Acid-Base Chemistry
Redox Chemistry

Basic Inorganic Chemistry

Lesson 7, 2016.Q1

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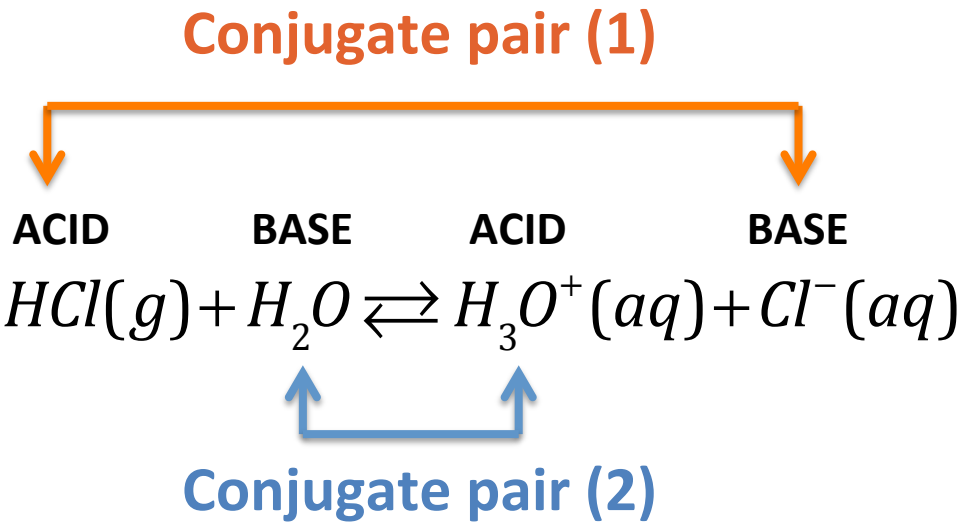
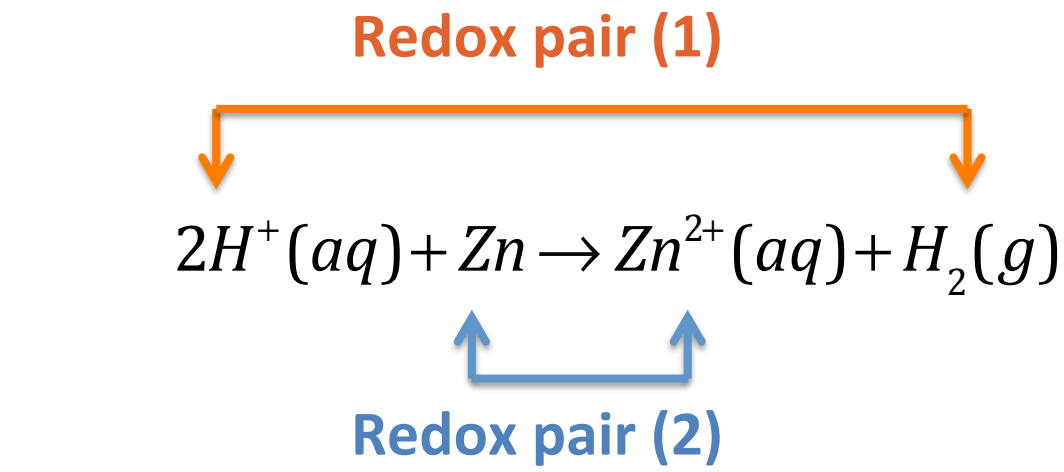
Acid-base reactions

Brønsted-Lowry



Redox reactions



Reduction, + e$^-$

Oxidation, - e$^-$

How do we know something happened?

Oxidation number

Rules

- Elements are always zero
- The sum of oxidation number is equal to the charge of molecule / ion
- H: +1 (hydride: -1)
- O: -2 (peroxides: -1)
- Halides: -1 if not an oxo-acid

