CHEM 3.6 (5 credits)

Demonstrate understanding of equilibrium principals in aqueous systems

- sparingly soluble ionic solids
- acidic and basic solutions

- concentrations of dissolved species
- K_s calculations
- common ion effect
- predicting precipitation/dissolution

- K_a and pK_a calculations
- concentration of species present in solution
- pH and conductivity
- titration curves and selection of indicators

Do now:

What is an acid?

What is a base?

What is the difference between a concentrated and a strong acid?

CHEM 3.6 AS91392 (5 credits)

Demonstrate understanding of equilibrium principals in aqueous systems
external

CHEM 3.3 AS91389 (3 credits)

Demonstrate understanding of chemical processes in the world around us
internal (literacy reading and writing credits)

Similarities

CHEM 3.3 requires knowledge of acids and bases at curriculum level 8 (NCEA Level 3).

The first part of CHEM 3.6 also requires knowledge of acids and bases but more in-depth than CHEM 3.3.

We will cover acids and bases together until the end of this week before splitting off into groups for CHEM 3.3 and CHEM 3.6

powerpoints and
text book work

independent work
with checkpoints

Acids and Bases

Brainstorm what you recall from level 2…

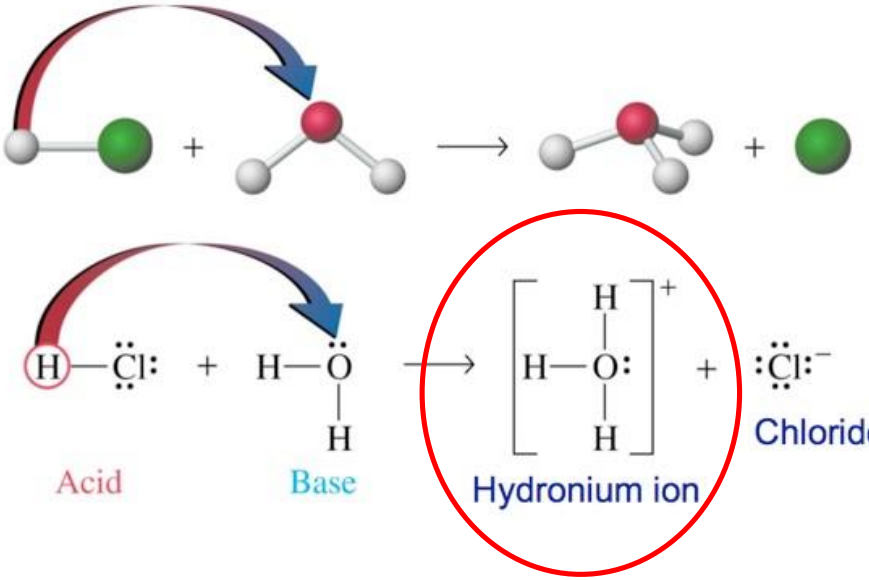
These key words might help you…

pH K_w hydronium ion concentrated strong alkali

Acids and Bases

An acid is a proton donor

A base is a proton acceptor



Write equations for HNO_3 and CO_3^{2-} reacting with water

Amphiprotic substances

Some compounds can act as both acids and bases.

Write two equations for the reaction of HCO_3^- with water to show it acting as both an acid and a base.

Do now:

Write two equations for $H_2PO_4^-$ reacting with water.

As an acid:

