AP Chemistry Reactions

Basic Reaction Types

Reaction	Example
Synthesis	$2H_2 + O_2 \rightarrow 2H_2O$
Decomposition	$2NaCl \rightarrow 2Na + Cl_2$
Single Replacement (metals replace metals, non metals replace non metals)	$Ag_2S + Ca \rightarrow CaS + 2Ag$ or $2MgO + 2Cl_2 \rightarrow 2MgCl_2 + O_2$
Double Replacement	$Na_2CO_3 + CaCl_2 \rightarrow 2NaCl + CaCO_3$
Combustion	$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$
Neutralization	$NaOH + HCl \rightarrow NaCl + H_2O$

AP Synthesis Reactions

Reaction	Example
metallic oxides + water → bases	$Na_2O + H_2O \rightarrow 2NaOH$ net: $Na_2O + H_2O \rightarrow 2Na^+ + 2OH^-$
non metallic oxides + water → acids	$SO_3 + H_2O \rightarrow H_2SO_4$ net: $SO_3 + H_2O \rightarrow H^+ + HSO_4^-$
metallic oxides + non metallic oxides → salts	$Na_2O + SO_3 \rightarrow Na_2SO_4$
alkali metal + water → base + hydrogen	$Na + H_2O \rightarrow NaOH + H_2$ net: $Na + H_2O \rightarrow Na^+ + OH^- + H_2$

Basic Decomposition Reactions

Substance	Reaction
Ammonium Carbonate	$(NH_4)_2CO_3 \rightarrow 2NH_3 + CO_2 + H_2O$
Ammonium Hydroxide	$NH_4OH \rightarrow NH_3 + H_2O$
Sulphurous Acid	$H_2SO_3 \rightarrow SO_2 + H_2O$
Carbonic Acid	$H_2CO_3 \rightarrow CO_2 + H_2O$
Hydrogen Peroxide	$2H_2O_2 \rightarrow 2H_2O + O_2$

AP Decomposition Reactions

Reaction	Example
metallic carbonates → metallic oxide + carbon dioxide	$CaCO_3 \rightarrow CaO + CO_2$
metallic chlorates → metallic chlorides + oxygen	$2KClO_3 \rightarrow 2KCl + 3O_2$

Reactions Forming Gases

Reaction	Example
sulphide salt + acid	$K_2S\ (aq) + 2HCl\ (aq) \rightarrow \mathbf{H_2S\ (g)} + 2KCl\ (aq)$ net: $S^{2-}\ (aq) + 2H^+\ (aq) \rightarrow \mathbf{H_2S\ (g)}$
carbonate salt + acid	$K_2CO_3\ (aq) + 2HNO_3\ (aq) \rightarrow \mathit{H_2CO_3\ (aq)} + KNO_3\ (aq)$ net : $CO_3^{2-}\ (aq) + 2H^+\ (aq) \rightarrow H_2O\ (l) + \mathbf{CO_2\ (g)}$
sulphite salt + acid	$Na_2SO_3\ (aq) + 2HCl\ (aq) \rightarrow \mathit{H_2SO_3\ (aq)} + 2NaCl\ (aq)$ net : $SO_3^{2-}\ (aq) + 2H^+\ (aq) \rightarrow H_2O\ (l) + \mathbf{SO_2\ (g)}$
ammonium salt + base	$NH_4Cl\ (aq) + NaOH\ (aq) \rightarrow \mathit{NH_4OH\ (aq)} + NaCl\ (aq)$ net :$NH_4^+\ (aq) + OH^-\ (aq) \rightarrow H_2O\ (l) + \mathbf{NH_3\ (g)}$

Complex Ions
Metal ions combine with a concentrated/saturated/excess solution of a ligand (ex. Cl^-, F^-, CN^-, OH^-, NH_3, H_2O)
Coordination number is double the charge of the metal ion
Example: $Zn^{2+} + 4OH^- \rightarrow [Zn(OH)_4]^{2-}$

Strong Acids
HI, HBr, HCl, HNO_3, $HClO_4$, $HClO_3$, HIO_4, H_2SO_4

Strong Bases
LiOH, NaOH, KOH, RbOH, CsOH, $Ca(OH)_2$, $Sr(OH)_2$, $Ba(OH)_2$

Acid Base Equilibria

Reaction	Example
Weak Acid and Water	$HF + H_2O \rightleftharpoons F^- + H_3O^+$
Weak Base and Water	$NH_3 + H_2O \rightleftharpoons NH_4^+ + OH^-$
Weak Acid and Weak Base	$HF + NH_3 \rightleftharpoons F^- + NH_4^+$

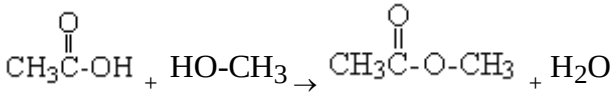
Neutralization Reactions

Reaction	Example
Strong Acid and Strong Base	$HCl + NaOH \rightarrow H_2O + NaCl$ net: $OH^- + H^+ \rightarrow H_2O$
Strong Acid and Weak Base	$HCl + NH_3 \rightarrow NH_4Cl$ net: $H^+ + NH_3 \rightarrow NH_4^+$ or $H_3O^+ + NH_3 \rightarrow NH_4^+ + H_2O$
Weak Acid and Strong Base	$HF + NaOH \rightarrow NaF + H_2O$ net: $HF + OH^- \rightarrow F^- + H_2O$

