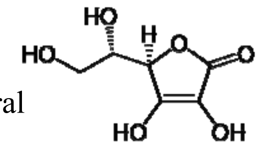
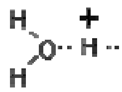
Lesson 1 For Book 2

Acid and Alkalis



- Actually, there are many things existing in our daily life which are an acid or an alkaline/base. For example, **vitamin C** is a natural organic acid, which can be used as an anti-oxidant (抗___化劑) While **caustic soda** (NaOH) is used in drain cleaners.

What is an acid?



- An acid is a speiecs which can **produce hydrated hydrogen ions** , H_3O^+, i.e. $H_2O \rightarrow H^+$, when the species is dissolved in ______.There are two types of acid, they are ino_______acids and o______ acids.
- "**Basicity**" of an acid describes the **maxium** number of hydrogen ions (protons) that **one** acid molecule can produce in water.
  1. monobasic --- e.g. HCl , $HCl + H_2O \rightarrow H_3O^+ +$ ____ --- only one H_3O^+
  2. dibasic --- e.g. H_2SO_4 , $H_2SO_4 +$ ___$H_2O \rightarrow$ ___$H_3O^+ + SO_4^{2-}$ --- two ____
  3. tribasic --- e.g. H_3PO_4 , H_3PO_4 + ___$H_2O \rightarrow$___$H_3O^+ + PO_4^{3-}$ --- three____
- The above equations are describing the **dissociation of strong acid**, that is, the **irreversible** dissolution of acid in water to produce h_______ proton(s) .

> *Further Thinking*
> Please order the following *inorganic acid* in increasing strength by **inspection** only.
> HNO_3 , H_2CO_3 , H_3PO_4
> → In fact, basicity of an acid is n____ related to its strength !!!

Some facts about acids

1. Acids have a _____ taste. 2. Acids can change _____litmus paper _____.
3. Acids can conduct *electricity*. (Why? As they can produce mobile p_____ ions.)

→ Acids are **electrolytes,** which means a source of *mobile ions*.

4. Acids can react with *metals* to give out s____+ h________ gas → A____ B____

e.g. Please write down the reaction between Calcium and HNO_3.

5. Acids can react with *metal oxides and hydroxides* to give out s____ and **water**.

→ It is a typical type of *neutralization* , an ____thermic reaction.

e.g Please write down the reaction between Lithium oxide and Sulphuric acid.

→ Be careful of the *mole ratio* =

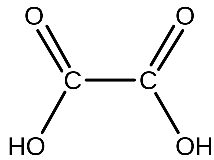
6. Acids can react with *metal carbonates and hydrogencarbonates* to give out salt + water + ____ _____ gas , which can turn l____ water milky.

→ It is n___ a ~~neutralization~~ process as _____ gas is also produced.

e.g. Please write down the reaction between sodium carbonate and hydrochloric acid.

Exercise 1 Successive ionization of an acid

It is known that an polybasic acid will give out its protons one by one.



a) Please write down the successive ionization equations of the organic acid, **oxalic acid**. (Hint = What is the basicity of it? ___.)

→

→

b) If oxalic acid and sulphuric acid are allowed to react with **lime water**, which contains C_______ hydroxides, which acid will react more vigorously?

→ Remember that o_____ acids are relatively **weaker** than inorganic acids.

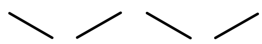
<u>What is an alkalis/bases ?</u>

- A base is a species which will accept a proton from an a____ to produce a ____ **anion**, when the species is dissolved in water. There are two types of bases, they are ino_______bases and o______ bases.
- Similar to acids, if a base can dissolve in water irr_______ to give OH^- ions, the dissolution process is called **dissocation**. If a base (which is not very soluble in water) can dissolve in water **reversibly** $\rightleftharpoons$ to give OH^- ions, the process is called **i**_________. e.g $NH_3(aq) + H_2O(l) \rightleftharpoons NH_4^+(aq) +$ ___ (aq)

→ Remember that all **ions** should be in the state (___) .

<u>Further Thinking</u>

Do you think that there is an organic base? Do you think that there is an polybasic



base? Here is an example, with ____ **basic sites**.

<u>Some facts about bases</u>

1) Bases usually taste bitter. 2) Bases have a slippery feel.

3) Bases can turn ___ litmus paper ___.

4) Bases are electrolytes, as they dissolve in _____to give mobile ions e.g. ____

5) Bases can react with **acids** to give <u>salt and water</u> → *Neutralization*

6) Bases can react with **non-metal oxides** (e.g. CO_2 (g)) → *Acid base reaction*

→ Do you know that non-metal oxides e.g. CO_2 or SO_2 or SO_3 is acidic. CO_2 is one of the causes of acidic rain as CO_2 can dissolve in water/river to give _____ acid.

7) Bases can react with **ammonium compounds** to give salt + water + _______ gas, which can turn red litmus paper ____.

e.g. $\mathbf{(NH_4)_2}CO_3(aq) + 2\ NaOH(aq) \rightarrow Na_2CO_3(s) + 2H_2O(l) + 2\mathbf{NH_3(g)}$

<u>New concept ---Why ammonia is basic but its ammounium salt is acidic?</u>

Remember the following **exchange of roles** --- there must be *a pair of acid and base*.