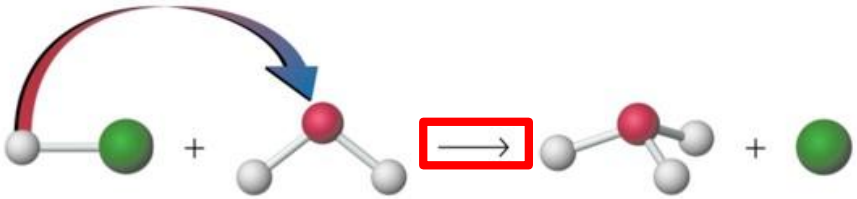
$H_2PO_4^- + H_2O$ 

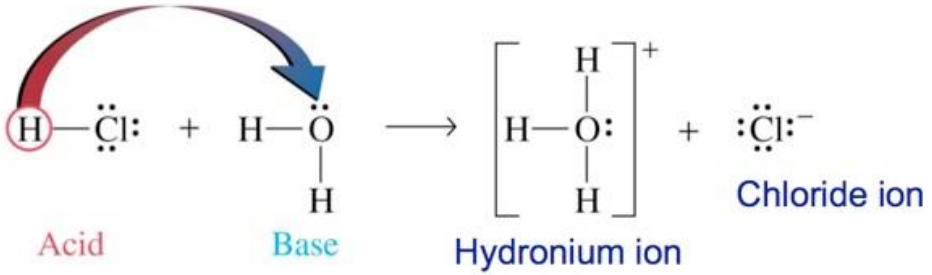
As a base:

$H_2PO_4^- + H_2O$ 

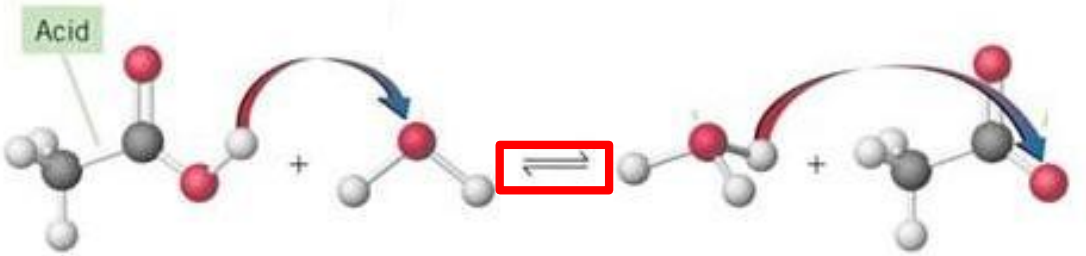
Strong and weak acids

A **strong** acid completely dissociates in water

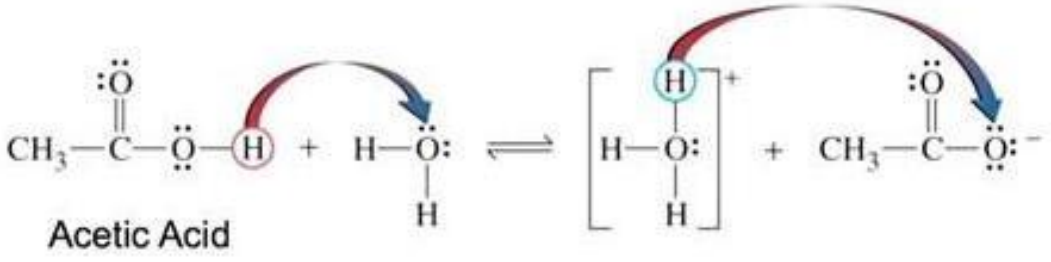




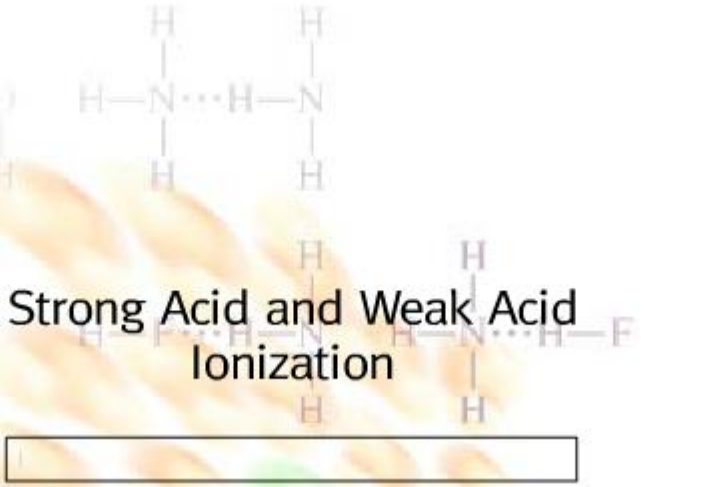
A **weak** acid does not completely dissociate in water



Concentrated and dilute mean different things than strong and weak!



