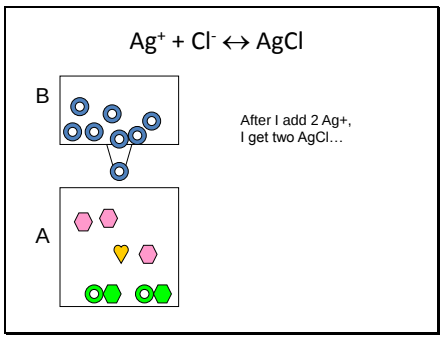


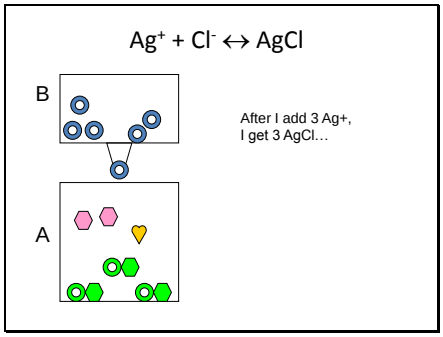
Slide 26



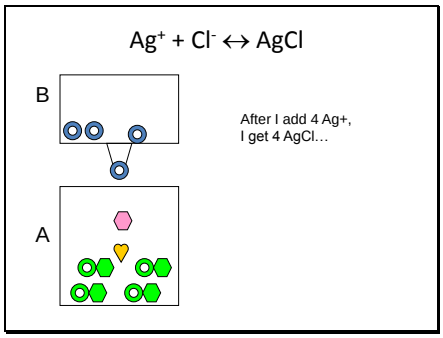
Slide 27



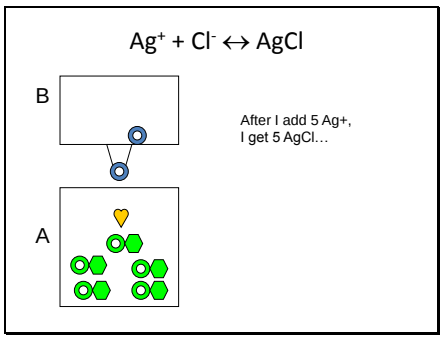
Slide 28



Slide 29

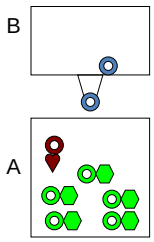


Slide 30



Slide 31

$Ag^+ + Cl^- \leftrightarrow AgCl$



After I add 6 Ag+, I get 5 AgCl and 1 $AgCrO_4$ complex which is red-brown

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Mercuric Nitrate Method

It is also possible to react the chloride with mercury (pH<2.5) - which is how you did the lab:

$Hg^{2+}_{(aq)} + 2\ Cl^-_{(aq)} \leftrightarrow HgCl_{2\ (aq)}$

Diphenylcarbazone will complex with Hg^{2+} to form a purple color.

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Sample problem

100.0 mL of waste water is titrated using the Mohr method. A chromate endpoint is reached after addition of 16.43 mL of 0.09762 M $AgNO_3$. What is the chloride concentration in mg Cl^-/L?

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Solution

The Mohr titration has 1:1 stoichiometry

$M_1V_1 = M_2V_2$

M_1 (100.0 mL) = (0.09762 M) (16.43 mL)

$M_1 = 0.01604$ M Cl^-

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Units! Units! Units!

mg/L is the more common unit for Cl^- concentration (as well as Cl_2 actually)

$M_1 = 0.01604$ M Cl^-

How do I get the units right?

Slide 36

Units! Units! Units!

$M_1 = \frac{0.01604 \text{ moles } Cl^-}{1 \text{ L solution}}$

We just need to convert moles to mg!

Slide 37

Units! Units! Units!

$$\frac{0.01604 \text{ moles } Cl^-}{1 \text{ L solution}} * \frac{35.453 \text{ g } Cl^-}{\text{mole } Cl^-} * \frac{1000 \text{ mg}}{1 \text{ g}}$$

= 568.6 mg/L

(which is actually pretty high – anything above 250 mg/L will taste salty)

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Sample problem

100.0 mL of waste water is titrated using the Mercuric Nitrate method. A diphenylcarbazone endpoint is reached after addition of 16.43 mL of 0.09762 M $Hg(NO_3)_2$. What is the chloride concentration in mg/L?

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Solution

The Mercuric Nitrate titration has 2:1 stoichiometry

$i_2M_1V_1 = i_1M_2V_2$

$1 M_1 (100.0 \text{ mL}) = 2 (0.09762 \text{ M}) (16.43 \text{ mL})$

$M_1 = 0.03208 \text{ M } Cl^-$

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Units! Units! Units!

mg/L is the more common unit for Cl^- concentration (as well as Cl_2 actually)

M_1 = 0.03208 M Cl^-

How do I get the units right?

Slide 41

Units! Units! Units!

$$M_1 = \frac{0.03208 \text{ moles } Cl^-}{1 \text{ L solution}}$$

We just need to convert moles to mg!

Slide 42

Units! Units! Units!

$$\frac{0.03208 \text{ moles } Cl^-}{1 \text{ L solution}} * \frac{35.453 \text{ g } Cl^-}{\text{mole } Cl^-} * \frac{1000 \text{ mg}}{1 \text{ g}}$$

= 1137.2 mg/L

(which is actually pretty high – anything above 250 mg/L will taste salty)