Examples

$\overset{0}{H_2}$ $\overset{+1\ -1}{NaCl}$

$\overset{+1-2}{H_2O}$ $\overset{+1}{H^+}$ $\overset{-2\ +1}{OH^-}$

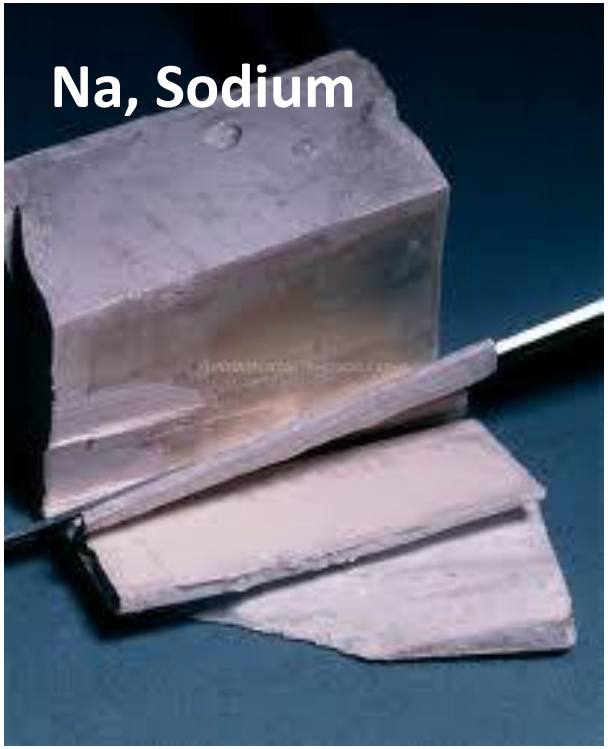
$\overset{+1-2}{HCl}$ $\overset{+1}{H^+}$ $\overset{-1}{Cl^-}$

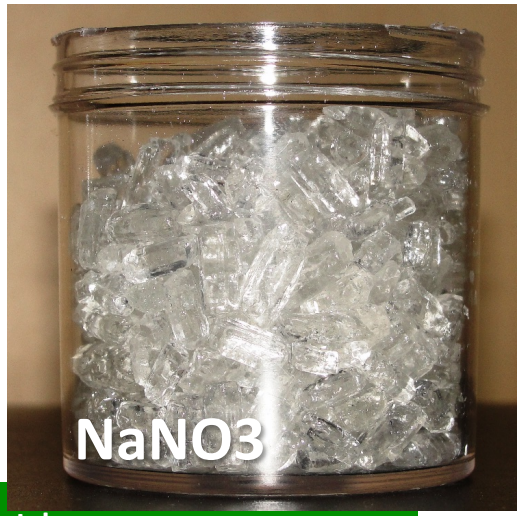
$\overset{+4\ -2}{CO_2}$ $\overset{+4\ -2}{SO_2}$ $\overset{+6\ -2}{SO_3}$

H_2SO_3 H_2SO_4

Oxidation number – valence state

NaCl





Balancing redox equations: half cell method

$Zn + Cu^{2+}(aq)$? $= Zn^{2+}(aq) + Cu$?

$Zn = Zn^{2+}(aq) + 2e^-$ *oxidation*

$Cu^{2+}(aq) + 2e^- = Cu$ *reduction*

$Zn + Cu^{2+}(aq) = Zn^{2+}(aq) + Cu$

Balancing redox equations

$Fe^{2+} + MnO_4^- + ? = Fe^{3+} + Mn^{2+} + ??$

+2 +3

$Fe^{2+} = Fe^{3+} + 1e^-$

+7 +2

$MnO_4^- + 5e^- = Mn^{2+} + O?$

$5Fe^{2+} + MnO_4^- + ? = 5Fe^{3+} + Mn^{2+} + ??$

in acid: $+ H^+ =$ $+ H_2O$

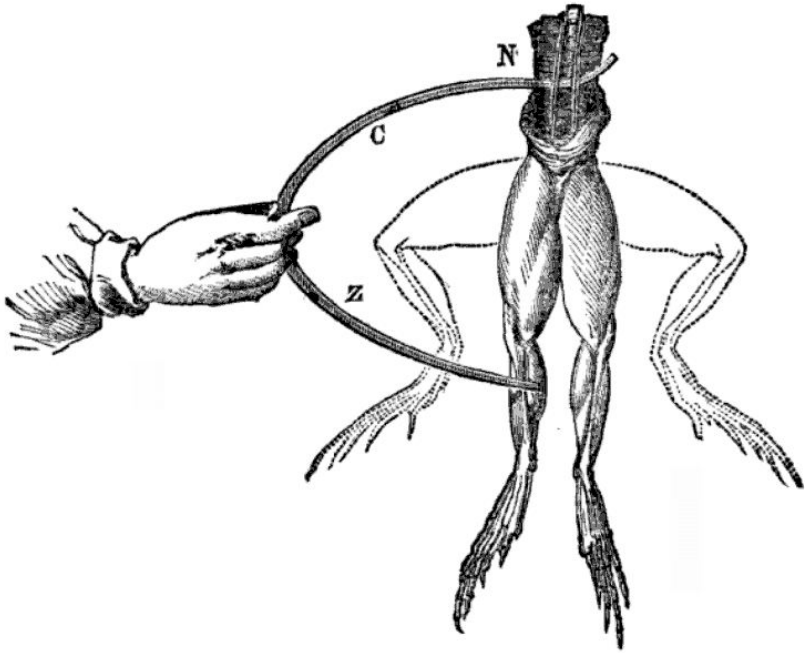
$5Fe^{2+} + MnO_4^- + 8H^+ = 5Fe^{3+} + Mn^{2+} + 4H_2O$