Strong and weak acids



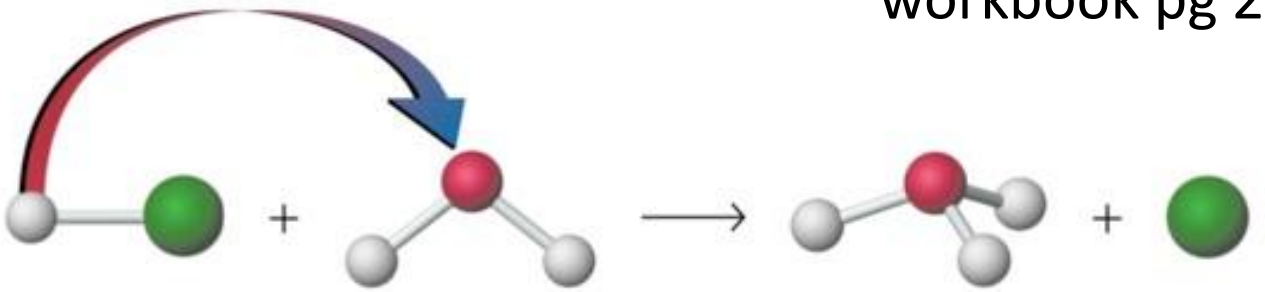
Strong and weak acids

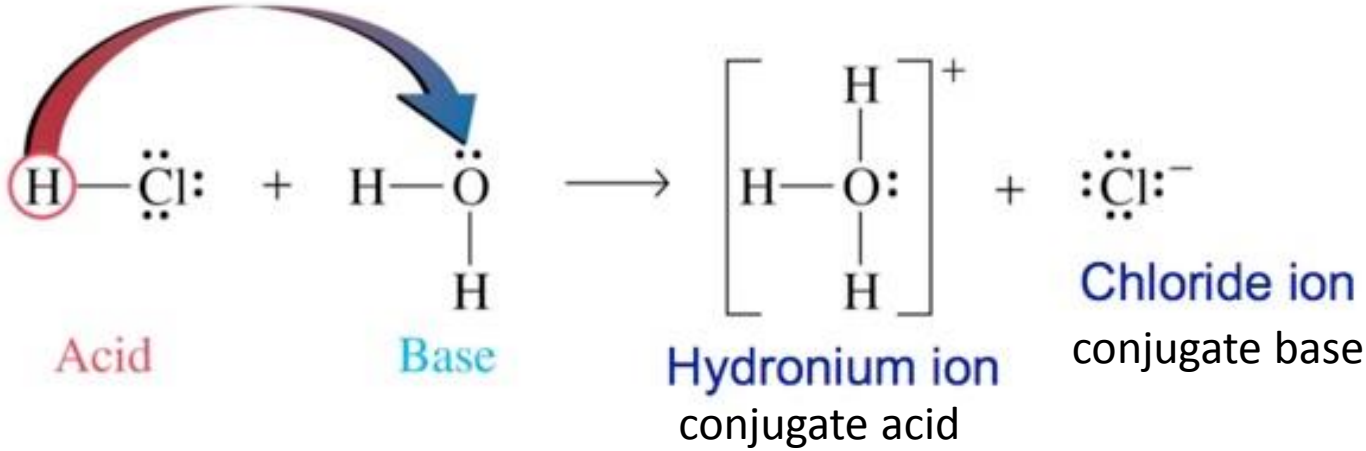
Write three sentences to describe the difference between a strong acid and a weak acid. Write equations for the reactions of sulphuric acid (H_2SO_4), a strong acid, and carbonic acid (H_2CO_3), a weak acid, to help explain your answer.

