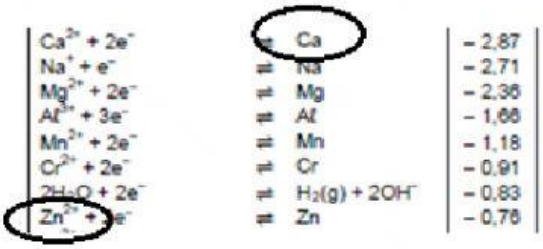
Spontaneous and non-spontaneous reactions

We need to determine if the following reactions would spontaneously reacted.

Do ensure the reactions are spontaneous you need to ensure the reactions **follow the C-rule.** In other words, will the element that is more likely to oxidise – in fact oxidise and the element that is more likely to reduce – actually reduce.

Example 1

Will Ca and Zn^{+2} react with each other spontaneously?



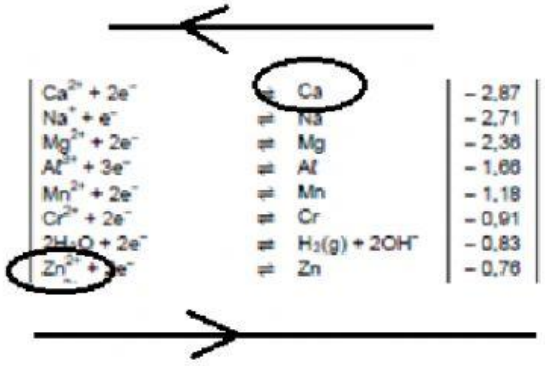
$Ca^{2+} + 2e^-$	⇌	Ca	− 2,87
$Na^+ + e^-$	⇌	Na	− 2,71
$Mg^{2+} + 2e^-$	⇌	Mg	− 2,36
$Al^{3+} + 3e^-$	⇌	Al	− 1,66
$Mn^{2+} + 2e^-$	⇌	Mn	− 1,18
$Cr^{2+} + 2e^-$	⇌	Cr	− 0,91
$2H_2O + 2e^-$	⇌	$H_2(g) + 2OH^-$	− 0,83
$Zn^{2+} + 2e^-$	⇌	Zn	− 0,76

Yes, since the uncharged Ca is on the right of the arrow, the only thing it can do is to give off electrons and oxidise. And thus must be read from right to left.

The charged Zn^{+2} is on the left of the arrow and thus the only thing it can do is gain electrons and be read from left to right.

The element that is higher on the table thus oxidises and the one lower down will reduce.

This reaction now follows the **C-rule** and it is **spontaneous.**



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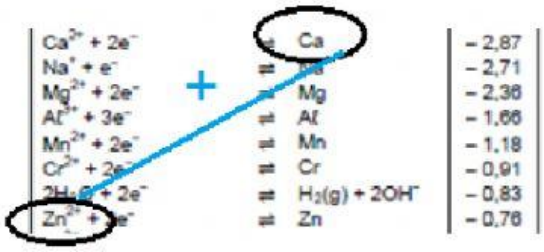
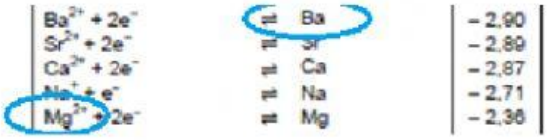
Another way to look at this- if you connect the 2 substances- does the line have a positive gradient?



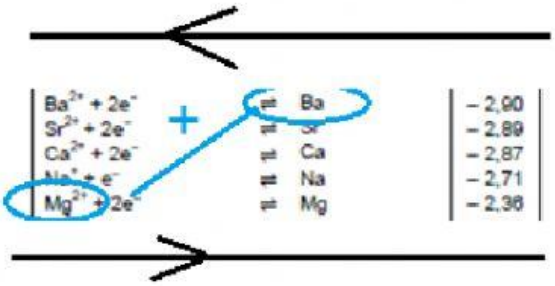
Example 2

Will Ba and $MgSO_4$ react spontaneously?

Firstly you need to realise that Ba is uncharged and Mg is charged- Mg^{+2}, since it is in a compound.



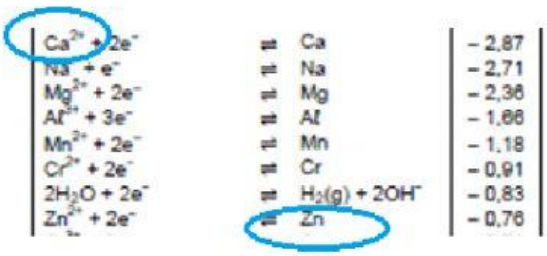
Ba is on the right of the arrow and must be read right to left and Mg+2 must be read from left to right.



The reaction follows the **C-rule and is thus spontaneous**.

Example 3

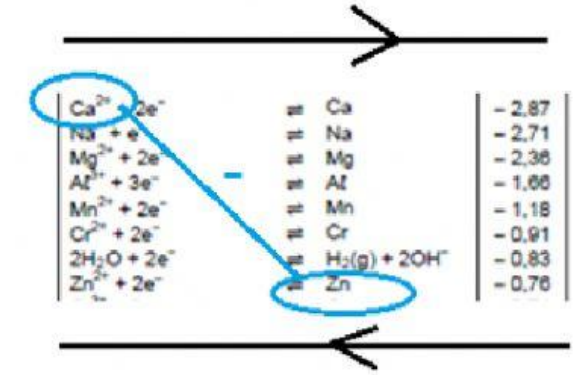
Will Ca^{+2} and Zn react spontaneously?

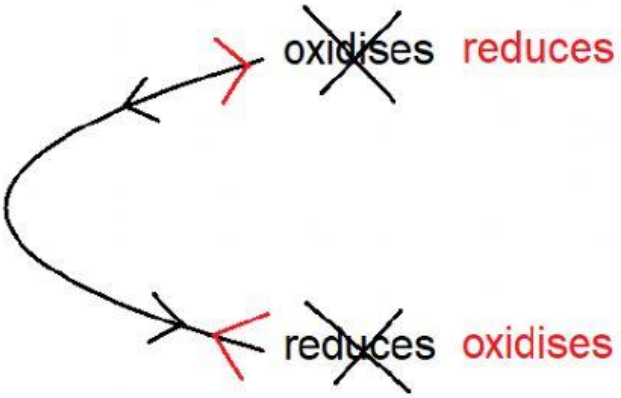


The Ca^{+2} will have to gain electrons and be read from left to right (the one higher on the table thus reduces).

The Zn can only lose electrons and will be read from right to left (the one lower on the table thus oxidises).

This reaction **does not follow the C-rule**



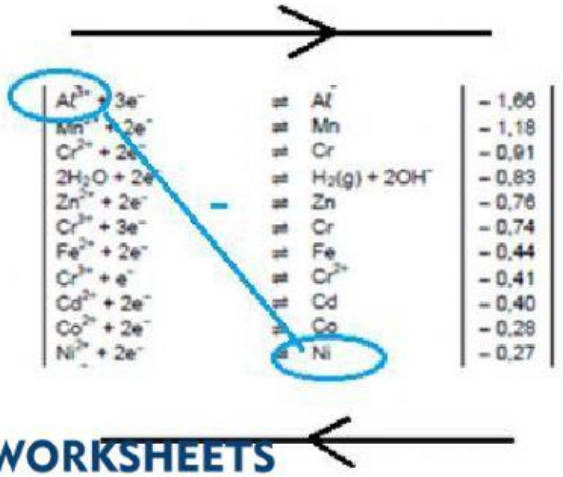


✗ non-spontaneous

Example 4

Will Ni and $Al(NO_3)_3$ react spontaneously?

*firstly Ni is neutral, but Al is charged – Al^{+3}



No the reaction is not spontaneous – since the Al^{+3} needs to be read from left to right and Ni needs to be read right to left. This does not follow the C-rule

The reaction is non-spontaneous.

Exercise 2

State whether the following reactions will be spontaneous or non-spontaneous.

2.1 Li and Zn^{+2} spontaneous / non-spontaneous

2.2 Li and $ZnSO_4$ spontaneous / non-spontaneous

2.3 Mg and $ZnSO_4$ spontaneous / non-spontaneous

2.4 Fe(iii) and Ni^{+2} spontaneous / non-spontaneous

2.5 $Al_2(SO_4)_3$ and Pt spontaneous / non-spontaneous

2.6 K and $NaNO_3$ spontaneous / non-spontaneous

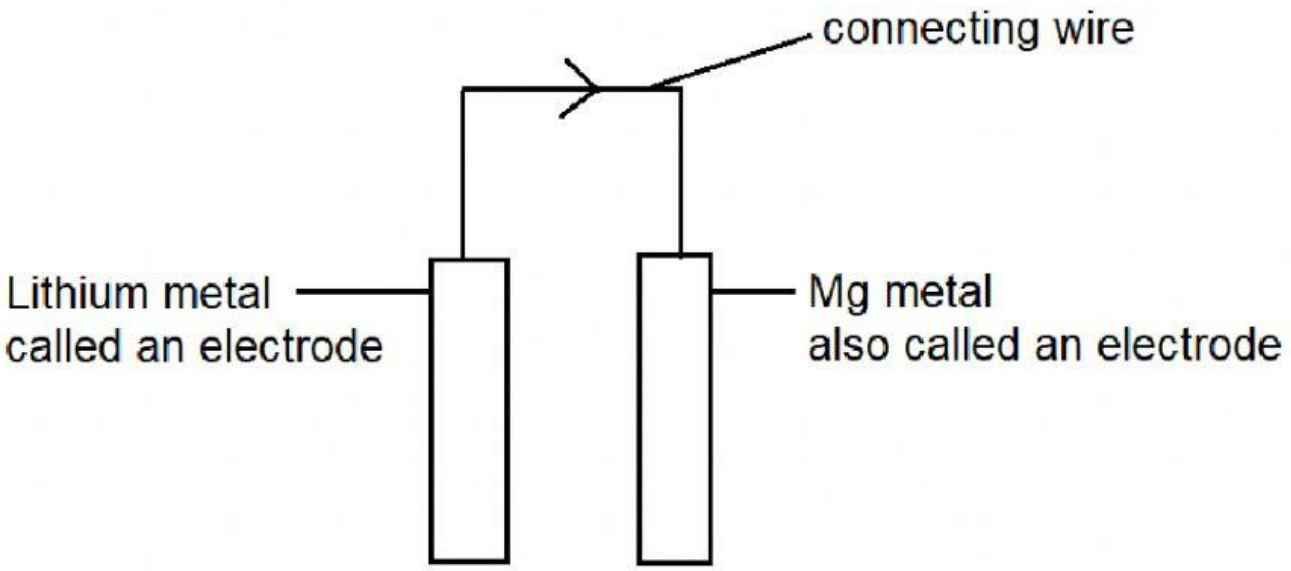
2.7 $Ag(NO_3)_3$ and Cl^- spontaneous / non-spontaneous

2.8 Ca and $Pb(NO_3)_2$ spontaneous / non-spontaneous

Batteries

Now if we can connect an element that wants to lose electrons (oxidise- and is high on the table) with an element that wants to gain electrons (reduce- and is lower on the table) then we can create electricity.

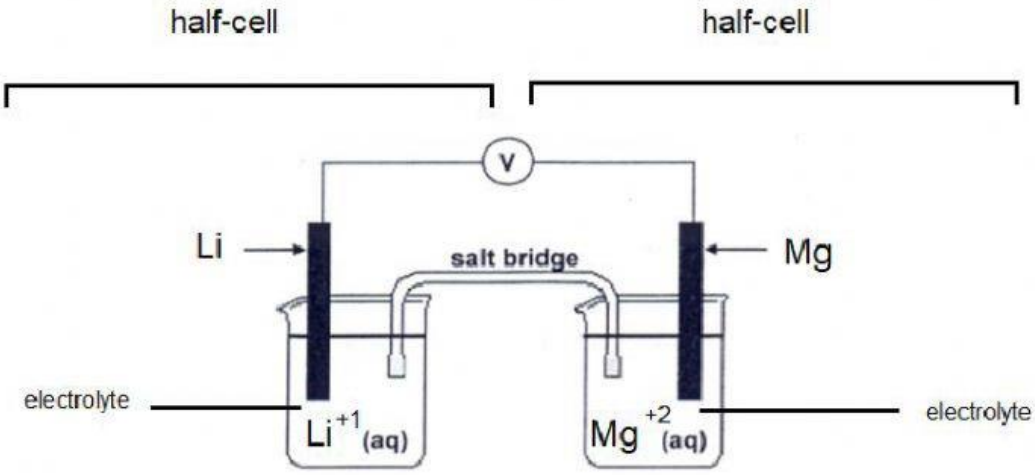
This is actually the principle on which batteries work.



Since Li wants to give off electrons (oxidise) and Mg wants to gain electrons (reduce)

It creates a flow of electrons – and thus electricity.

However this wouldn't really work- because the circuit isn't complete. Thus the setup looks like this:



The whole setup is known as a galvanic cell (the basic setup of a battery)

The Li-electrode in the Li^{+1} solution is known as a half-cell