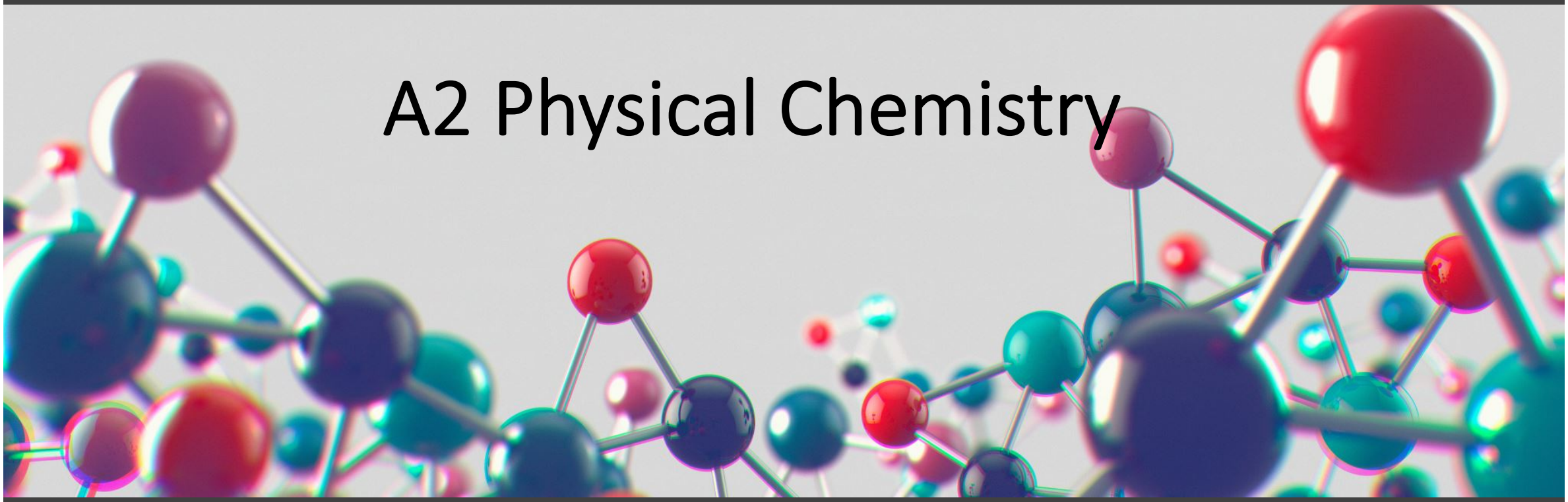

A2 Physical Chemistry

Cell Notation and Using Electrode Potentials

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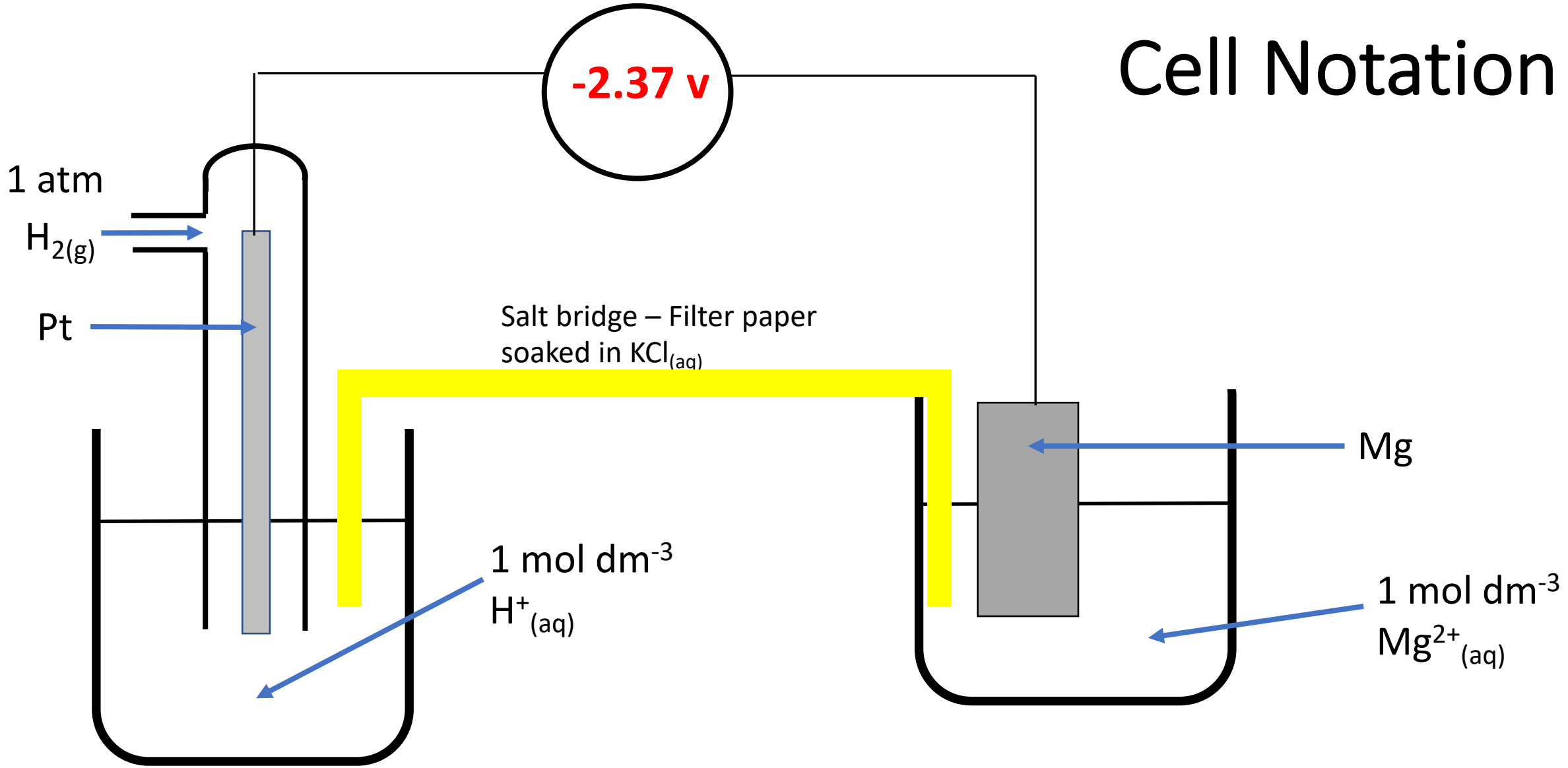
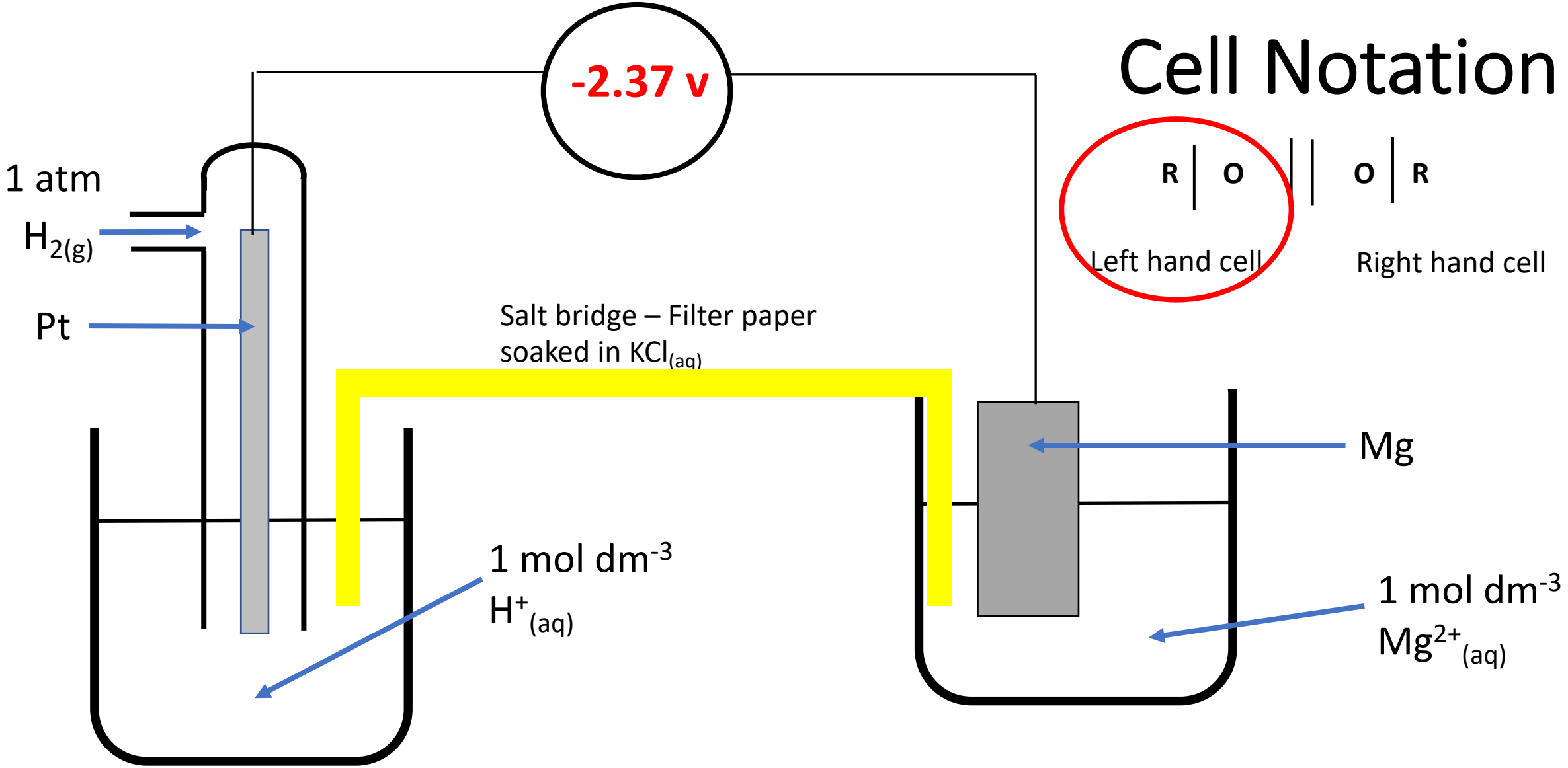
Cell Notation



