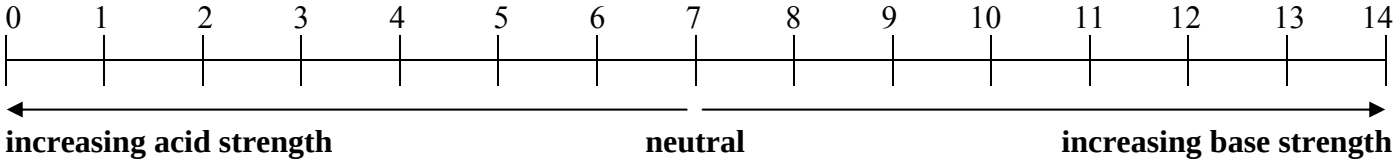
Answers to Unit 7, Lesson 01: Review of Acids and Bases

Property	Acids	Bases
Arrhenius Definition	A substance that dissolves in water to produce H+ ions	A substance that dissolves in water to produce OH- ions
How to recognize from a chemical formula	the **first** element is always hydrogen (H)	the first element is usually a metal and the negative ion is OH-
Examples	HCl, HNO_3, H_2SO_4	NaOH, $Mg(OH)_2$, $Zn(OH)_2$
Which ion gives them their properties?	H^+ (also written H_3O^+, known as the hydronium ion)	OH^- (the hydroxide ion)
Are they electrolytes?	yes, they conduct electricity in solution	yes, they conduct electricity in solution
Taste	sour	bitter
Skin feel	watery	slippery (soapy)
Colour with phenolphthalein	colourless	pink
Colour with red or blue litmus paper	red	blue
Colour with Bromothymol blue	yellow	blue
Reaction with metals	produce H_2 (g) and a salt	no reaction
Reaction with carbonates	produce CO_2 (g), H_2O (l) and a salt	no reaction
pH	less than 7.0	greater than 7.0



Writing the reactions of acids with metals to produce hydrogen gas and a salt:

$2\ Li\ (s) + H_2SO_4\ (aq) \rightarrow H_2\ (g) + Li_2SO_4\ (aq)$

$Zn\ (s) + 2\ HNO_3\ (aq) \rightarrow H_2\ (g) + Zn(NO_3)_2\ (aq)$

Writing the reactions of acids with carbonates to produce carbon dioxide, water and a salt:

$2\ HBr\ (aq) + Na_2CO_3\ (s) \rightarrow 2\ NaBr\ (aq) + H_2O\ (l) + CO_2\ (g)$

$2\ HC\ell O_3\ (aq) + CaCO_3\ (s) \rightarrow Ca(C\ell O_3)_2\ (aq) + H_2O\ (l) + CO_2\ (g)$

Naming Acids

Acids are written with hydrogen as their first element.

The name of the acid depends on the name of its negative ion.

The following are the naming rules:

- if the name of the ion ends in "ide", name the acid **hydro___ic acid**
- if the name of the ion ends in "ate", change the "ate" suffix to **___ic acid**
- if the name of the ion ends in "ite", change the "ite" suffix to **___ous acid**

Formula of Acid	Name of the Ion	Name of the Acid
HCl	chlor**ide**	hydrochloric acid
$HClO_3$	chlor**ate**	chloric acid
H_2SO_3	sulf**ite**	sulfurous acid
HIO_4	period**ate**	periodic acid
HI	iod**ide**	hydroiodic acid
HNO_2	nitr**ite**	nitrous acid
HCN	cyan**ide**	hydrocyanic acid
H_2S	sulf**ide**	hydrosulfuric acid
H_2CrO_4	chrom**ate**	chromic acid

Strength of Acids and Bases

Acids and bases are described in terms of their concentration and their strength.