Electrochemical cells:
when all this comes to life

Luigi Galvani
1737-1798

Alessandro Giuseppe
Antonio Anastasio Volta
1745-1827

Early electrochemistry



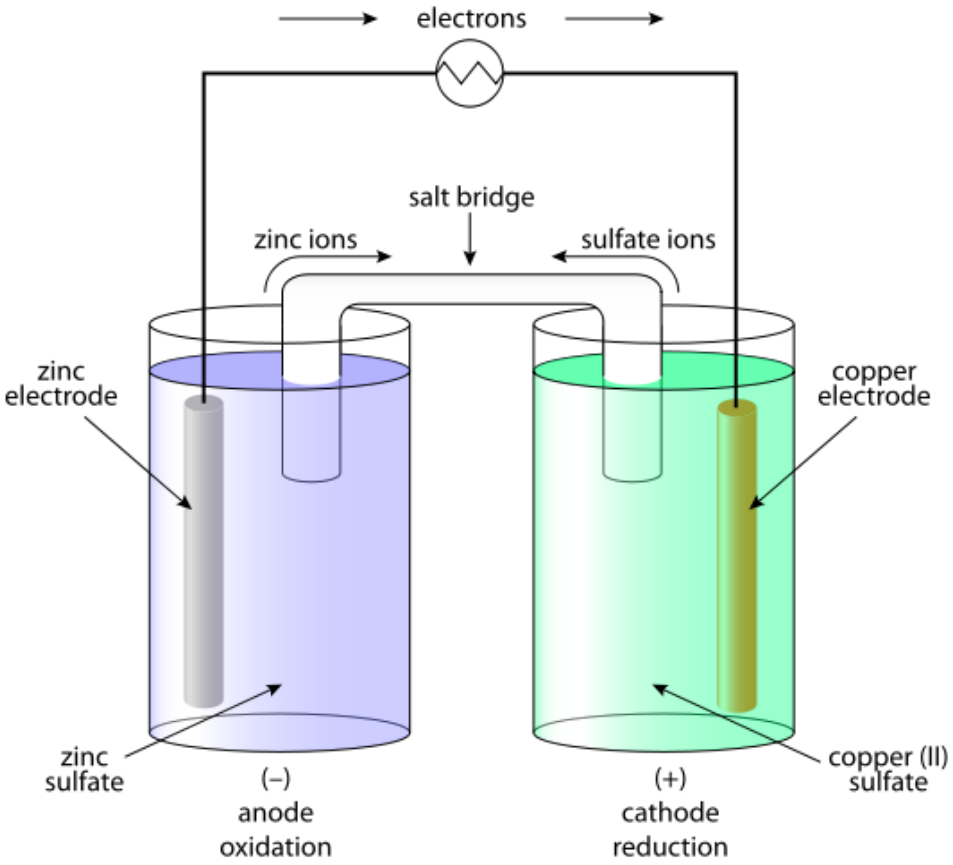
Galvani and his frogs (~1770-80)

"Frankenstein;
or, The Modern Prometheus,"
Mary Shelley, 1818

Voltaic pie
Form 1800

Galvanic cell (battery)

Oxidation
Anode



Reduction
Cathode

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Standard electrode potential

Standard hydrogen electrode

- 1 atm H_2
- 1 M HCl
- Pt (inert) electrode
- Theoretical! (idealized)