$2H^+_{(aq)} + 2e^- \rightleftharpoons H_{2(g)}$

$Mg^{2+}_{(aq)} + 2e^- \rightleftharpoons Mg_{(s)}$

Standard Electrode Potential = 0 volts



Cell Notation

R | O || O | R

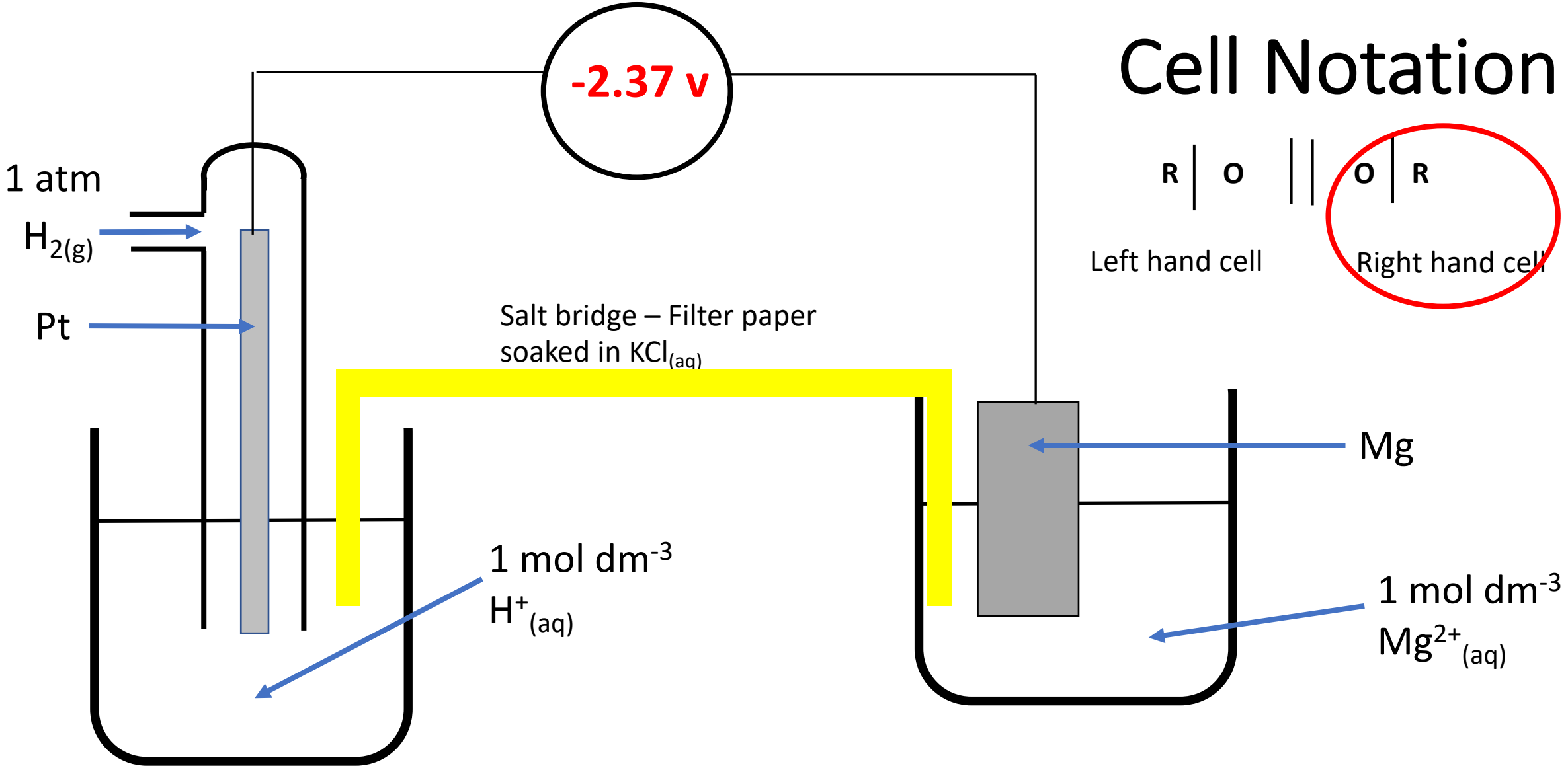
Left hand cell

Right hand cell

$2H^+_{(aq)} + 2e^- \rightleftharpoons H_{2(g)}$

$Mg^{2+}_{(aq)} + 2e^- \rightleftharpoons Mg_{(s)}$

Standard Electrode Potential = 0 volts



Cell Notation

R | O || O | R

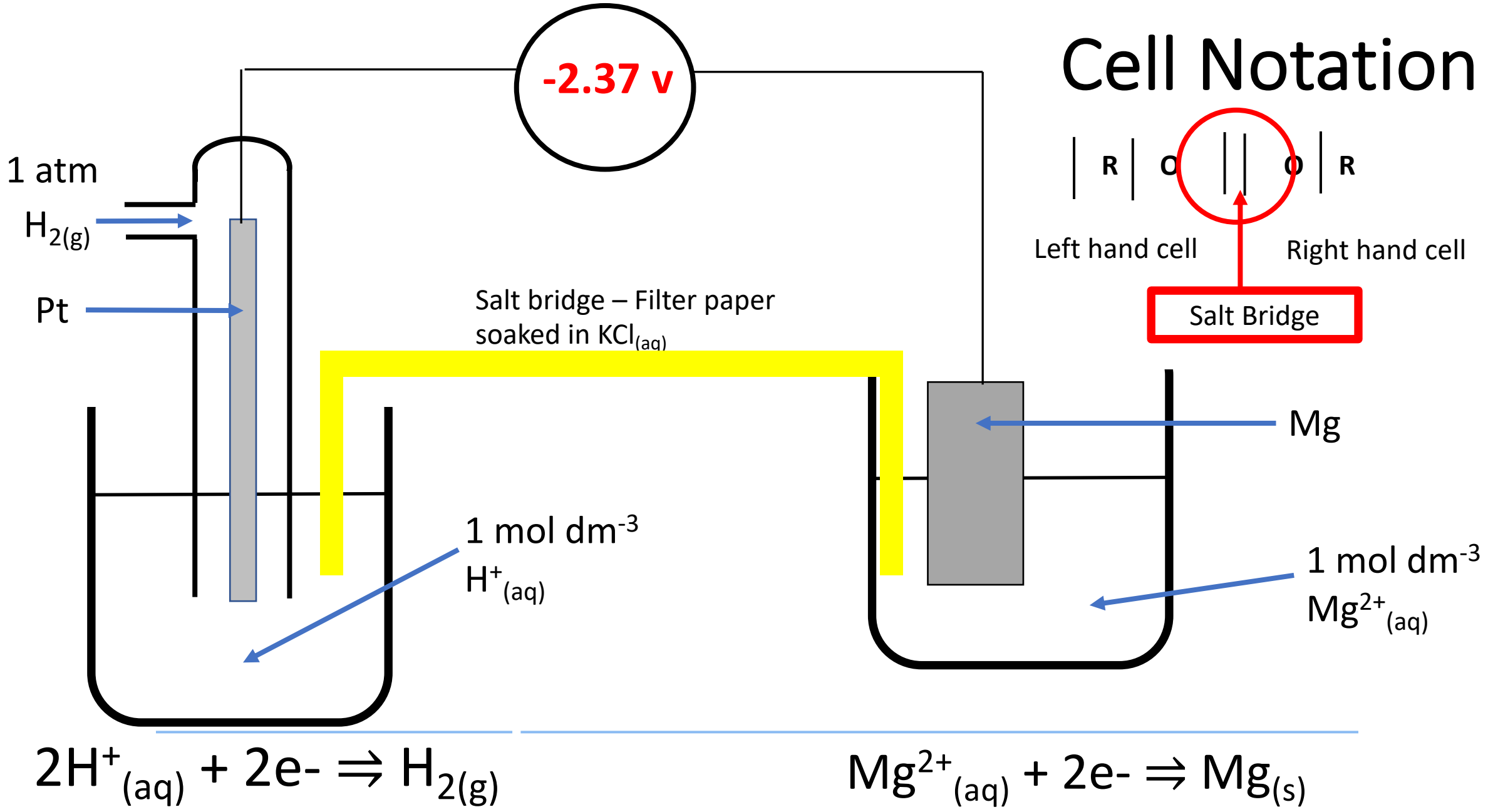
Left hand cell

Right hand cell

$2H^+_{(aq)} + 2e^- \rightleftharpoons H_{2(g)}$

$Mg^{2+}_{(aq)} + 2e^- \rightleftharpoons Mg_{(s)}$

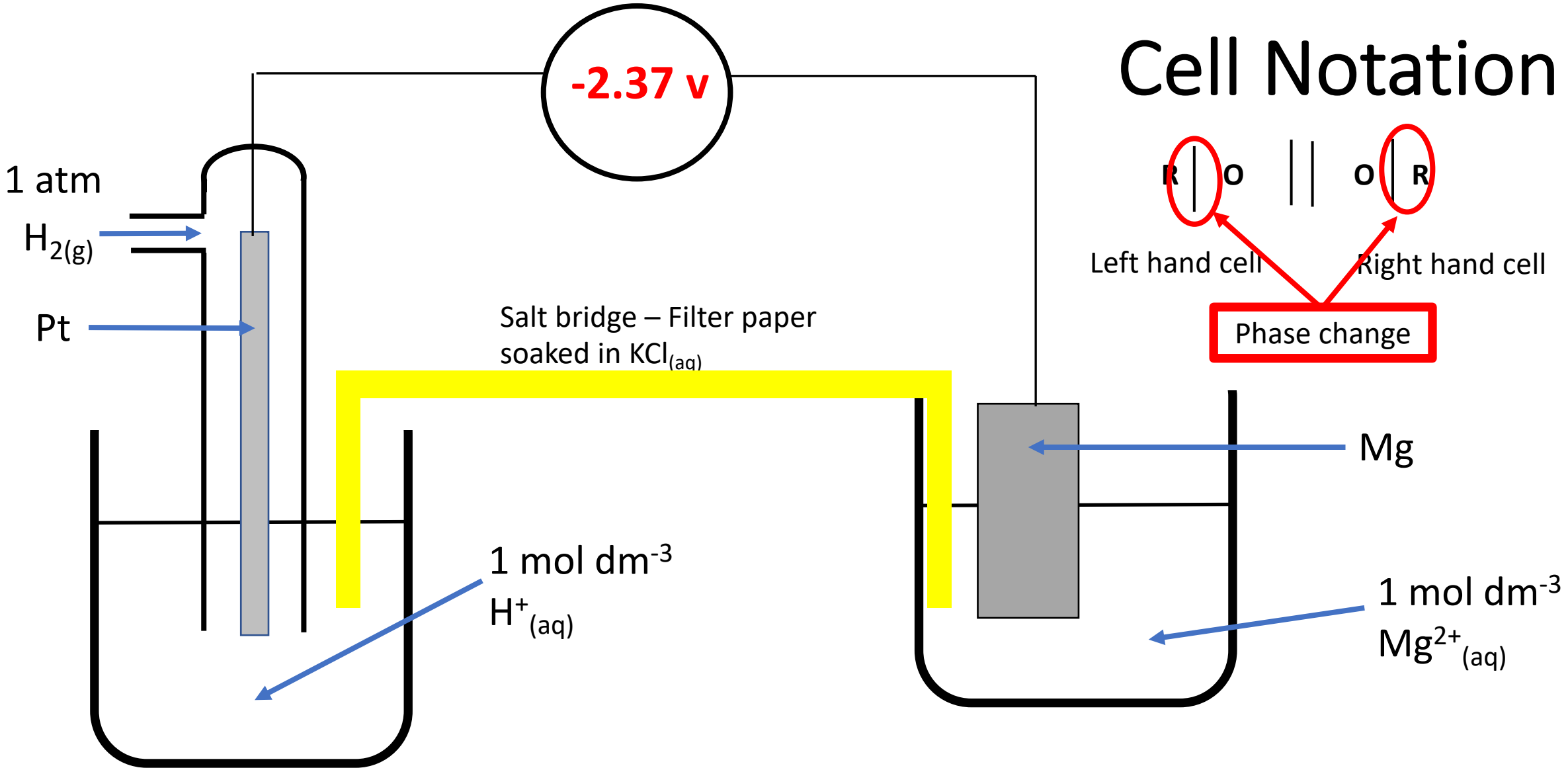
Standard Electrode Potential = 0 volts



$2H^+_{(aq)} + 2e^- \rightleftharpoons H_{2(g)}$

$Mg^{2+}_{(aq)} + 2e^- \rightleftharpoons Mg_{(s)}$

Standard Electrode Potential = 0 volts

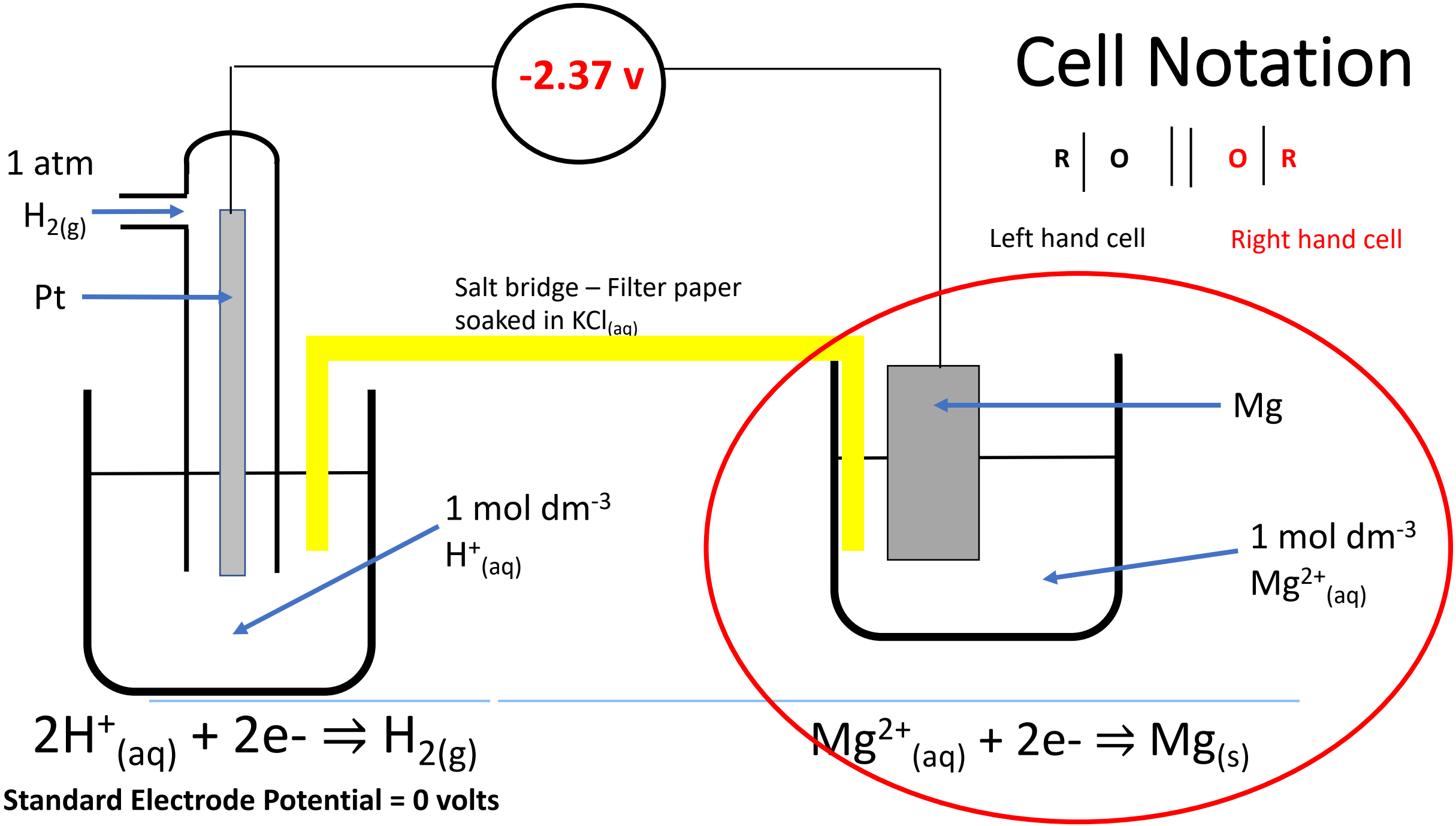


Cell Notation

$2H^+_{(aq)} + 2e^- \rightleftharpoons H_{2(g)}$

$Mg^{2+}_{(aq)} + 2e^- \rightleftharpoons Mg_{(s)}$

Standard Electrode Potential = 0 volts



Cell Notation

R | O || O | R

Left hand cell

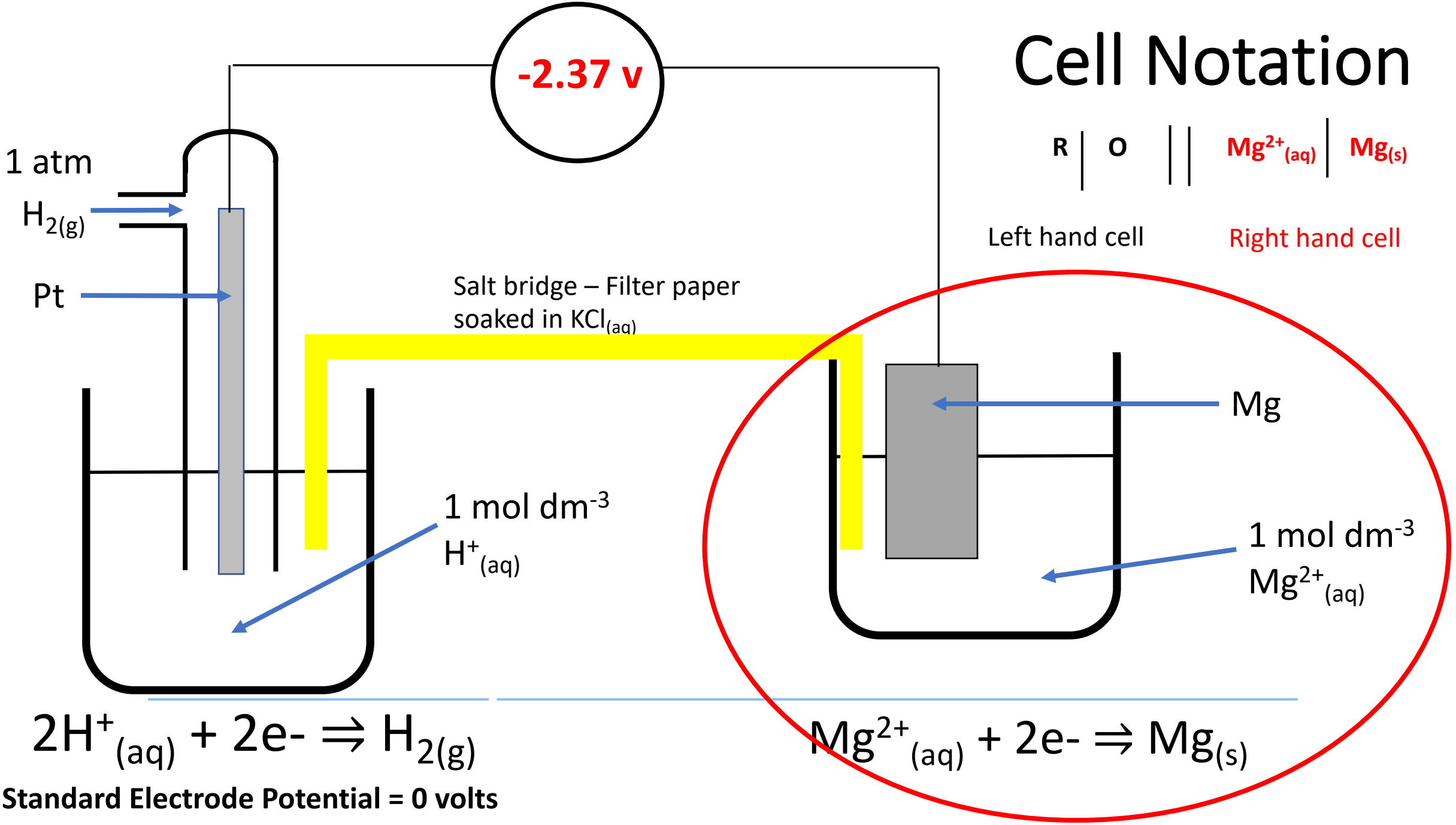
Right hand cell

Standard Electrode Potential = 0 volts

Cell Notation

R | O || $Mg^{2+}_{(aq)}$ | $Mg_{(s)}$

Left hand cell Right hand cell



$2H^+_{(aq)} + 2e^- \rightleftharpoons H_{2(g)}$

$Mg^{2+}_{(aq)} + 2e^- \rightleftharpoons Mg_{(s)}$

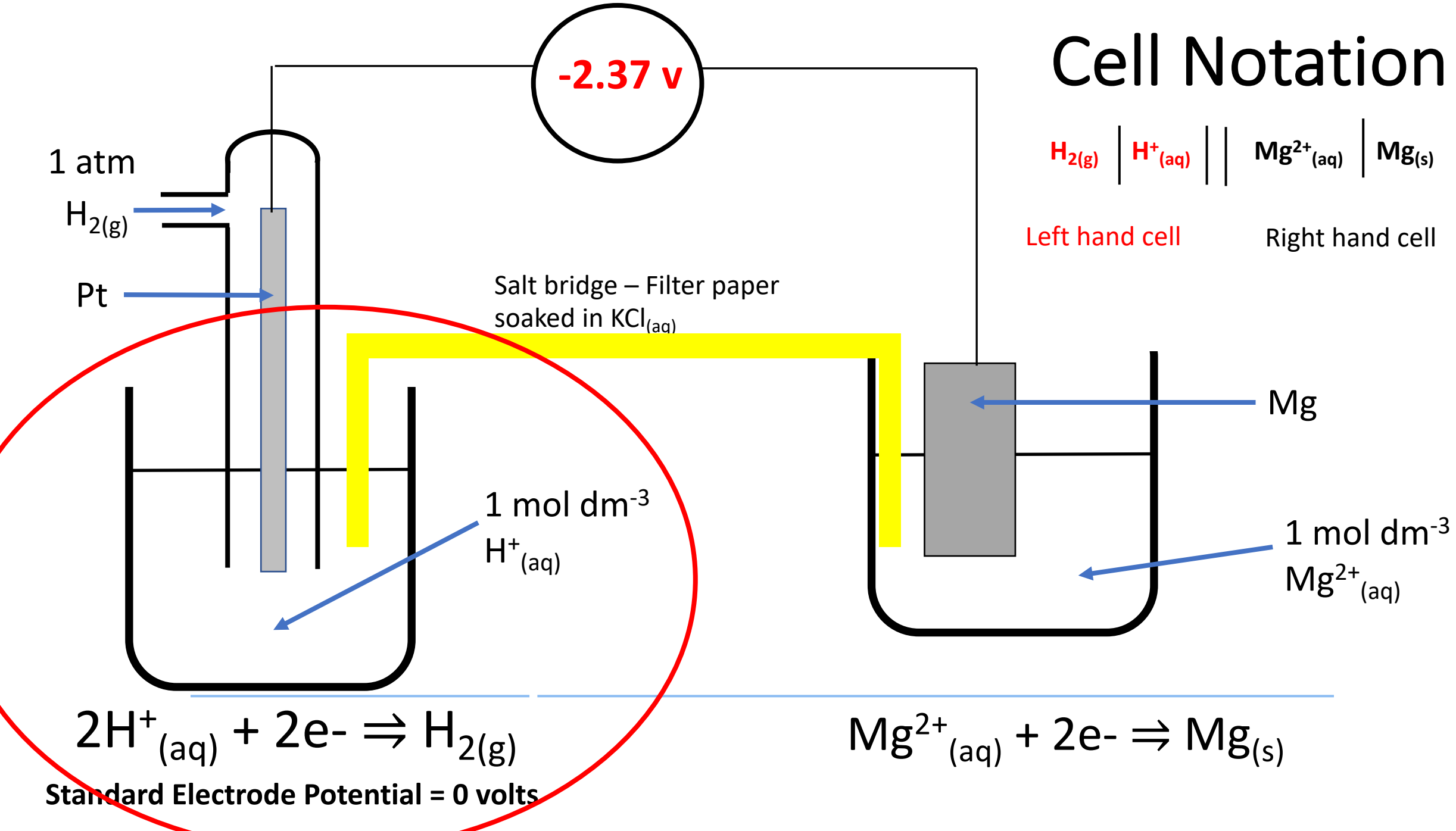
Standard Electrode Potential = 0 volts

Cell Notation

$H_{2(g)} \mid H^+_{(aq)} \mid\mid Mg^{2+}_{(aq)} \mid Mg_{(s)}$

Left hand cell

Right hand cell



$2H^+_{(aq)} + 2e^- \rightleftharpoons H_{2(g)}$

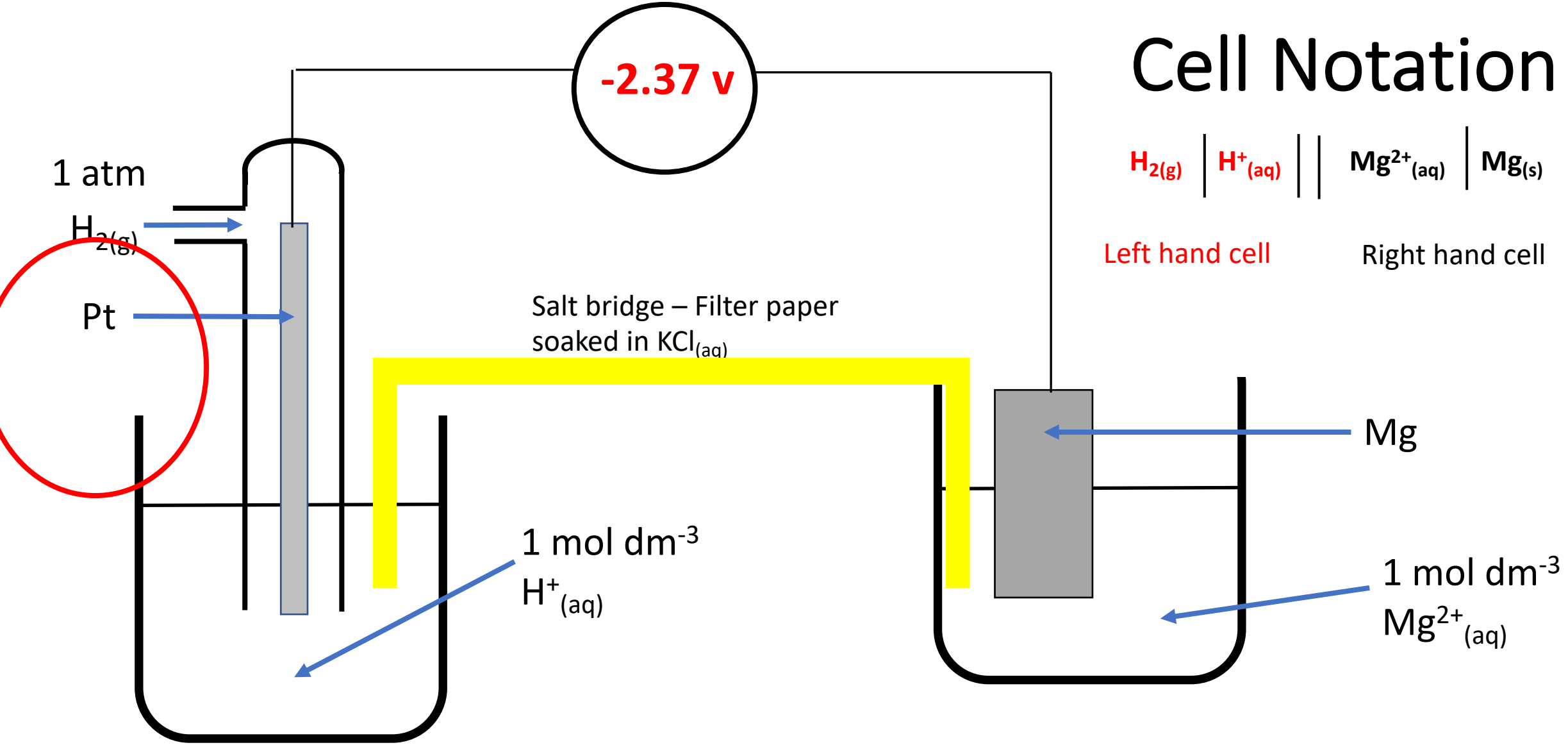
Standard Electrode Potential = 0 volts