Conjugate pairs

When an acid dissolves in water the ion produced from the removal of H^+ is called its **conjugate base**. When a base dissolves in water the ion produced from the addition of H^+ is called its **conjugate acid**.

workbook pg 205 and 206





Measuring the acidity of solutions

How do we measure how acidic a solution is?

pH

We can measure the pH or pOH of strong acids and bases because the solutions dissociate completely into their ions, so the concentration of H_3O^+ or OH^- is the same as the concentration of the acid or base

$pH = -\log_{10}[H_3O^+]$ $pOH = -\log_{10}[OH^-]$ $14 = pH + pOH$

$K_w = [H_3O^+]\,[OH^-] = 1 \times 10^{-14}$

pH calculations for strong acids and bases

Calculate the pH of the following solutions…

a) A 0.025 $mol.L^{-1}$ solution of HCl

$pH = -\log_{10}0.025 = 1.60$

b) A 0.004 $mol.L^{-1}$ solution of KOH

$pOH = -\log_{10}0.004 = 2.40$ **$pH = 14 - 2.40 = 11.60$**

Calculate $[H_3O^+]$ for the following solutions

a) A solution of HCl with a pH of 2.8

$[H_3O^+] = 10^{-2.8} = 1.58 \times 10^{-3}\ mol.L^{-1}$

b) A solution whose pH is 4.31

$[H_3O^+] = 10^{-4.31} = 4.90 \times 10^{-5}\ mol.L^{-1}$

Workbook pg 225 Q2, 226, 228

Do now:

Calculate the pH of the following solutions

0.05 mol.L^{-1} solution of HCl

A 0.04 mol.L^{-1} solution of KOH

Calculate [H_3O^+] for the following solutions

A solution whose pH is 10.4

A solution where [OH^-] = 10^{-9}

Calculate[OH^-] for the following solutions

A solution whose pH is 6.5

A solution where [H_3O^+] = 10^{-3}

Strong and weak acids:

Why is the pH of a 0.5 mol.L^{-1} HCl solution (a strong acid) different to the pH of a 0.5 mol.L^{-1} CH_3COOH solution (a weak acid)?

Acid Rain

2012 Exam

QUESTION ONE

(a) Write equations for the reactions occurring when each of the following is added to water.

(i) HCl

$$HCl + H_2O \rightarrow H_3O^+ + Cl^-$$

(ii) CH_3NH_2

$$CH_3NH_2 + H_2O \rightleftharpoons OH^- + CH_3NH_3^+$$

(iii) NH_4Cl

$$NH_4Cl \rightarrow NH_4^+ + Cl^-$$

$$NH_4^+ + H_2O \rightleftharpoons NH_3 + H_3O^+$$

Properties

What is the difference between the pH of a strong acid and a weak acid?

Strong acid – complete dissociation – means higher concentration of H_3O^+ so a lower pH

Weak acid – incomplete dissociation – means lower concentration of H_3O^+ so a higher pH

What is the difference in the conductivity of a strong acid and a weak acid?

Strong acid – complete dissociation – means many ions in solution which can conduct charge

Weak acid – incomplete dissociation – means fewer ions in solution so can not conduct as much charge

Acidic and basic salts

When a strong acid and a strong base react together in equal amounts the solution is neutral (pH = 7).

eg. $NaOH + HCl \rightarrow Na^+ + Cl^- + H_2O$

neutral

When a strong acid and a weak base react together in equal amounts the solution is slightly acidic (pH < 7).

eg. $NH_3 + HCl \rightarrow NH_4^+ + Cl^-$

neutral

$NH_4^+ + H_2O \rightleftharpoons H_3O^+ + NH_3$

When a weak acid and a strong base react together in equal amounts the solution is slightly basic (pH > 7).

eg. $NaOH + CH_3COOH \rightarrow H_2O + Na^+ + CH_3COO^-$

neutral

$CH_3COO^- + H_2O \rightleftharpoons CH_3COOH + OH^-$

Do now:

Complete Q 4 and 5 in your workbook pg 229

You need to be able to write equations for weak acids (eg NH_4^+, CH_3COOH and HOCl) and weak bases (eg NH_3, CH_3COO^-) reacting with water.

2013 Exam

QUESTION ONE

(a) 1 mol of each of the following substances was placed in separate flasks, and water was added to these flasks to give a total volume of 1 L for each solution.

