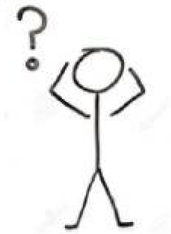
Galvanic/voltaic cells

How then do we determine which one will oxidise or reduce, if they don't give us a full reaction?



CAPS

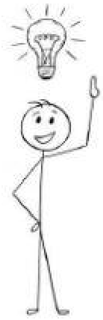
TABLE 4B: STANDARD REDUCTION POTENTIALS

Increasing oxidising ability ↓

Half-reactions			E° (V)
$Li^+ + e^-$	⇌	Li	−3,05
$K^+ + e^-$	⇌	K	−2,93
$Cs^+ + e^-$	⇌	Cs	−2,92
$Ba^{2+} + 2e^-$	⇌	Ba	−2,90
$Sr^{2+} + 2e^-$	⇌	Sr	−2,89
$Ca^{2+} + 2e^-$	⇌	Ca	−2,87
$Na^+ + e^-$	⇌	Na	−2,71
$Mg^{2+} + 2e^-$	⇌	Mg	−2,36
$Al^{3+} + 3e^-$	⇌	Al	−1,66
$Mn^{2+} + 2e^-$	⇌	Mn	−1,18
$Cr^{2+} + 2e^-$	⇌	Cr	−0,91
$2H_2O + 2e^-$	⇌	$H_2(g) + 2OH^-$	−0,83
$Zn^{2+} + 2e^-$	⇌	Zn	−0,76
$Cr^{3+} + 3e^-$	⇌	Cr	−0,74
$Fe^{2+} + 2e^-$	⇌	Fe	−0,44
$Cr^{3+} + e^-$	⇌	Cr^{2+}	−0,41
$Cd^{2+} + 2e^-$	⇌	Cd	−0,40
$Co^{2+} + 2e^-$	⇌	Co	−0,28
$Ni^{2+} + 2e^-$	⇌	Ni	−0,27
$Sn^{2+} + 2e^-$	⇌	Sn	−0,14
$Pb^{2+} + 2e^-$	⇌	Pb	−0,13
$Fe^{3+} + 3e^-$	⇌	Fe	−0,06
$\mathbf{2H^+ + 2e^-}$	⇌	$\mathbf{H_2(g)}$	**0,00**
$S + 2H^+ + 2e^-$	⇌	$H_2S(g)$	+0,14
$Sn^{4+} + 2e^-$	⇌	Sn^{2+}	+0,15
$Cu^{2+} + e^-$	⇌	Cu^+	+0,16
$SO_4^{2-} + 4H^+ + 2e^-$	⇌	$SO_2(g) + 2H_2O$	+0,17
$Cu^{2+} + 2e^-$	⇌	Cu	+0,34
$2H_2O + O_2 + 4e^-$	⇌	$4OH^-$	+0,40
$SO_2 + 4H^+ + 4e^-$	⇌	$S + 2H_2O$	+0,45
$Cu^+ + e^-$	⇌	Cu	+0,52
$I_2 + 2e^-$	⇌	$2I^-$	+0,54
$O_2(g) + 2H^+ + 2e^-$	⇌	H_2O_2	+0,68
$Fe^{3+} + e^-$	⇌	Fe^{2+}	+0,77
$NO_3^- + 2H^+ + e^-$	⇌	$NO_2(g) + H_2O$	+0,80
$Ag^+ + e^-$	⇌	Ag	+0,80
$Hg^{2+} + 2e^-$	⇌	$Hg(\ell)$	+0,85
$NO_3^- + 4H^+ + 3e^-$	⇌	$NO(g) + 2H_2O$	+0,96
$Br_2(\ell) + 2e^-$	⇌	$2Br^-$	+1,07
$Pt^{2+} + 2e^-$	⇌	Pt	+1,20
$MnO_2 + 4H^+ + 2e^-$	⇌	$Mn^{2+} + 2H_2O$	+1,23
$O_2(g) + 4H^+ + 4e^-$	⇌	$2H_2O$	+1,23
$Cr_2O_7^{2-} + 14H^+ + 6e^-$	⇌	$2Cr^{3+} + 7H_2O$	+1,33
$Cl_2(g) + 2e^-$	⇌	$2Cl^-$	+1,36
$MnO_4^- + 8H^+ + 5e^-$	⇌	$Mn^{2+} + 4H_2O$	+1,51
$H_2O_2 + 2H^+ + 2e^-$	⇌	$2H_2O$	+1,77
$Co^{3+} + e^-$	⇌	Co^{2+}	+1,81
$F_2(g) + 2e^-$	⇌	$2F^-$	+2,87

Increasing reducing ability ↑

Notice the elements at the top of the table are ones that really want to give away electrons or oxidise (like the group 1 and 2 metals



Notice the elements at the bottom of the table are ones that really want to gain electrons or reduce (like the group 7 elements)

*we will only be using the list with Li at the top (you can always ignore the one with F at the top)

Now it becomes a question of: which element **most** wants to oxidise

The element on the table have been carefully organised from most likely to oxidise (the higher it is on the table) to less likely to oxidise (the lower it is on the table)

The higher an element is on the list of standard reduction potential- the more likely it is to oxidise.

The lower down an element is on this list, the more likely it is to reduce.