$Mg^{2+}_{(aq)} + 2e^- \rightleftharpoons Mg_{(s)}$

Cell Notation

$H_{2(g)} \mid H^+_{(aq)} \mid\mid Mg^{2+}_{(aq)} \mid Mg_{(s)}$

Left hand cell Right hand cell

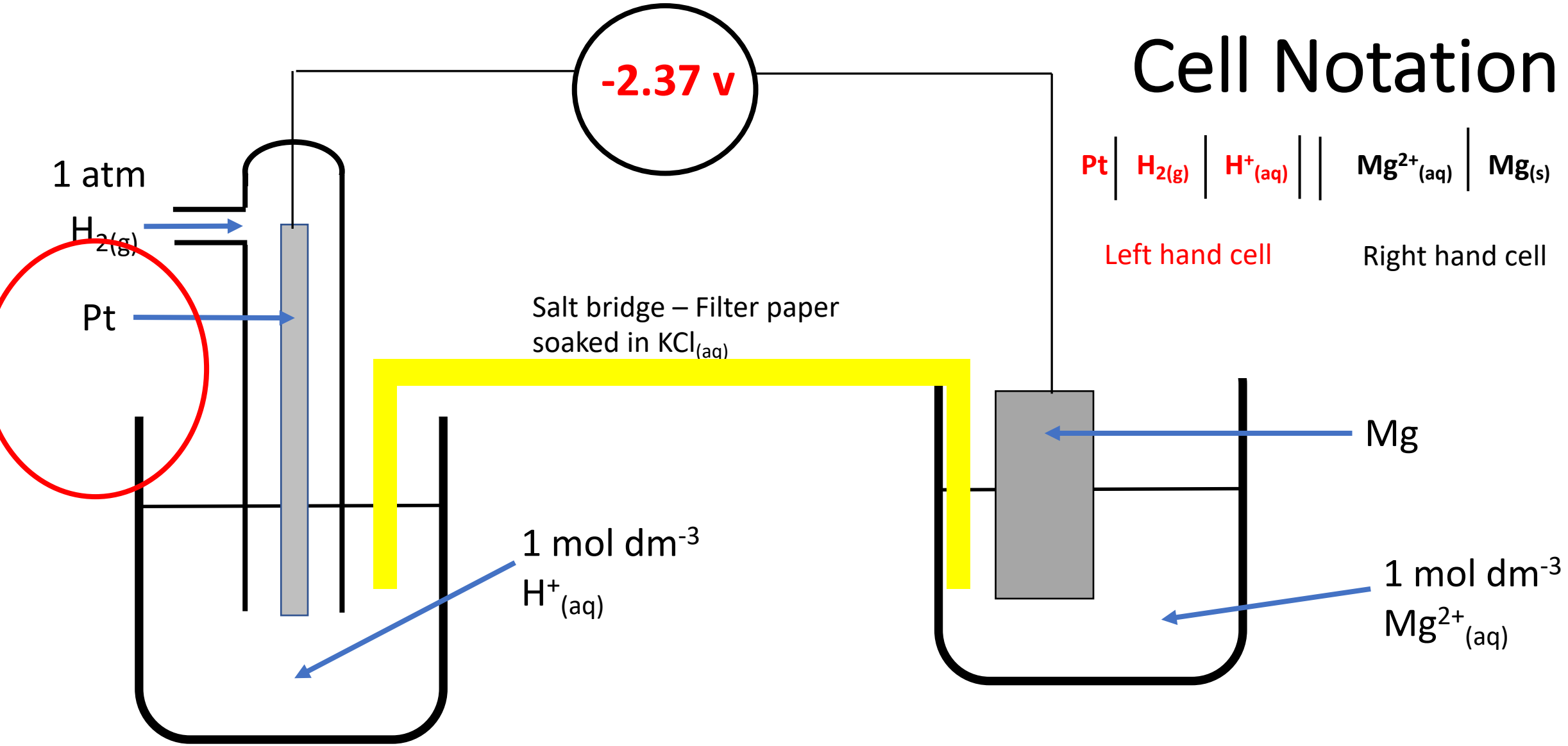


$2H^+_{(aq)} + 2e^- \rightleftharpoons H_{2(g)}$

$Mg^{2+}_{(aq)} + 2e^- \rightleftharpoons Mg_{(s)}$

Standard Electrode Potential = 0 volts

Cell Notation



Pt | $H_{2(g)}$ | $H^+_{(aq)}$ || $Mg^{2+}_{(aq)}$ | $Mg_{(s)}$

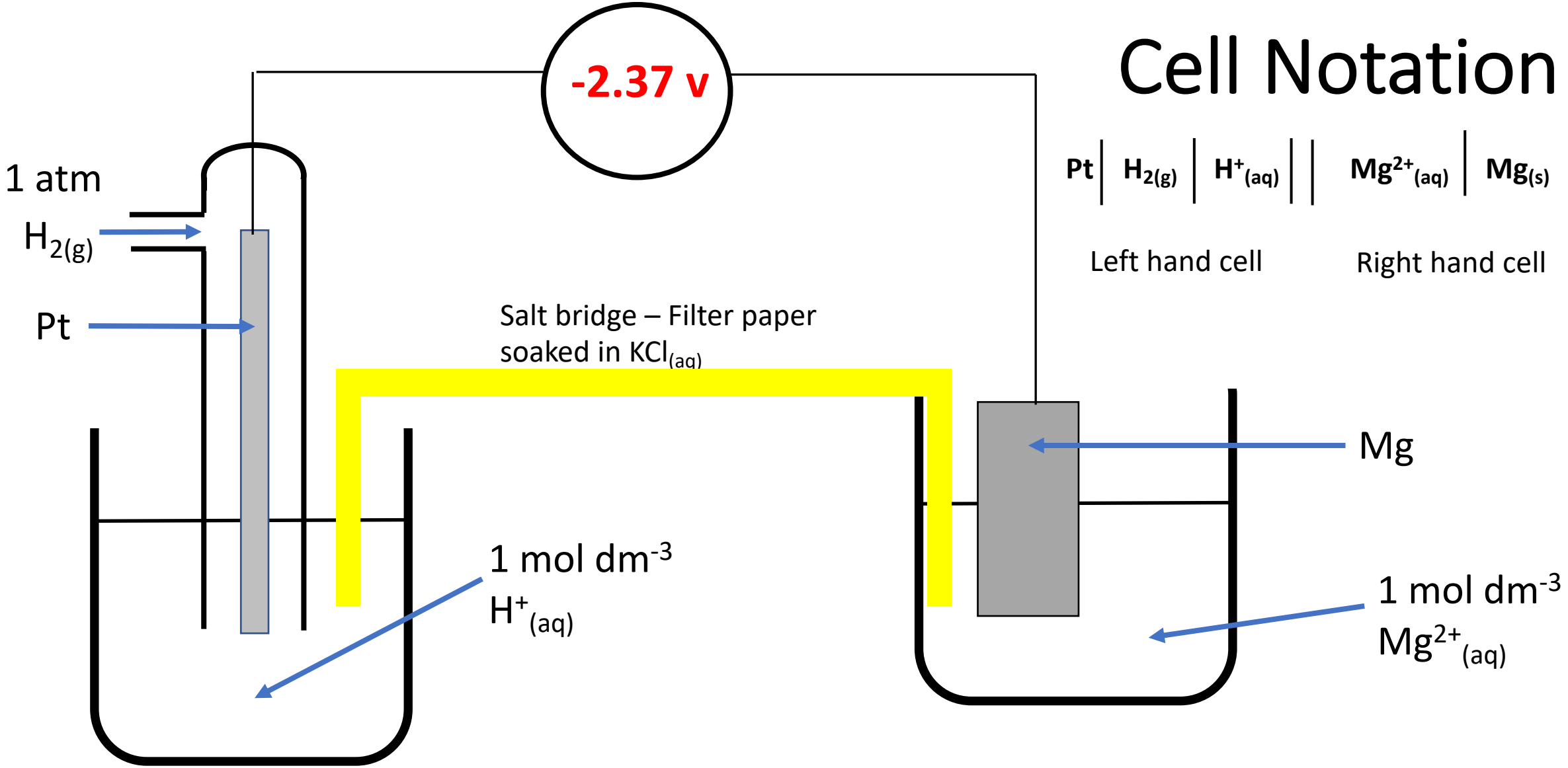
Left hand cell Right hand cell

$2H^+_{(aq)} + 2e^- \rightleftharpoons H_{2(g)}$

$Mg^{2+}_{(aq)} + 2e^- \rightleftharpoons Mg_{(s)}$

Standard Electrode Potential = 0 volts

Cell Notation



Pt | $H_{2(g)}$ | $H^+_{(aq)}$ || $Mg^{2+}_{(aq)}$ | $Mg_{(s)}$

Left hand cell Right hand cell

$2H^+_{(aq)} + 2e^- \rightleftharpoons H_{2(g)}$

$Mg^{2+}_{(aq)} + 2e^- \rightleftharpoons Mg_{(s)}$

Standard Electrode Potential = 0 volts

Cell Notation

$$Pt \mid H_{2(g)} \mid H^{+}_{(aq)} \mid\mid Mg^{2+}_{(aq)} \mid Mg_{(s)} \qquad E^{\ominus} = -2.37\ v$$

Using Standard Electrode Potentials

$K^+(aq) + e^-$	→ $K(s)$	-2.93
$Ca^{2+}(aq) + 2e^-$	→ $Ca(s)$	-2.87
$Na^+(aq) + e^-$	→ $Na(s)$	-2.71
$Mg^{2+}(aq) + 2e^-$	→ $Mg(s)$	-2.37
$Al^{3+}(aq) + 3e^-$	→ $Al(s)$	-1.66
$Zn^{2+}(aq) + 2e^-$	→ $Zn(s)$	-0.76
$Fe^{2+}(aq) + 2e^-$	→ $Fe(s)$	-0.44
$Pb^{2+}(aq) + 2e^-$	→ $Pb(s)$	-0.13
$2H^+(aq) + 2e^-$	→ $H_2(g)$	0.00
$Cu^{2+}(aq) + e^-$	→ $Cu^+(aq)$	0.15
$Ag^+(aq) + e^-$	→ $Ag(s)$	0.80
$Au^{3+}(aq) + 3e^-$	→ $Au(s)$	1.50

What would be the cell potential of:

$$Ag_{(s)} \mid Ag^+_{(aq)} \parallel Fe^{2+}_{(aq)} \mid Fe_{(s)}$$

Using Standard Electrode Potentials

$K^+(aq) + e^-$	→ $K(s)$	-2.93
$Ca^{2+}(aq) + 2e^-$	→ $Ca(s)$	-2.87
$Na^+(aq) + e^-$	→ $Na(s)$	-2.71
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$Ag^+(aq) + e^-$	→ $Ag(s)$	0.80
$Au^{3+}(aq) + 3e^-$	→ $Au(s)$	1.50

What would be the cell potential of:

$Ag_{(s)} \mid Ag^+_{(aq)} \parallel Fe^{2+}_{(aq)} \mid Fe_{(s)}$

0.80 v

Using Standard Electrode Potentials

$K^+(aq) + e^-$	→ $K(s)$	-2.93
$Ca^{2+}(aq) + 2e^-$	→ $Ca(s)$	-2.87
$Na^+(aq) + e^-$	→ $Na(s)$	-2.71
$Mg^{2+}(aq) + 2e^-$	→ $Mg(s)$	-2.37
$Al^{3+}(aq) + 3e^-$	→ $Al(s)$	-1.66
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0.80 v

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What would be the cell potential of:

$Ag_{(s)} \mid Ag^+_{(aq)} \parallel Fe^{2+}_{(aq)} \mid Fe_{(s)}$

+0.80 v -0.44 v

Using Standard Electrode Potentials

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$Ca^{2+}(aq) + 2e^-$	→ $Ca(s)$	-2.87
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$Al^{3+}(aq) + 3e^-$	→ $Al(s)$	-1.66
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What would be the cell potential of:

$Ag_{(s)} \mid Ag^+_{(aq)} \parallel Fe^{2+}_{(aq)} \mid Fe_{(s)}$

+0.80 v -0.44 v

Cell potential = Right Cell Potential – Left Cell Potential

Using Standard Electrode Potentials

$K^+(aq) + e^-$	→ $K(s)$	-2.93
$Ca^{2+}(aq) + 2e^-$	→ $Ca(s)$	-2.87
$Na^+(aq) + e^-$	→ $Na(s)$	-2.71
$Mg^{2+}(aq) + 2e^-$	→ $Mg(s)$	-2.37
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$Ag^+(aq) + e^-$	→ $Ag(s)$	0.80
$Au^{3+}(aq) + 3e^-$	→ $Au(s)$	1.50

What would be the cell potential of:

$$Ag_{(s)} \mid Ag^+_{(aq)} \parallel Fe^{2+}_{(aq)} \mid Fe_{(s)}$$

+0.80 v -0.44 v

Cell potential = Right Cell Potential – Left Cell Potential

Cell potential = -0.44 – 0.80 = -1.24 v

Using Standard Electrode Potentials

$K^+(aq) + e^-$	→ $K(s)$	-2.93
$Ca^{2+}(aq) + 2e^-$	→ $Ca(s)$	-2.87
$Na^+(aq) + e^-$	→ $Na(s)$	-2.71
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$Zn^{2+}(aq) + 2e^-$	→ $Zn(s)$	-0.76
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$Pb^{2+}(aq) + 2e^-$	→ $Pb(s)$	-0.13
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+0.80 v -0.44 v

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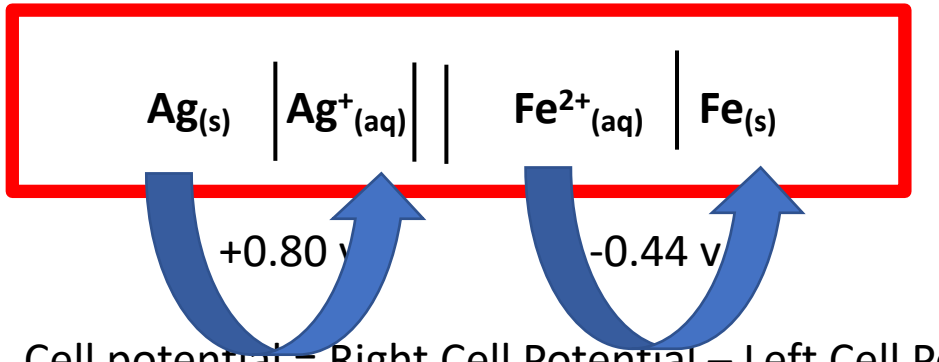
$Ag^+(aq) + e^-$	→ $Ag(s)$	0.80
$Au^{3+}(aq) + 3e^-$	→ $Au(s)$	1.50

What would be the cell potential of:



Cell potential = Right Cell Potential – Left Cell Potential

Cell potential = -0.44 – 0.80 = -1.24 v

This refers to the following reaction

$$2Ag_{(s)} + Fe^{2+}_{(aq)} \rightarrow 2Ag^{+}_{(aq)} + Fe_{(s)} \qquad \textbf{-1.24 v}$$

Using Standard Electrode Potentials

$K^+(aq) + e^-$	→ $K(s)$	-2.93
$Ca^{2+}(aq) + 2e^-$	→ $Ca(s)$	-2.87
$Na^+(aq) + e^-$	→ $Na(s)$	-2.71
$Mg^{2+}(aq) + 2e^-$	→ $Mg(s)$	-2.37
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$Ag^+(aq) + e^-$	→ $Ag(s)$	0.80
$Au^{3+}(aq) + 3e^-$	→ $Au(s)$	1.50

What would be the cell potential of:

$$Ag_{(s)} \mid Ag^+_{(aq)} \parallel Fe^{2+}_{(aq)} \mid Fe_{(s)}$$

+0.80 v -0.44 v

Cell potential = Right Cell Potential – Left Cell Potential

Cell potential = -0.44 – 0.80 = -1.24 v

This refers to the following reaction

$$2Ag_{(s)} + Fe^{2+}_{(aq)} \rightarrow 2Ag^+_{(aq)} + Fe_{(s)} \qquad \textbf{-1.24 v}$$

The negative cell potential indicates that this reaction is not feasible. If I add silver metal to a solution of Fe^{2+} ions a reaction will not occur.

Using Standard Electrode Potentials

$K^+(aq) + e^-$	→ $K(s)$	-2.93
$Ca^{2+}(aq) + 2e^-$	→ $Ca(s)$	-2.87
$Na^+(aq) + e^-$	→ $Na(s)$	-2.71
$Mg^{2+}(aq) + 2e^-$	→ $Mg(s)$	-2.37
$Al^{3+}(aq) + 3e^-$	→ $Al(s)$	-1.66
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$2H^+(aq) + 2e^-$	→ $H_2(g)$	0.00
$Cu^{2+}(aq) + e^-$	→ $Cu^+(aq)$	0.15
$Ag^+(aq) + e^-$	→ $Ag(s)$	0.80
$Au^{3+}(aq) + 3e^-$	→ $Au(s)$	1.50

What would be the cell potential of:

$$Fe_{(s)} \mid Fe^{2+}_{(aq)} \parallel Ag^{+}_{(aq)} \mid Ag_{(s)}$$

Using Standard Electrode Potentials

$K^+(aq) + e^-$	→ $K(s)$	-2.93
$Ca^{2+}(aq) + 2e^-$	→ $Ca(s)$	-2.87
$Na^+(aq) + e^-$	→ $Na(s)$	-2.71
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$Cu^{2+}(aq) + e^-$	→ $Cu^+(aq)$	0.15
$Ag^+(aq) + e^-$	→ $Ag(s)$	0.80
$Au^{3+}(aq) + 3e^-$	→ $Au(s)$	1.50

What would be the cell potential of:

$Fe_{(s)} \mid Fe^{2+}_{(aq)} \parallel Ag^+_{(aq)} \mid Ag_{(s)}$

-0.44 v

+0.80 v

Using Standard Electrode Potentials

$K^+(aq) + e^-$	→ $K(s)$	-2.93
$Ca^{2+}(aq) + 2e^-$	→ $Ca(s)$	-2.87
$Na^+(aq) + e^-$	→ $Na(s)$	-2.71
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$Ag^+(aq) + e^-$	→ $Ag(s)$	0.80
$Au^{3+}(aq) + 3e^-$	→ $Au(s)$	1.50

What would be the cell potential of:

$Fe_{(s)} \mid Fe^{2+}_{(aq)} \parallel Ag^+_{(aq)} \mid Ag_{(s)}$

-0.44 v +0.80 v

Cell potential = Right Cell Potential – Left Cell Potential

Cell potential = -0.80 – (-0.44) = +1.24 v

Using Standard Electrode Potentials

$K^+(aq) + e^-$	→ $K(s)$	-2.93
$Ca^{2+}(aq) + 2e^-$	→ $Ca(s)$	-2.87
$Na^+(aq) + e^-$	→ $Na(s)$	-2.71
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$Ag^+(aq) + e^-$	→ $Ag(s)$	0.80
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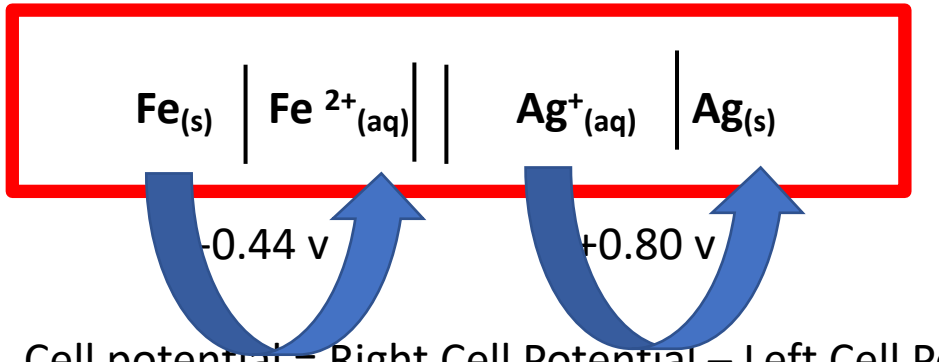
What would be the cell potential of:



Cell potential = Right Cell Potential – Left Cell Potential

Cell potential = -0.44 – 0.80 = -1.24 v

This refers to the following reaction

$$2Ag^+_{(aq)} + Fe_{(s)} \rightarrow 2Ag_{(s)} + Fe^{2+}_{(aq)} \qquad +1.24\ v$$

The positive cell potential indicates that this reaction is feasible. If I add iron metal to a solution of Ag^+ ions a reaction will occur.

Using Standard Electrode Potentials

$K^+(aq) + e^-$	→ $K(s)$	-2.93
$Ca^{2+}(aq) + 2e^-$	→ $Ca(s)$	-2.87
$Na^+(aq) + e^-$	→ $Na(s)$	-2.71
$Mg^{2+}(aq) + 2e^-$	→ $Mg(s)$	-2.37
$Al^{3+}(aq) + 3e^-$	→ $Al(s)$	-1.66
$Zn^{2+}(aq) + 2e^-$	→ $Zn(s)$	-0.76
$Fe^{2+}(aq) + 2e^-$	→ $Fe(s)$	-0.44
$Pb^{2+}(aq) + 2e^-$	→ $Pb(s)$	-0.13
$2H^+(aq) + 2e^-$	→ $H_2(g)$	0.00
$Cu^{2+}(aq) + e^-$	→ $Cu^+(aq)$	0.15
$Ag^+(aq) + e^-$	→ $Ag(s)$	0.80
$Au^{3+}(aq) + 3e^-$	→ $Au(s)$	1.50

Limitations of predictions

If the cell potential is greater than + 0.30V a reaction proceeds even under non-standard conditions but may be slow. **E values give no indication of rate.**

Using Standard Electrode Potentials

$K^+(aq) + e^-$	→ $K(s)$	-2.93
$Ca^{2+}(aq) + 2e^-$	→ $Ca(s)$	-2.87
$Na^+(aq) + e^-$	→ $Na(s)$	-2.71
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Changing concentration changes E values

For the half equation :

$Ag^+_{(aq)} + e^- \rightarrow Ag_{(a)}$ E = +0.80 v under standard conditions

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This decreases the number of electrons on the metal and the cell potential becomes more positive.

The overall cell potential with Fe becomes more positive.

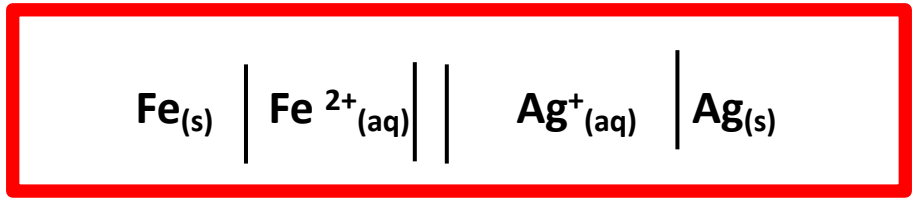
Making batteries

Let's go back to this reaction

What is the point of separating the two reactants?

Making batteries

Let's go back to this reaction



What is the point of separating the two reactants?

If we added Fe solid to a solution of $Ag^{+}_{(aq)}$ a reaction would occur.

$$2Ag^{+}_{(aq)} + Fe_{(s)} \rightarrow 2Ag_{(s)} + Fe^{2+}_{(aq)}$$

Making batteries

Let's go back to this reaction

$$Fe_{(s)} \mid Fe^{2+}_{(aq)} \parallel Ag^{+}_{(aq)} \mid Ag_{(s)}$$

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If we added Fe solid to a solution of $Ag^{+}_{(aq)}$ a reaction would occur.

$$2Ag^{+}_{(aq)} + Fe_{(s)} \rightarrow 2Ag_{(s)} + Fe^{2+}_{(aq)}$$

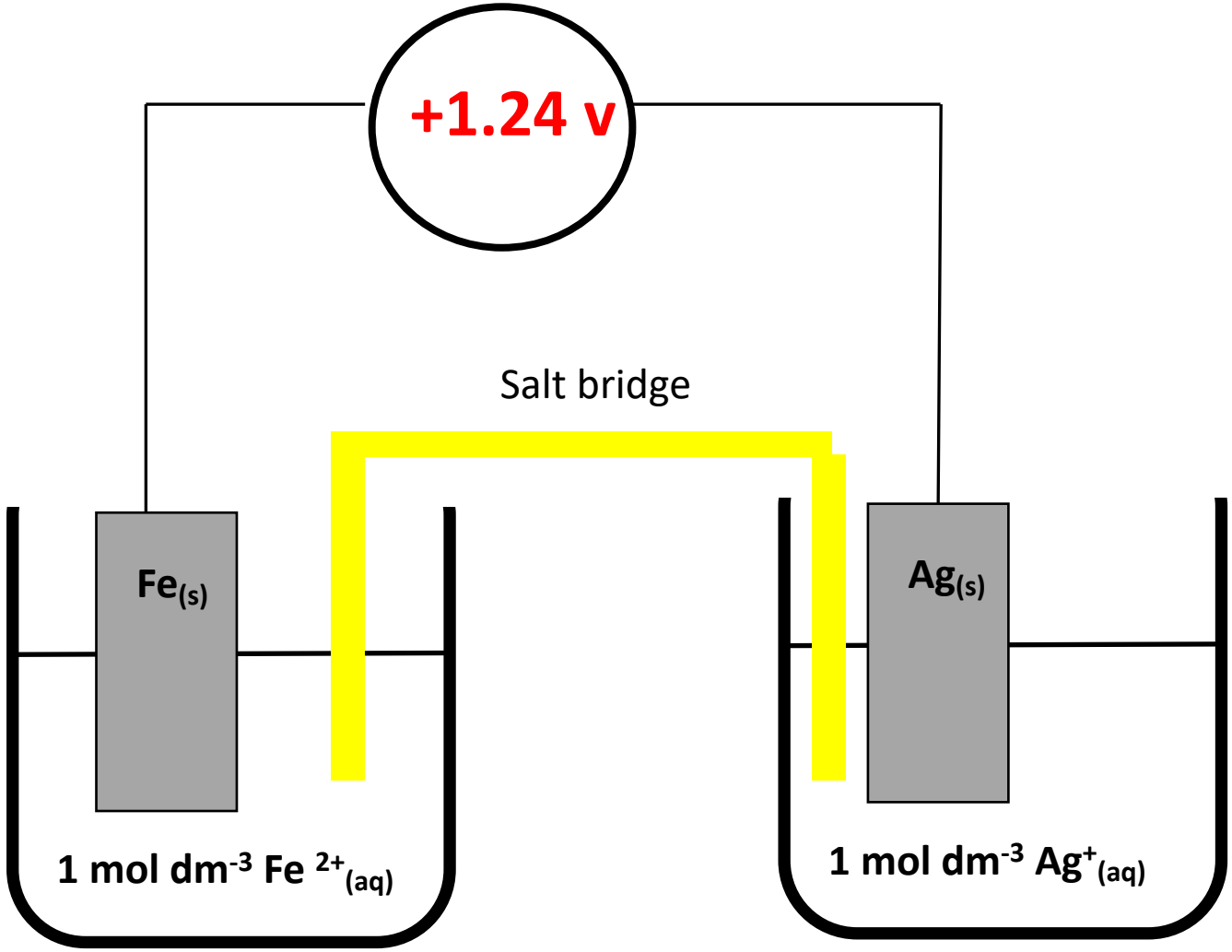
By separating the reactants we can make the electrons travel through a wire and generate electricity.

$2Ag^{+}_{(aq)} + Fe_{(s)} \rightarrow 2Ag_{(s)} + Fe^{2+}_{(aq)}$

$Fe_{(s)} \mid Fe^{2+}_{(aq)} \parallel Ag^{+}_{(aq)} \mid Ag_{(s)}$

Making batteries

The high resistance voltmeter stops the electrons following.



