O Level Chemistry
Chap 11: Acids and Bases

Acids

1) Acids are compounds which produce hydrogen ions, H^+, when dissolved in water. All acids contain hydrogen, but not all hydrogen-containing compounds are acids (e.g. NH_3, CH_4).

2) Physical properties of acids
a. Acids have a sour taste
b. Acids can dissolve in water to form solutions which conduct electricity.
c. Acids turn blue litmus paper red.

3) Chemical properties of acids
a. **reactive metal** + acid → salt + hydrogen gas
e.g. Mg (s) + H_2SO_4 (aq) → $MgSO_4$ (aq) + H_2 (g)

Testing for H_2 (Chap 12)
Test: Place a lighted splint at mouth of test tube.
Observation: Lighted splint extinguishes with a 'pop'.

Exceptions:
- Unreactive metals metals like copper and silver will not react with dilute acids.
- When concentrated nitric acid is reacted with metals, hydrogen gas is not produced. Instead, a nitrate, water and nitrogen dioxide gas are formed.
- Lead appears not to react with dilute HCl and H_2SO_4. A layer of insoluble lead (II) chloride or sulfate is formed between the lead and the dilute acid from the initial reaction. It quickly forms a coating around the metal, preventing further reaction.

b. **carbonate** + acid → salt + water + carbon dioxide
e.g. $CaCO_3$ (s) + 2HCl (aq) → $CaCl_2$ (aq) + H_2O (l) + CO_2 (g)

Note: Hydrogencarbonates (HCO_3) also react the same way.
Testing for CO_2 (Chap 12)
Test: Bubble the gas through limewater (calcium hydroxide).
Observation: CO_2 reacts with limewater to form a white precipitate.

c. **base** + acid → salt + water [Neutralisation]
e.g. ZnO (s) + H_2SO_4 (aq) → $ZnSO_4$ (aq) + H_2O (l)

Note: All bases, metal oxides or hydroxides, react with acids in the same way.

4) Role of water in acidity
Acids are covalent compounds which show the properties of acids only in aqueous state. This is because acids dissociate in water to produce H^+ ions which are responsible for acidic properties.

Example of HCl:
- Hydrogen chloride in organic solvent (e.g. alcohol): Acids in the absence of water exists as simple covalent molecules. No dissociation occurs- remain as HCl molecule.
- Aqueous hydrogen chloride (hydrochloric acid): HCl molecules are dissociated/ ionised

into H^+ and Cl^- ions.
$HCl\ (aq) \rightarrow H^+\ (aq) + Cl^-\ (aq)$

Qn: Explain why anhydrous citric acid does not conduct electricity but aqueous citric acid does.
Acids only conduct electricity in aqueous state because; free moving ions needed for conducting electricity are present only in aqueous citric acid. No dissociation can occur without water (in anhydrous citric acid).

Note: Acids conduct electricity by ions; metals and graphite conduct electricity by electrons.

Bases

5) A base is any metal oxide or hydroxide that reacts with an acid to produce salt and water only through neutralisation. Bases that are soluble in water are alkalis. Most bases are insoluble in water except alkalis, which include hydroxides of alkali metals (alkalis) and ammonia. Non-alkali bases like copper (II) oxide are insoluble and will not exist in aqueous state.

6) Chemical properties of bases (and alkalis)

a. base + acid → salt + water
through a neutralisation reaction.

e.g. $NaOH\ (aq) + HCl\ (aq) \rightarrow NaCl\ (aq) + H_2O\ (l)$

In a neutralisation reaction, H^+ ions from the acid and OH^- ions from the base react to form a salt and water. The ionic eqn for any neutralisation reaction is
$H^+\ (aq) + OH^-\ (aq) \rightarrow H_2O\ (l)$

Note:
- If more than a salt and water is formed, it is not a neutralisation reaction. No gases are produced.
- Neutralisation reactions are exothermic.
- If equal amounts of HCl and NaOH are added, the resulting mixture is pH 7. Should HCl be in excess, the resulting mixture is pH 1.

b. Bases, except ammonia, heated with ammonium salts give off ammonia gas.
ammonium salt + base $\xrightarrow{\text{heat}}$ salt + ammonia gas + water
e.g. $2NH_4Cl\ (s) + Ca(OH)_2\ (aq) \rightarrow CaCl_2\ (aq) + 2NH_3\ (g) + 2H_2O\ (l)$

Testing for NH_3 (Chap 12)
Test: Place a moist red litmus paper at the mouth of the test tube.
Observation: The moist red litmus paper turns blue.
The hydroxide ions (OH^-) from the base and the ammonium ions (NH_4^+) react to produce ammonia gas and water. The ionic equation is
$OH^-\ (aq) + NH_4^+\ (aq) \rightarrow NH_3\ (g) + H_2O$

Alkalis- a small class of bases

7) An alkali is a base that is soluble in water, and which dissociates to form hydroxide ions when dissolved in water. All alkalis are hydroxides of alkali metals (e.g. Lithium hydroxide) except ammonia.

base + water → alkali
e.e. sodium oxide (s) + water (l) → sodium hydroxide (aq)

Therefore, an alkali is the solution formed when a base dissolves in water.