Thermodynamics behind it

$$E^0_{cell} = -\frac{\Delta G^0}{nF} = \left(\frac{RT}{nF}\right)\ln K$$

F: Faraday number
n: number of electrons

$E^0_{cell} = E^0_{cathode} - E^0_{anode}$

If $E^0_{cell} > 0$, spontaneous reaction

Q3-4 Chemical thermodynamics

Redox / Reduction potential

Reduction Half-Reaction	Standard Reduction Potential (V)
$O_2(g)+4H^+(aq)+4e^- \rightarrow 2H2O(l)$	+1.23
$Ag^+(aq)+e^- \rightarrow Ag(s)$	+0.80
$Fe^{3+}(aq)+e^- \rightarrow Fe^{2+}(aq)$	+0.77
$I_2(l)+2e^- \rightarrow 2I^+(aq)$	+0.54
$Cu^{2+}(aq)+2e^- \rightarrow Cu(s)$	+0.34
$Sn^{4+}(aq)+2e^- \rightarrow Sn^{2+}(aq)$	+0.15
$2H^+(aq)+2e^- \rightarrow H2(g)$	**0.00**
$Sn^{2+}(aq)+2e^- \rightarrow Sn(g)$	-0.14
$Fe^{2+}(aq)+2e^- \rightarrow Fe(s)$	-0.44
$Cr^{3+}(aq)+3e^- \rightarrow Cr(s)$	-0.74
$Zn^{2+}(aq)+2e^- \rightarrow Zn(s)$	-0.76
$Mn^{2+}(aq)+2e^- \rightarrow Mn(s)$	-1.18
$Na^+(aq)+e^- \rightarrow Na(s)$	-2.71
$Li^+(aq)+e^- \rightarrow Li(s)$	-3.04

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Will a reaction go?

$$E^0_{cell} = E^0_{cathode} - E^0_{anode}$$

Reduction Half-Reaction	Standard Reduction Potential (V)
$Ag^+(aq) + e^- \rightarrow Ag(s)$	+0.80
$Fe^{3+}(aq) + e^- \rightarrow Fe^{2+}(aq)$	+0.77
$Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$	+0.34
$2H^+(aq) + 2e^- \rightarrow H2(g)$	**0.00**
$Fe^{2+}(aq) + 2e^- \rightarrow Fe(s)$	-0.44
$Zn^{2+}(aq) + 2e^- \rightarrow Zn(s)$	-0.76

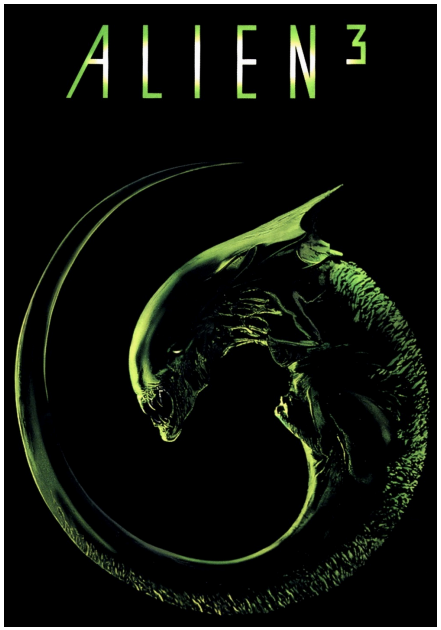
Zn + HCl ?

Ag + HCl ?

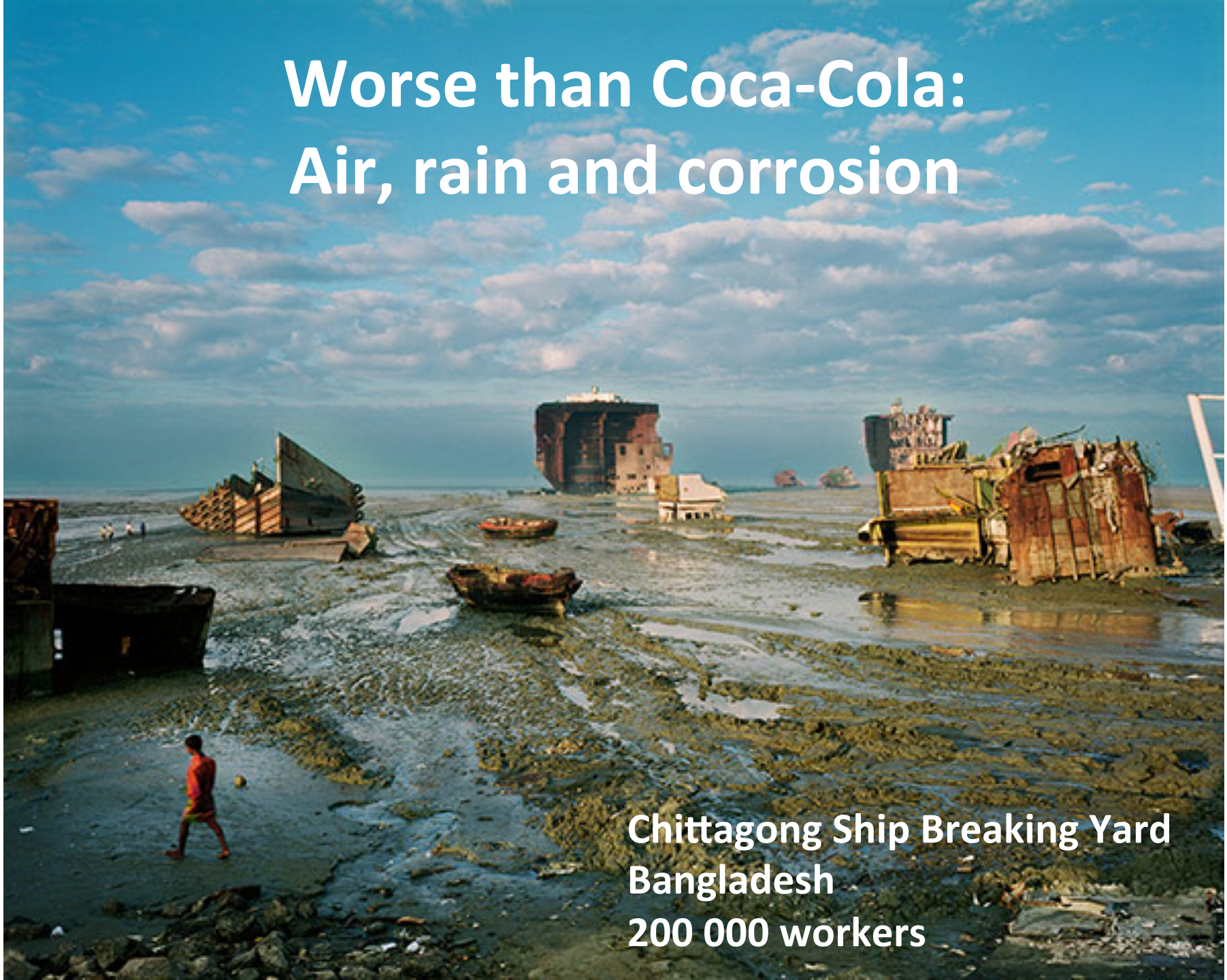
Fe + HCl ?

$E^0_{cell} = 0V - (-0.76V) > 0\ V$

When we dissolve metals it doesn't matter how strong is the acid!



Worse than Coca-Cola: Air, rain and corrosion



Chittagong Ship Breaking Yard
Bangladesh
200 000 workers


F*ck Corrosion (gold)
Varna Necropolis
4560-4450 BC

When water is stronger than Coca-Cola: Why does copper rust?

INTERPRETING REACTIONS: WHAT DOES HAPPEN AND WHY?

Using what we learned:
putting together redox and acid-base chemistry

Typical reactions of acid

- Dissolving salts and oxides:

  $CaCO_3+HCl = CaCl_2+H_2O+CO_2$

K matters

  $2FeOOH + 6HCl = 2FeCl_3+4H_2O$

  $2FeOOH + 3H_2ox = Fe_2(ox)_3+4H_2O$

Complex formation!

- Coca Cola dissolving teeth , penny…

Typical reactions of acids

- Dissolving metals

  $2HCl+Zn = ZnCl_2+H_2$

  $HCl + Cu = ??$

K doesn't matter
Not even acid-base!

Redox reaction: H^+

$3Cu + 8HNO_3 \rightarrow 3Cu(NO_3)_2 + 2NO + 4\ H_2O$

Redox reaction: NO_3^-

What should I know for a test?

- Calculate oxidation numbers
- Balance simple equations
- Decide if a reaction goes or not based on standard redox potential