$2Ag^{+}_{(aq)} + Fe_{(s)} \rightarrow 2Ag_{(s)} + Fe^{2+}_{(aq)}$

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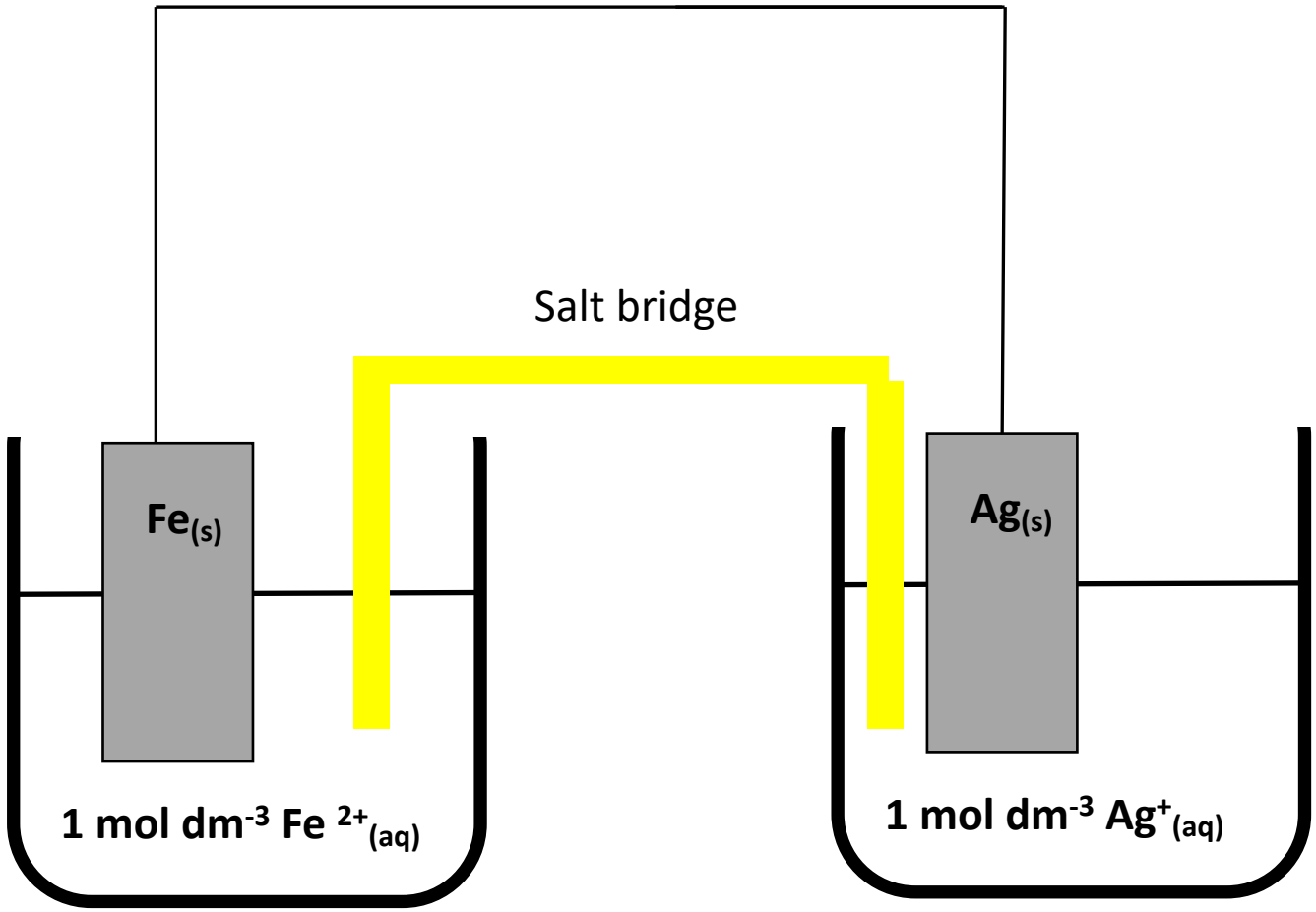
Making batteries

When removed which way will the electrons follow?



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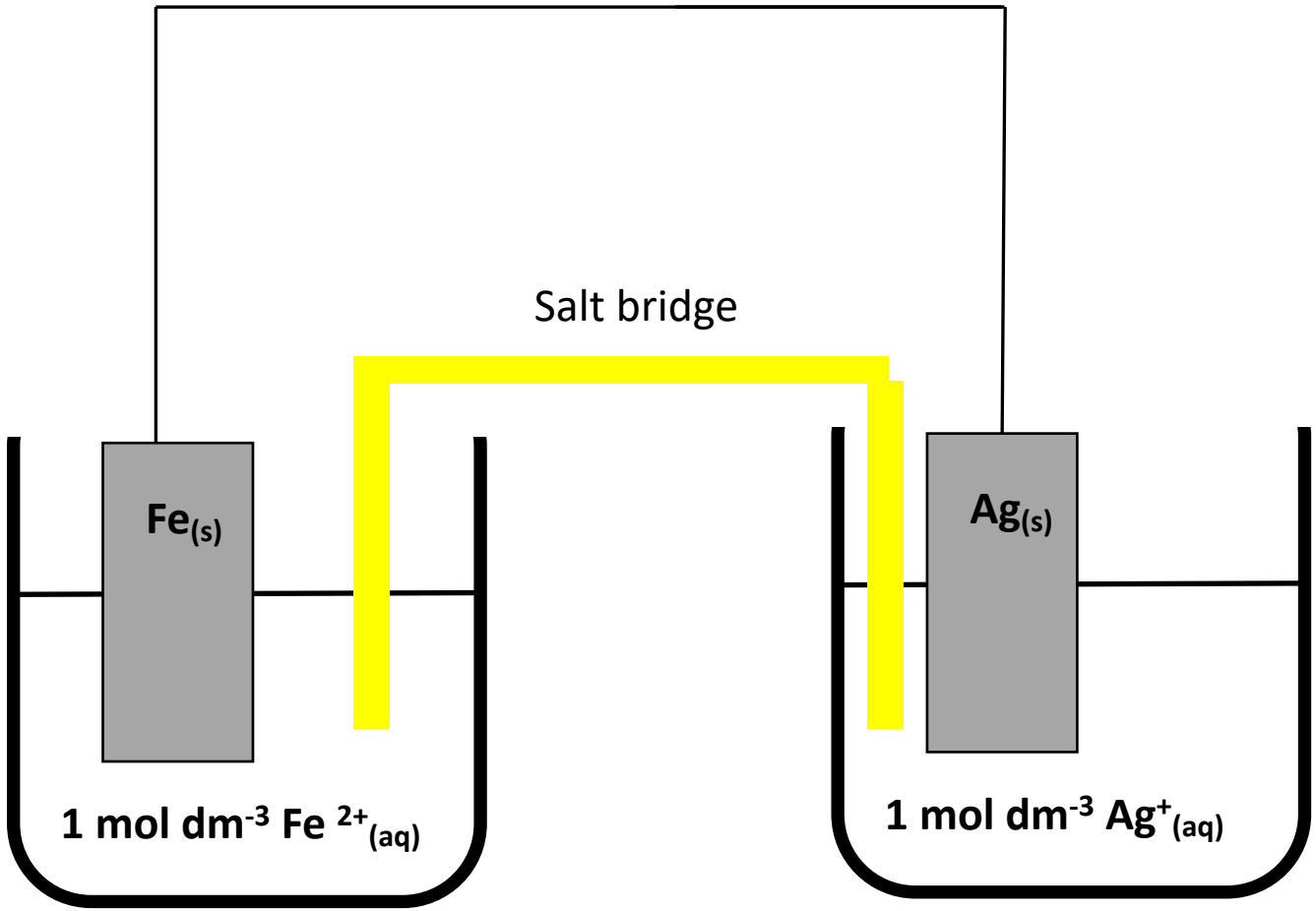
-0.44 v

+0.80 v



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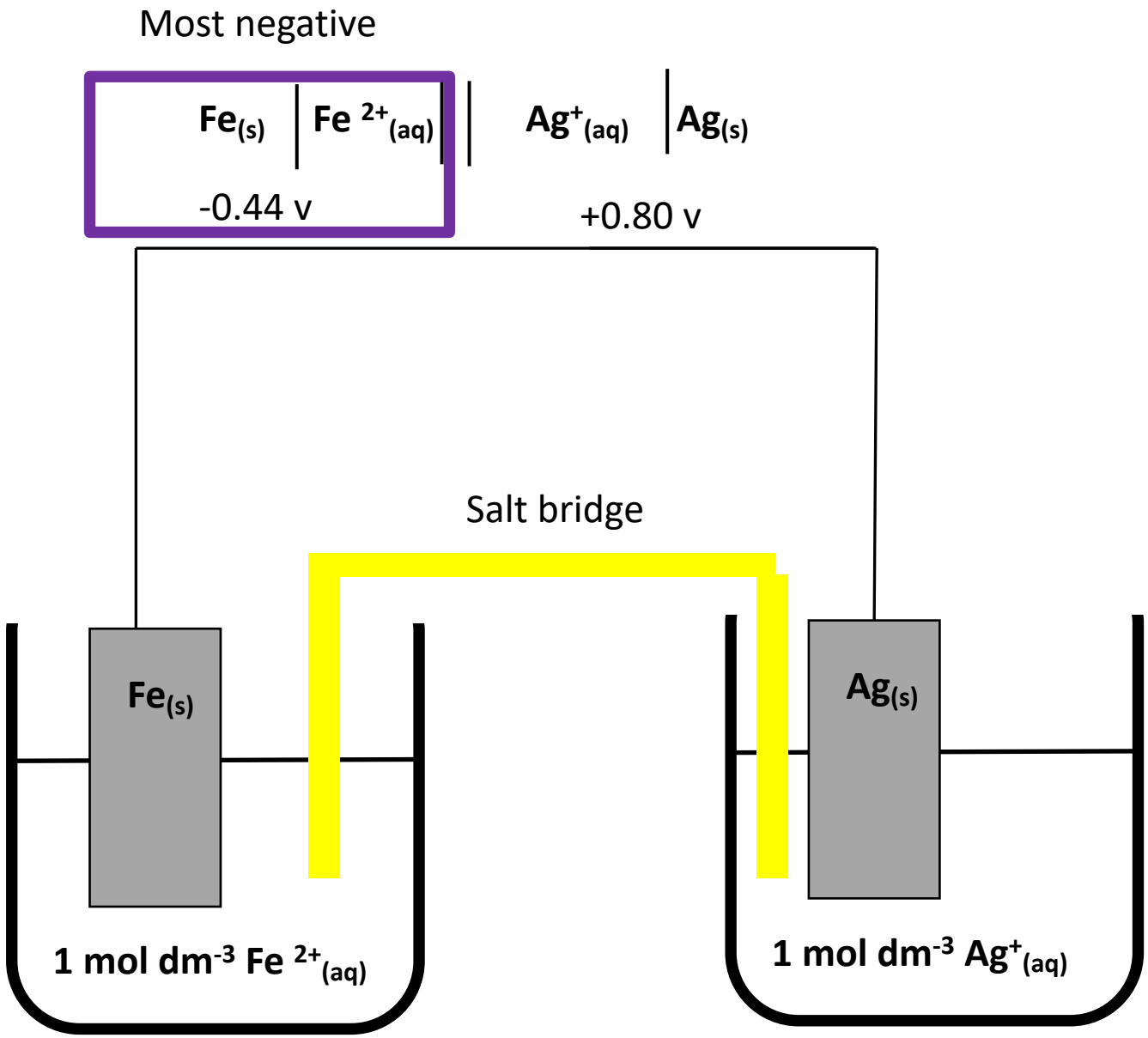
Making batteries