1. **Concentration** indicates how much acid or base is dissolved in a certain amount of solution

eg. 5.0% V/V acetic acid: **5.0 mL of acetic acid in 100.0 mL of solution**

eg. 3.0 M HCH_3COO (aq): **3.0 moles of acetic acid in 1.0 L of solution**

eg. 0.010 M HCl: **0.010 moles of HCl in 1.0 L of solution**

eg. 6.0 M NaOH: **6.0 moles of NaOH in 1.0 L of solution**

2. **Strength** indicates how much the acid or base **ionizes/dissociates** to form **ions** in solution

Strong Acids:

- completely **ionize and dissociates** into ions in solution; essentially all of the acid is converted to **ions**
- are **very good** electrolytes in solution
- pH is **very low** (close to **0** or **1**)

There are only 6 **common** strong acids (you must memorize them):

sulfuric acid	(H_2SO_4)	hydrochloric acid	(HCℓ)
nitric acid	(HNO_3)	hydrobromic acid	(HBr)
chloric acid	($HClO_3$)	hydroiodic acid	(HI)

Ionization and dissociation reactions (go to completion so use a → arrow)

$$HCl\,(g) \xrightarrow{H_2O} H^{1+}\,(aq) + C\ell^{1-}\,(aq)$$

$$HNO_3\,(l) \xrightarrow{H_2O} H^{1+}\,(aq) + NO_3^{1-}\,(aq)$$

} essentially all of the acid is converted to ions in solution

Trends in acid strength:

- acid strength increases down a group on the periodic table eg. HF (weak) < HCℓ < HBr < HI
- acid strength increases across a period (→) eg. H_3P < H_2S < HCℓ
- acid strength increases as the # of oxygen atoms increases eg. HCℓO < $HCℓO_2$ < $HCℓO_3$ < $HCℓO_4$

Weak Acids:

- less than 1% of the acid molecules **ionizes and dissociates** (separates) into ions in solution
- almost all of the acid is found in solution as **intact molecules** with the H^+ ion still attached
- are **very poor** electrolytes in solution
- pH is between **4.5** and about **6.9** (this is not a guaranteed range, it depends on the acid concentration)
- if an acid is NOT one of the six strong acids, then it is a **weak acid**

eg. $HNO_2 \xrightleftharpoons{H_2O} H^{1+}(aq) + NO_2^{1-}(aq)$

eg. $HCH_3COO \xrightleftharpoons{H_2O} H^{1+}(aq) + CH_3COO^{1-}(aq)$

less than one in 100 acid molecules is converted to ions in solution; almost all of the acid is found as intact molecules

Strong Bases:

- completely **dissociate** into ions in solution; essentially all of the base is converted to **ions**
- are **very good** electrolytes in solution
- pH is **very high** (close to **13** or **14**)

The strong bases are: (memorize them)

- the oxides and hydroxides of the Group I metals: **LiOH & Li_2O, NaOH & Na_2O, KOH & K_2O** etc
- the oxides and hydroxides of the Group II metals (except **Be**): **$Mg(OH)_2$ & MgO, $Ca(OH)_2$ & CaO, $Sr(OH)_2$ & SrO etc**

eg. $NaOH(s) \xrightarrow{H_2O} Na^{1+}(aq) + OH^{1-}(aq)$

essentially all of the base is converted to ions in solution

eg. $CaO(s) + \underset{(H_2O)}{H-OH(l)} \xrightarrow{H_2O} Ca^{2+}(aq) + 2\ OH^{1-}(aq)$

Weak Bases:

- less than 1% of the molecules **dissociate** into ions in solution (often because of poor solubility)
- almost all of the base is found in solution as **intact 'molecules'** with the OH^- still attached
- many weak bases are **insoluble** in water
- are **very poor** electrolytes in solution
- pH is between **7.1** and about **9.5** (again, this is not guaranteed, it depends on the base's concentration)
- if a base is NOT one of the strong bases, then it is a **weak base**

eg. $Sc(OH)_3(s) \xrightleftharpoons{H_2O} Sc^{3+}(aq) + 3\ OH^{1-}(aq)$

eg. $Pb(OH)_4(s) \xrightleftharpoons{H_2O} Pb^{4+}(aq) + 4\ OH^{1-}(aq)$

very little base is converted to ions in solution. Recall, these substances are only slightly soluble in water, so very little of the solid dissolves and dissociates