$NH_3(aq) + H_2O(l) \rightleftharpoons NH_4^+(aq) + OH^-(aq)$

Base Acid Acid Base

8) Bases can react with metal salts (which provide metal i___) to give soluble or insoluble **metal hydroxides** and **another metal salt**. → **Precipitation process**

Colour of Metal-ions containing solution	Ionic equation of common precipitations	Colour of precipitates
Al^{3+} pale green	$Al^{3+}(aq) + 3OH^-(aq) \rightarrow Al(OH)_3(s)$	white
Ag^+ colourless	$2Ag^+(aq)+2OH^-(aq) \rightarrow \mathbf{Ag_2O(s)} + H_2O$	Dark brown
Cu^{2+} blue	$Cu^{2+}(aq) + 2OH^-(aq) \rightarrow Cu(OH)_2(s)$	Deep blue
Fe^{2+} green	$Fe^{2+}(aq) + 2OH^-(aq) \rightarrow Fe(OH)_2(s)$	Dark green
Fe^{3+} yellow	$Fe^{3+}(aq) + 3OH^-(aq) \rightarrow Fe(OH)_3(s)$	Reddish brown
Mg^{2+} colourless	$Mg^{2+}(aq) + 2OH^-(aq) \rightarrow Mg(OH)_2(s)$	White
Ni^{2+} green	$Ni^{2+}(aq) + 2OH^-(aq) \rightarrow Ni(OH)_2(s)$	Green
Pb^{2+} colourless	$Pb^{2+}(aq) + 2OH^-(aq) \rightarrow Pb(OH)_2(s)$	White
Zn^{2+} colourless	$Zn^{2+}(aq) + 2OH^-(aq) \rightarrow Zn(OH)_2(s)$	White

<u>*Extra Information*</u>

1) When **excess NaOH(aq)** is added on the solution with *$Al(OH)_3(s)$, $Pb(OH)_2(s)$ and $Zn(OH)_2(s)$* precipitates respectively, what will happen?

→ the ppt. will dissolve to form a ________ solution.

2) When **excess NH_3(aq)** is added on *$Zn(OH)_2(s)$ and $Ag_2O(s)$*, what will happen?

→ the ppt. will dissolve to form a ________ solution.

*3) When **excess NH_3(aq)** is added on *$Cu(OH)_2(s)$*, what will happen?

→ the ppt. will dissolve to form a deep _____ solution.

Three important inorganic acids

1. Concentrated/ diluted hydrochloric acid (   )

   → Corrosive, volatile which gives out HCl (g, toxic w____ fume)

2. Concentrated/ diluted nitric acid (   )

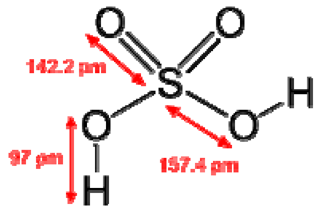
   → volatile and most specially, it has **oxidizing power**

   → must be stored in brown bottle so as to prevent light d__________

   i.e. $4HNO_3(aq) \rightarrow 2H_2O(l) + 4NO_2(\text{brown gas}) + O_2(g)$

3. * Concentrated/ diluted sulphuric acid (   )

   → highly corrosive as it is **dehydrating and oxidizing**



e.g H_2SO_4 can remove water from **sugar** and other carbohydrates, to produce **carbon, heat, steam**, …

$(CH_2O)_n$+Sulfuric acid→**C**(black graphitic foam) +steam+Sulfuric acid/water mixture

*How can we produce H_2SO_4? --- **Contact Process***

In the first step, sulphur is burned to produce sulphur dioxide.

$$S\ (s) + O_2\ (g) \rightarrow SO_2\ (g)$$

This is then oxidized to sulphur trioxide using oxygen in the presence of a **vanadium(V) oxide catalyst**.

$$2\ SO_2\ (g) + O_2\ (g) \rightarrow 2\ SO_3\ (g)\ (\text{in presence of } V_2O_5)$$

The sulfur trioxide is absorbed into 97–98% H_2SO_4 to form **oleum ($H_2S_2O_7$).** The oleum is then diluted with water to form **two moles of** concentrated sulfuric acid.

$$H_2SO_4\ (l) + SO_3 \rightarrow H_2S_2O_7\ (l)$$

$$H_2S_2O_7\ (l) + H_2O\ (l) \rightarrow \mathbf{2\ H_2SO_4\ (l)}$$

Why we don't directly dissolving SO_3 in water to form the acid?

p.s. It is a *highly exothermic* reaction → d__________.

Basic calculation about Concentration and molarity

- An solution of acid/ base should have a unique concentraion/molarity

  → you prepare a **standard solution of NaOH (with known _________)** by weighing and dissolving a certain mass of solid _____ into a certain volume of water.

By considering the two definitions, we can prepare an acid/base with known conc..

1) **Concentration** = mass of solute per unit volume of the solution.

   → with the unit $g/\ dm^3$

2) **Molarity** = no of moles of solute per dm^3 of the solution.

   → with the unit of $mol\ dm^{-3}$ / M