8) Alkalis will produce hydroxide ions when dissolved in water.

Dissociation: $NaOH\ (aq) \xrightarrow{water} Na^+\ (aq) + OH^-\ (aq)$
When ammonia gas is dissolved in water, ammonium ions and hydroxide ions are formed.
Reaction with water: $NH_3 + H_2O \rightleftharpoons NH_4^+ + OH^-$

The OH^- ions produced are responsible for the properties of alkalis.

9) Physical properties of alkalis
a. Alkalis have a bitter taste and soapy feel.
b. Alkalis turn red litmus paper blue.

10) Chemical properties of alkalis
a. Alkalis produce hydroxide ions when dissolved in water.
b. **Acid** + alkali → salt + water
through a neutralisation reaction.
c. **ammonium salt** + alkali → salt + ammonia + water
d. salt (metal A) + alkali → salt (of metal B) + metal hydroxide [Precipitation]
e.g. iron (II) sulfate + sodium hydroxide → iron (II) hydroxide + sodium sulfate

Strength and pH

11) The strength of an acid/alkali refers to the extent to which it dissociates into ions when dissolved in water. [state the ion]

12) Difference between strong and weak acids:
- A strong acid dissociates completely in aqueous state to form H^+ ions. Almost all molecules dissociate to result in a high concentration of H^+ ions in the solution, hence a strongly acidic pH. (e.g. HCl, pH 1)
$HCl\ (aq) \rightarrow H^+\ (aq) + Cl^-\ (aq)$
- A weak acid dissociates only partially in aqueous solution to form few H^+ ions. Few molecules dissociate to result in a low concentration of H^+ ions in the solution, hence a less acidic pH. (e.g. CH_3COOH, pH 3)
$CH_3COOH\ (aq) \rightleftharpoons H^+\ (aq) + CH_3COO^-\ (aq)$

13) pH can be calculated using:
- an indicator (universal indicator, litmus)
- pH probe connected to a data logger

14) The pH of a solution is calculated based on the concentration of hydrogen or hydroxide ions in the solution.
high concentration of H^+ ions → low pH → strong acid
equal concentration of H^+ and OH^- ions → neutral solution (H_2O)
pH can therefore be used to compare the strength of acids and alkalis of similar concentration.

15) Testing for relative acidity (weak/strong acid):
Qn: Describe a simple test to determine the stronger acid between 2 different acids.

- Add a few drops of Universal Indicator into solutions of equal concentrations of each acid.
- A strong acid will give red while a weak acid will give yellow or orange.

OR (without using indicators)

- Add magnesium ribbon into both acids (equal concentration) in separate test tubes.
- The acid which can completely react with the magnesium in a shorter time is the stronger acid.

<u>pH of soils</u>

16) Importance of controlling pH in soils:
The pH of soil affects the growth and development of plants. Most plants grow best at pH 6 to 7, and they will not grow in soil that is too acidic.

17) Controlling excess acidity:
When the soil becomes too acidic, it can be treated with bases like quicklime (calcium oxide) and slaked lime (calcium hydroxide). These bases react with the acids in the soil and raise the pH for healthy plant growth.

<u>Oxides</u>

18)

	Acidic	Basic	Amphoteric	Neutral
Examples	CO_2 SO_2 SO_3 Phosphorus (V) oxide, P_4O_{10}	MgO CaO CuO	ZnO Aluminium oxide, Al_2O_3 Lead (II) oxide, PbO	H_2O Carbon monoxide, CO Nitric oxide, NO
Oxides of	Non-metals	Metals	Some metals	Some non-metals
Solubility	Mostly soluble- dissolve in water to form acids	Mostly insoluble except alkalis	Soluble	Insoluble
Reacts with	+ **alkali** → salt + water	+ **acid** → salt + water	+ **acid OR alkali** → salt + water	Do not react with acids or alkalis
Others		Solids at room temperature	Behave as both acidic and basic oxide	

Sulfur dioxide and sulfuric acid

19) Sulfur dioxide is an acidic oxide.
Uses of sulfur dioxide[state]:
   a. Bleaching agent
   b. Bleaching of wood pulp in the manufacture of paper by removing oxygen (in the manufacture of wood pup for paper)
   c. Food preservative by killing bacteria

20) Uses of sulfuric acid [state]:
   a. Maunfacture of fertilisers (ammonium sulfate, superphosphate)
   b. Maunfacture of detergents
   c. As a battery acid

Notes: