Standard Potential Table

- If the electrode has a positive potential with respect to the SHE, then that means it is a strongly reducing electrode

$F_2 + 2e–$	$2F^-$	+2.87
$Co^{3+} + e–$	Co^{2+}	+1.1
$Au^+ + e–$	Au	+1.69
$Ce^{4+} + e–$	Ce^{3+}	+1.61
$Br_2 + 2e–$	$2Br^-$	+1.09
$Ag^+ + e–$	Ag	+0.80
$Cu^{2+} + 2e–$	Cu	+0.34
$Sn^{4+} + 2e–$	Sn^{2+}	+0.15
$2H^+ + 2e–$	H_2	0.0000

25

Standard Potential Tables

- If the measured potential is negative, the electrode is more oxidizing than the SHE

$2H^+ + 2e–$	H_2	0.0000
$Pb^{2+} + 2e–$	Pb	-0.13
$Sn^{2+} + 2e–$	Sn	-0.14
$In^{3+} + 3e–$	In	-0.34
$Fe^{2+} + 2e–$	Fe	-0.44
$Zn^{2+} + 2e–$	Zn	-0.76
$V^{2+} + 2e–$	V	-1.19
$Cs^+ + e–$	Cs	-2.92
$Li^+ + e–$	Li	-3.05

26

Selected Standard Electrode Potentials

Half-Reaction	E^0 (V)
$F_2(g) + 2e^- \rightleftharpoons 2F^-(aq)$	+2.87
$Cl_2(g) + 2e^- \rightleftharpoons 2Cl^-(aq)$	+1.36
$MnO_2(s) + 4H^+(aq) + 2e^- \rightleftharpoons Mn^{2+}(aq) + 2H_2O(l)$	+1.23
$NO_3^-(aq) + 4H^+(aq) + 3e^- \rightleftharpoons NO(g) + 2H_2O(l)$	+0.96
$Ag^+(aq) + e^- \rightleftharpoons Ag(s)$	+0.80
$Fe^{3+}(aq) + e^- \rightleftharpoons Fe^{2+}(aq)$	+0.77
$O_2(g) + 2H_2O(l) + 4e^- \rightleftharpoons 4OH^-(aq)$	+0.40
$Cu^{2+}(aq) + 2e^- \rightleftharpoons Cu(s)$	+0.34
$2H^+(aq) + 2e^- \rightleftharpoons H_2(g)$	0.00
$N_2(g) + 5H^+(aq) + 4e^- \rightleftharpoons N_2H_5^+(aq)$	−0.23
$Fe^{2+}(aq) + 2e^- \rightleftharpoons Fe(s)$	−0.44
$2H_2O(l) + 2e^- \rightleftharpoons H_2(g) + 2OH^-(aq)$	−0.83
$Na^+(aq) + e^- \rightleftharpoons Na(s)$	−2.71
$Li^+(aq) + e^- \rightleftharpoons Li(s)$	−3.05

27

- $F_2(g)$ is the BEST oxidizing agent (and the most easily reduced i.e. it is electronegative)
- $Li^+(aq)$ is the WORST oxidizing agent (and the most difficult to reduce i.e. receive electrons)
- Li(s) is the BEST reducing agent (and the most easily oxidized i.e. it is electropositive)
- $F^-(aq)$ is the WORST reducing agent (and the most difficult to oxidize i.e. donate electrons)

28

Alkaline battery

- The alkaline battery gets its name because it has an alkaline electrolyte of potassium hydroxide, as opposed to the acidic electrolyte of the zinc-carbon batteries which are of a very similar nominal voltages and physical size.
- The half reactions are:
- $Zn (s) + 2OH^- (aq) \rightarrow ZnO (s) + H_2O (l) + 2e^-$
  $2MnO_2 (s) + H_2O (l) + 2e^- \rightarrow Mn_2O_3 (s) + 2OH^- (aq)$

53

Alkaline battery

- In an alkaline battery, the anode (negative terminal) is made of zinc powder (which allows more surface area for increased rate of reaction therefore increased electron flow) and the cathode (positive terminal) is composed of manganese dioxide. Alkaline batteries are comparable to zinc-carbon batteries, but the difference is that alkaline batteries use potassium hydroxide (KOH) as an electrolyte

54

Lithium Ion Batteries

- Lithium Ion Batteries based on lithium insertion into different solids
- Process of lithium insertion is known as intercalation
- Lithium has different electrochemical potentials in different solids
- Anode: Typically graphite; Li^+ has lower potential
- Cathode: Typically $LiCoO_2$ or $LiMnO_2$; Li+ has larger potential

55

Lithium Ion Battery

- Very expensive.
  Not usually available in "common" battery sizes
  Very common in laptop computers, moderate to high-end digital cameras and camcorders, and cellphones.
  Very low rate of self discharge.
  Volatile: Chance of explosion if short circuited, allowed to overheat, or not manufactured with rigorous quality standards.

56

Lead Acid Battery

- Moderately expensive.
  Moderate energy density.
  Moderate rate of self discharge.
  Higher discharge rates result in considerable loss of capacity.
  Environmental hazard due to Lead.
  Common use - Automobile batteries

61

Lithium rechargeable battery

- A graphite bar acts as the anode, a bar of lithium cobaltate acts as the cathode, and a polymer, swollen with a lithium salt, allows the passage of ions and serves as the electrolyte.
- In this cell, the carbon in the anode can reversibly form a lithium-carbon alloy.

62

Lithium rechargeable battery

- The advantage of this kind of battery is that Lithium possess the highest negative value of standard reduction potential.
- It is also a light metal and therefore less mass is required to generate 1 mole of electrons.
- Lithium ion battery technologies are widely used in portable electronic devices because they have high energy storage density and are rechargeable.

63

Nickel-Cadmium (NiCad) Battery

- Rechargeable, but not indefinitely
- $Cd(s) + NiO_2(s) + 2H_2O(l) \rightarrow Cd(OH)_2(s) + Ni(OH)_2(s)$
- Approximately 1.35 V
- Cadmium is highly toxic – these batteries should be recycled and not dumped.

64