In the box below, rank these solutions in order of **increasing** pH.

Justify your choice and include equations where appropriate.

CH_3NH_3Cl
CH_3NH_2
HCl

Order of increasing pH
$HCl < CH_3NH_3Cl < CH_3NH_2$

2013 Exam

* CH_3NH_3Cl is an ionic solid. In water it will break up completely into it's ions

$CH_3NH_3Cl_{(s)} \rightarrow CH_3NH_3^+{}_{(aq)} + Cl^-_{(aq)}$

$CH_3NH_3^+$ is a weak acid, so will will set up an equilibrium with water

$CH_3NH_3^+ + H_2O \rightleftharpoons CH_3NH_2 + H_3O^+$

as H_3O^+ forms (proton donated to H_2O) the $[H_3O^+]$ will be greater than $[OH^-]$ and $pH < 7$ however as it is a weak acid, the pH will

* CH_3NH_2 is a weak base that will partially dissociate in water $CH_3NH_2 + H_2O \rightleftharpoons CH_3NH_3^+ + OH^-$

as OH^- forms $[OH^-] > [H_3O^+]$ and $pH > 7$

2013 Exam

Achievement	Achievement with Merit	Achievement with Excellence
• Correct order. • TWO equations correct. • Recognises that HCl dissociates completely in water. OR Recognises that $CH_3NH_3^+$ OR CH_3NH_2 only partially react with water.	• THREE correct equations. • Recognises that HCl dissociate completely in water. AND Recognises that $CH_3NH_3^+$ or CH_3NH_2 only partially react with water.	• Discusses all the reactions correctly including concentrations of OH^- and H_3O^+ ions.

2013 Exam

(b) The conductivity of the 1 mol L^{-1} solutions formed in (a) can be measured.

In the box below, rank these solutions in order of **decreasing** conductivity.

Order of decreasing conductivity
$HCl = CH_3NH_3Cl > CH_3NH_2$

Compare and contrast the conductivity of each of the 1 mol L^{-1} solutions, with reference to species in solution.

2013 Exam

* CH_3NH_3Cl also completely breaks up into it's ions in water

$CH_3NH_3Cl_{(s)} \rightarrow CH_3NH_3^+{}_{(aq)} + Cl^-{}_{(aq)}$

as a result the [ions] is high, and the same as for HCl. As a result CH_3NH_3Cl has conductivity equally as high as for HCl.

* CH_3NH_2 is a weak base which only partially dissociates in water

$CH_3NH_2 + H_2O \rightleftharpoons CH_3NH_3^+ + H_3O^+$

Molecule

this means that only a few ions form, resulting in a low [ions] and a relatively low conductivity.

2013 Exam

Q	Evidence
(b)	$HCl = CH_3NH_3Cl > CH_3NH_2$ CH_3NH_3Cl and HCl will dissociate completely in water to produce 2 mol L^{-1} ions. CH_3NH_2 will only partially react with water to produce less than 1 mol L^{-1} of ions.

Achievement	Achievement with Merit	Achievement with Excellence
• CH_3NH_2 written last. • Links concentration of ions to degree of conductivity.	• CH_3NH_2 written last and discusses HCl / CH_3NH_3Cl AND CH_3NH_2. Links concentration of ions to degree of conductivity.	• Correct order with valid discussion. Links concentration of ions to degree of conductivity.

2012 Exam

QUESTION ONE

(c) Compare and contrast the pH and electrical conductivity of 0.100 mol L^{-1} solutions of HCl,

Q	Achievement	Achievement with Merit	Achievement with Excellence
(c)	• Either: Recognises reasons for pH variation are due to production of H_3O^+/OH^- OR Recognises conductivity is related to the number of ions in solution.	• Either: Recognises reasons for variations in pH and conductivity AND makes a valid comparison between one pair. OR Difference in pH correctly discussed for ALL 3 solutions. OR Difference in conductivity correctly discussed for ALL 3 solutions.	• Discussion addresses variation in BOTH pH (including whether acidic or basic) and conductivity using correct reasons for ALL 3 solutions.