Answers to Unit 7, Lesson 01: Naming Common Acids and Bases

1. Name the following acids and classify them as either strong or weak acids.

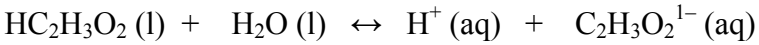
Formula	Name	Strong or Weak Acid
H_2CO_3	carbonic acid	weak
H_3PO_4	phosphoric acid	weak
H_2S	hydrosulfuric acid	weak
H_2SO_4	sulfuric acid	strong
HNO_3	nitric acid	strong
HBr	hydrobromic acid	strong
HF	hydrofluoric acid	weak
HI	hydroiodic acid	strong
$H_2C_2O_4$	oxalic acid	weak
H_2SO_3	sulfurous acid	weak
HNO_2	nitrous acid	weak
HIO	hypoiodous acid	weak
$HClO_3$	chloric acid	strong
$HBrO_3$	bromic acid	weak
$HClO_4$	perchloric acid	strong
HCH_3COO	acetic acid	weak
HClO	hypochlorous acid	weak

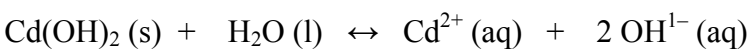
2. Name the following bases and classify them as either strong or weak bases. Use Roman numerals where needed.

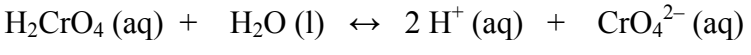
NaOH	sodium hydroxide	strong
ZnO	zinc oxide	weak
$Ca(OH)_2$	calcium hydroxide	strong
$Fe(OH)_3$	iron (III) hydroxide	weak
$Mg(OH)_2$	magnesium hydroxide	strong
$Al(OH)_3$	aluminum hydroxide	weak
BaO	barium oxide	strong
KOH	potassium hydroxide	strong
AgOH	silver hydroxide	weak
CdO	cadmium oxide	weak
Li_2O	lithium oxide	strong
$Sn(OH)_4$	tin (IV) hydroxide	weak
LiOH	lithium hydroxide	strong
NH_4OH	ammonium hydroxide	weak
K_2O	potassium oxide	strong
Ni_2O_3	nickel (III) oxide	weak
$Ba(OH)_2$	barium hydroxide	strong

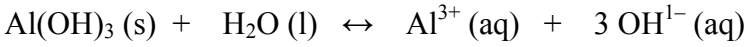
Answers to Unit 7, Lesson 01: Reactions of Acids and Bases

1. Write **balanced** chemical equations to show the dissociation of the following substances in water. For the strong acids and bases, they dissociate completely so use a "→" arrow. For the weak acids and bases, they do NOT dissociate completely so use a "↔" arrow.

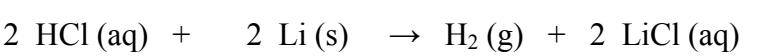


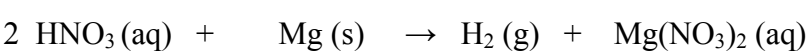


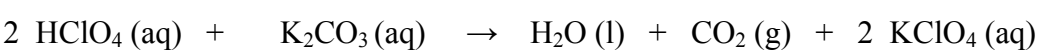


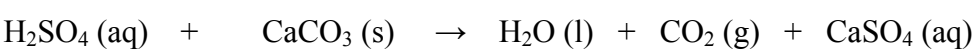


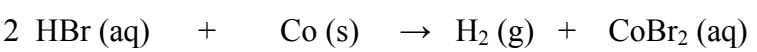
2. Write **balanced** chemical equations for the reactions between the following substances. Be sure that you can name all of the compounds from these equations. Assume that these reactions go to completion and that the salts dissolve in water.

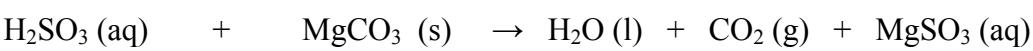




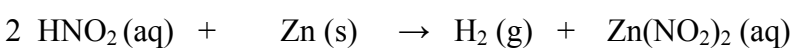




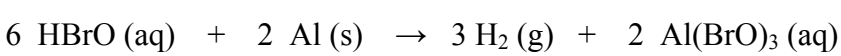




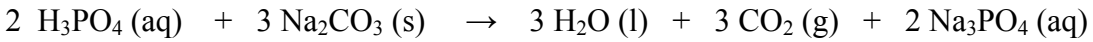
nitrous acid + zinc metal:



hypobromous acid and aluminum metal:



phosphoric acid and sodium carbonate:



hydrosulfuric acid and sodium metal