Exercise 1

Choose between the following elements, which is more likely to oxidise:

1.1) Li Ca

1.2) Al Mg

1.3) Na Pb

1.4) Pt Cu (look for the Cu next to the value +0,34)

1.5) Ag Ni

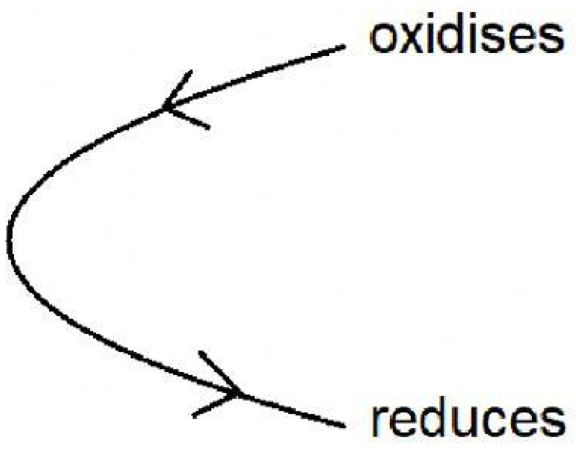
Now, how do we actually use this table to write oxidation and reduction half reactions?

Example 1

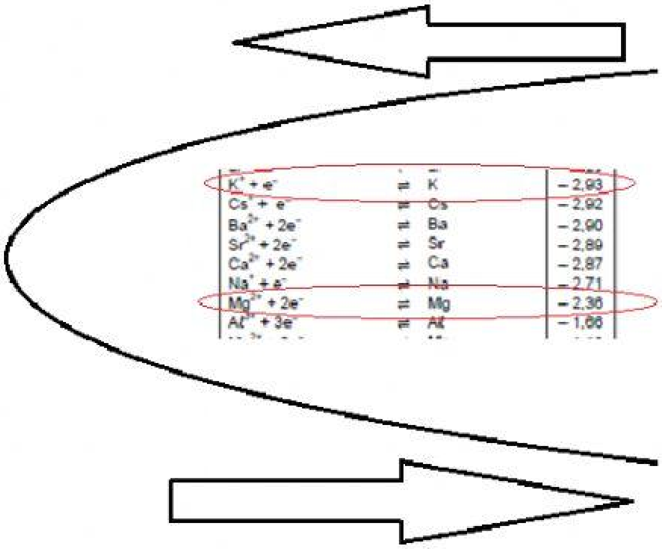
Let's say that K and Mg reacted together

Which one will oxidise?

Then you use the **'C-rule'** to write the reactions



✓ Spontaneous reaction



oxidise (read from right to left)

reduce (read from left to right)

Oxi: $K \rightarrow K^{+1} + 1e^-$ (x2)

Red: $Mg^{+2} + 2e^- \rightarrow Mg$

Redox: $Mg^{+2} + 2K \rightarrow 2K^{+1} + Mg$

<u>Example 2:</u>

Na and Cu

The one higher on the table is the one that will oxidise

$Na^+ + e^-$	⇌	Na	−2,71
$Mg^{2+} + 2e^-$	⇌	Mg	−2,36
$Al^{3+} + 3e^-$	⇌	Al	−1,66
$Mn^{2+} + 2e^-$	⇌	Mn	−1,18
$Cr^{2+} + 2e^-$	⇌	Cr	−0,91
$2H_2O + 2e^-$	⇌	$H_2(g) + 2OH^-$	−0,83
$Zn^{2+} + 2e^-$	⇌	Zn	−0,76
$Cr^{3+} + 3e^-$	⇌	Cr	−0,74
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$Co^{2+} + 2e^-$	⇌	Co	−0,28
$Ni^{2+} + 2e^-$	⇌	Ni	−0,27
$Sn^{2+} + 2e^-$	⇌	Sn	−0,14
$Pb^{2+} + 2e^-$	⇌	Pb	−0,13
$Fe^{3+} + 3e^-$	⇌	Fe	−0,06
$2H^+ + 2e^-$	⇌	**$H_2(g)$**	**0,00**
$S + 2H^+ + 2e^-$	⇌	$H_2S(g)$	+0,14
$Sn^{4+} + 2e^-$	⇌	Sn^{2+}	+0,15
$Cu^{2+} + e^-$	⇌	Cu^+	+0,16
$SO_4^{2-} + 4H^+ + 2e^-$	⇌	$SO_2(g) + 2H_2O$	+0,17
$Cu^{2+} + 2e^-$	⇌	Cu	+0,34

The one lower on the table is the one that will reduce

Sodium is higher up on the table and thus oxidises and Cu is lower down and thus reduces

Oxi: $Na \rightarrow Na^{+} + e^{-}$ (x2) *Make sure you read this from right to left from the table

Red: $Cu^{+2} + 2e^{-} \rightarrow Cu$ *Make sure you read this from left to right from the table

Redox: $2Na + Cu^{+2} \rightarrow 2Na^{+} + Cu$

<u>Example 3</u>

Mg and Al

Oxi: $Mg \rightarrow Mg^{+2} + 2e^{-}$ (x3)

Red: $Al^{+3} + 3e^{-} \rightarrow Al$ (x2)

Redox: $3Mg + 2Al^{+3} \rightarrow 3Mg^{+2} + 2Al$

Exercise:

Write the oxidation, reduction and redox reaction for the following: (You will need to use the **standard reduction potential table**)

1) Ba and Ca

Oxi: →

Red: →

Redox: →

2) Ca and Ni

Oxi: →

Red: →

Redox: →

3) Fe(ii) and Ag

Oxi: →

Red: →

Redox: →

4) Zn and Li

Oxi: →

Red: →

Redox: →