Lewis Acids and Bases
Lewis acids are electron acceptors; Lewis bases are electron donators.
Example: $BF_3 + NH_3 \rightarrow BF_3NH_3$
BF_3 is a Lewis acid and NH_3 is a Lewis bas

Ester Condensation Reactions
carboxylic acid + alcohol → ester + water

Example:



ethanoic acid + methanol → methyl ethanoate + water

Nuclear Reactions

Radiation	Example
Alpha	$^{210}_{84}Po \rightarrow {}^{206}_{82}Pb + {}^{4}_{2}He$
Beta	$^{14}_{6}C \rightarrow {}^{14}_{7}N + {}^{0}_{-1}e$
Gamma	$^{137}_{56}Ba^* \rightarrow {}^{137}_{56}Ba + {}^{0}_{0}\gamma$

Solubility Reactions
Example: Ca^{2+} (aq) + CO_3^{2-} (aq) → $CaCO_3$ (s)

Solubility Table

Anion	Cation	Solubility
All	Alkali ions: Li^+, Na^+, K^+, Rb^+, Cs^+, Fr^+	Soluble
All	Hydrogen ion: H^+	Soluble
All	Ammonium ion: NH_4^+	Soluble
Nitrate, NO_3^-	All	Soluble
Chloride, Cl^- or Bromide, Br^- or Iodide, I^-	All others	Soluble
	Ag^+, Pb^{2+}, Cu^+, Hg_2^{2+}	Insoluble
Fluoride, F^-	All others	Soluble
	Mg^{2+}, Ca^{2+}, Sr^{2+}, Ba^{2+}, Pb^{2+}	Insoluble
Sulphide, S^{2-}	Alkali ions, H^+, NH_4^+, Be^{2+}, Mg^{2+}, Ca^{2+}, Sr^{2+}, Ba^{2+}	Soluble
	All others	Insoluble
Hydroxide, OH^-	Alkali ions, H^+, NH_4^+, Ba^{2+}, Sr^{2+}	Soluble
	All others	Insoluble
Sulphate, SO_4^{2-}	All others	Soluble
	Ag^+, Ca^{2+}, Sr^{2+}, Ba^{2+}, Pb^{2+}	Insoluble
Carbonate, CO_3^{2-}, or Phosphate, PO_4^{3-} or Chromate CrO_4^{2-}, or Sulphite, SO_3^{2-}	Alkali ions, H^+, NH_4^+	Soluble
	All others	Insoluble

Reduction Oxidation (Redox) Reactions
Balance by "*POHE"* (*preliminary* balancing, *oxygen* (add H_2O), *hydrogen* (add H^+), *electrons* (to balance the charge)

Common Reduction Reactions:

Reactants (oxidizing agent)	Products formed
MnO_4^- (acidic solution)	Mn^{2+}
MnO_2	Mn^{2+}
MnO_4^- (basic or neutral solution)	MnO_2
$Cr_2O_7^{2-}$ (acidic solution)	Cr^{3+}
CrO_4^{2-} (basic solution)	CrO_2^-
halogens (ex. Cl_2)	halide ions (ex. Cl^-)
metal ions (ex. Cu^{2+})	metals (ex. Cu)
metall*ic* ions (higher oxidation number) (ex. Fe^{3+})	metall*ous* ions (lower oxidation number) (ex. Fe^{2+})
H_2O	H_2 + OH^-

Common Oxidation Reactions:

Reactants (reducing agent)	Products formed
halide ions (ex. Cl^-)	halogens (ex. Cl_2)
$S_2O_3^{2-}$	$S_4O_6^{2-}$
$C_2O_4^{2-}$	CO_2
metals (ex. Cu)	metal ions (ex. Cu^{2+})
metall*ous* ions (lower oxidation number) (ex. Fe^{2+})	metall*ic* ions (higher oxidation number) (ex. Fe^{3+})
H_2O_2	O_2 + H_2O
H_2O	O_2 + H^+

Common multivalent metals	Common metals with only one charge
Fe^{3+}/Fe^{2+}	Ag^+
Cu^{2+}/Cu^+	Zn^{2+}
Pb^{4+}/Pb^{2+}	Cd^{2+}
Sn^{4+}/Sn^{2+}	Al^{3+}
Co^{3+}/Co^{2+}	
Cr^{3+}/Cr^{2+}	
Ni^{3+}/Ni^{2+}	

Ion Colours
Most transition metals have ions that display colours, for example, copper (II), Cu^{2+}, is blue and nickel (II), Ni^{2+}, is green. Notable exceptions are zinc (Zn^{2+}) and silver (Ag^+) ions.
Some polyatomic ions also display colours, for example, permanganate, MnO_4^-, is purple, chromate, CrO_4^{2-}, is yellow, and dichromate, $Cr_2O_7^{2-}$, is orange.