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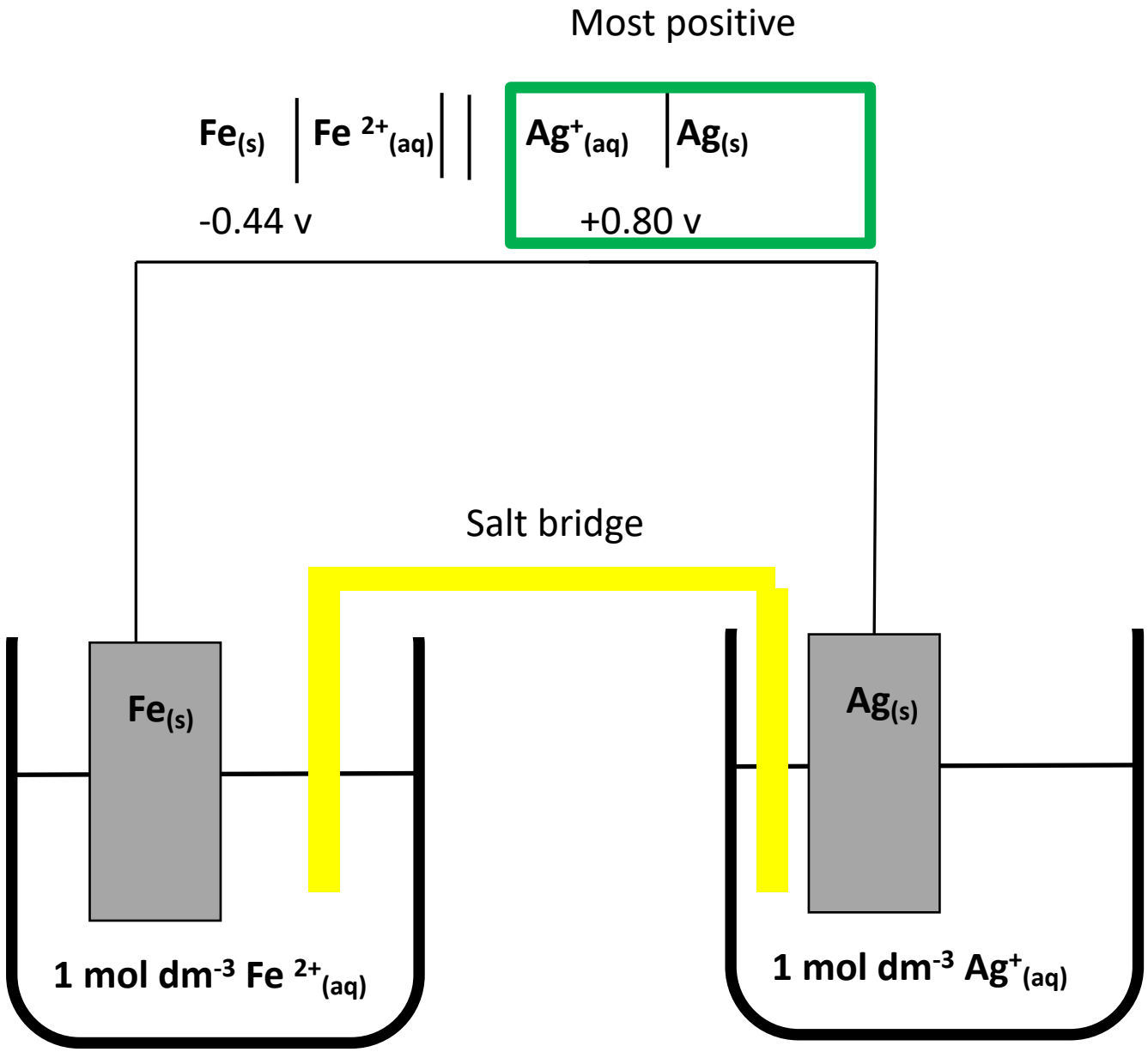
Making batteries



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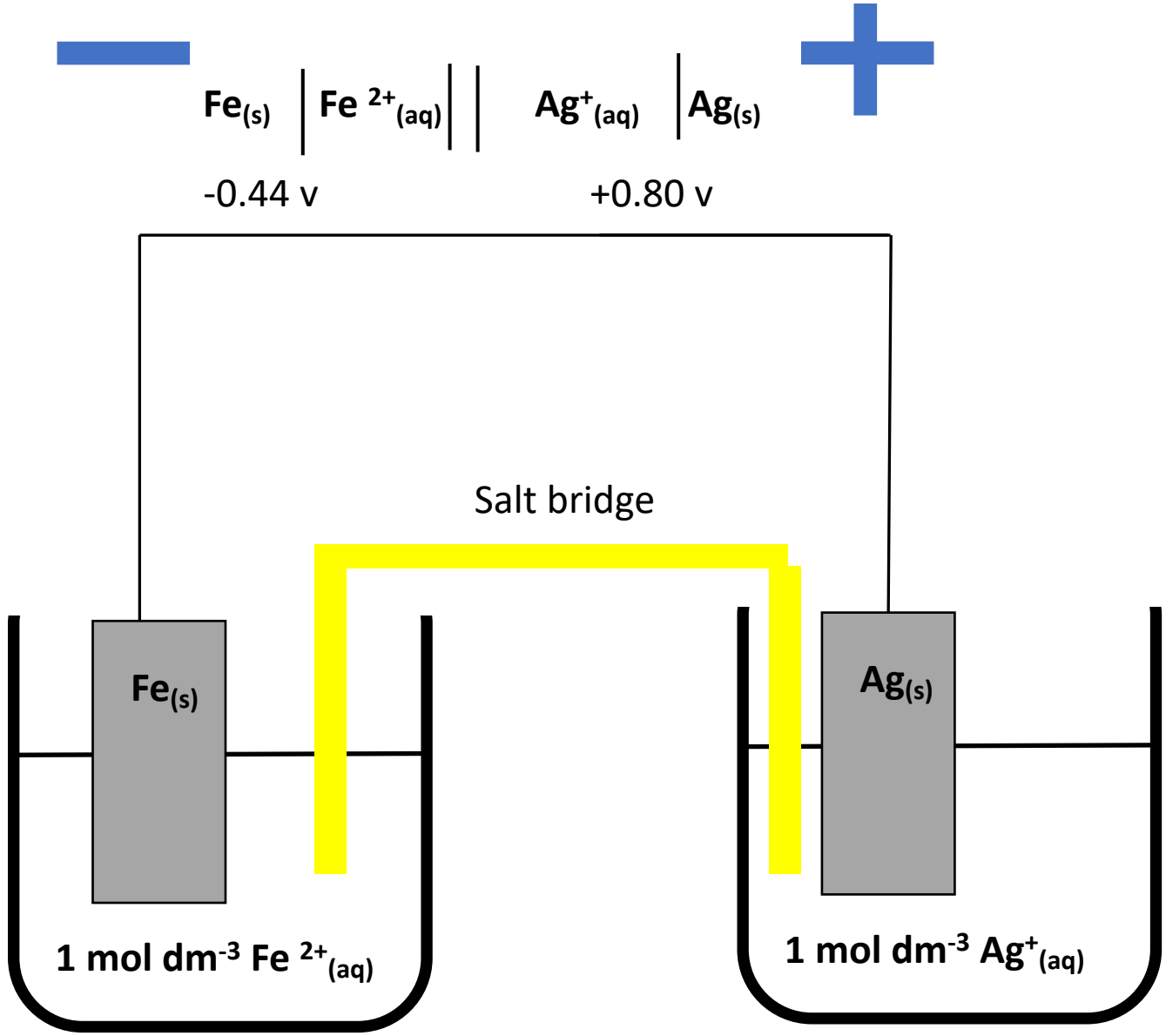
Making batteries



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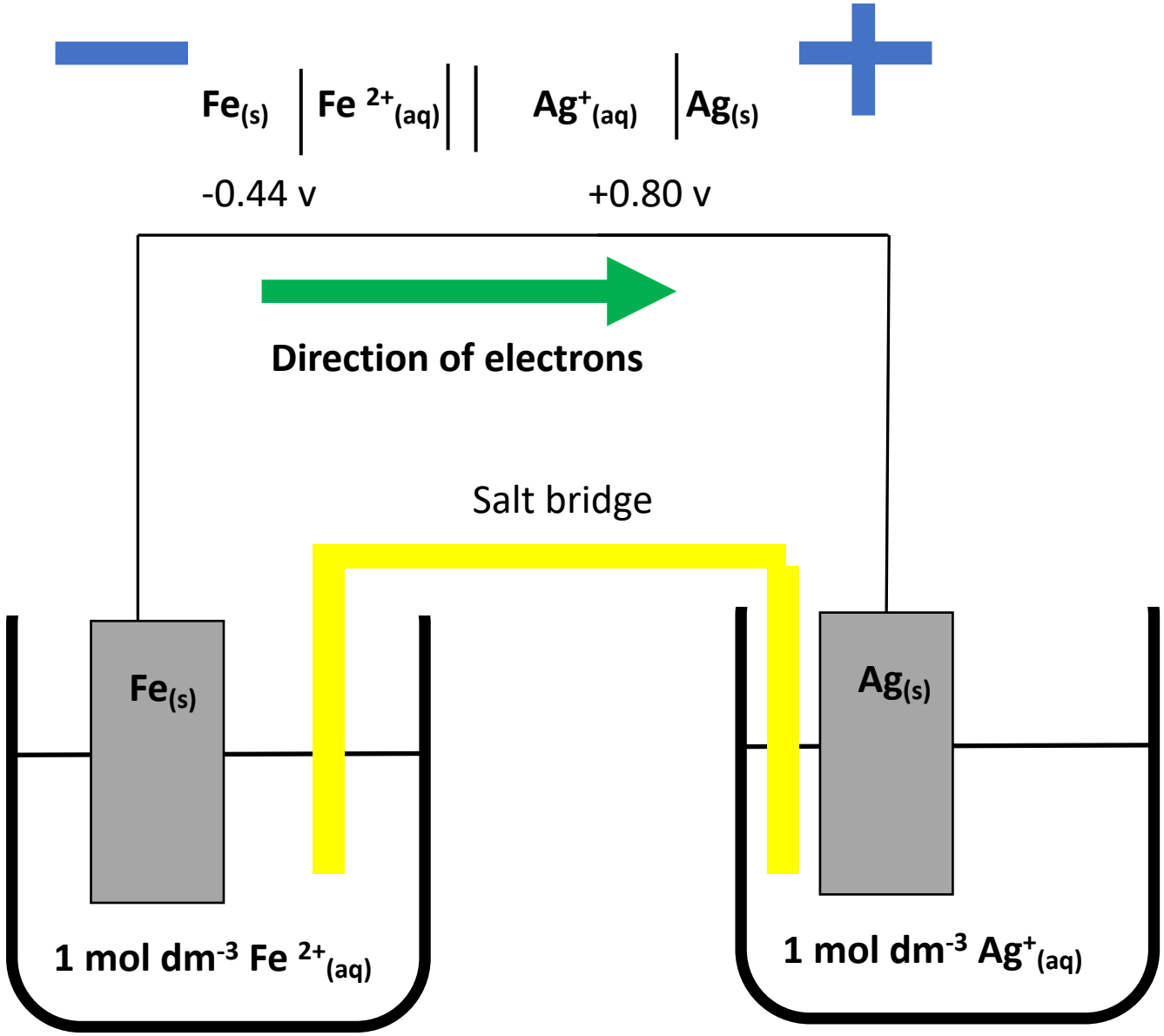
Making batteries



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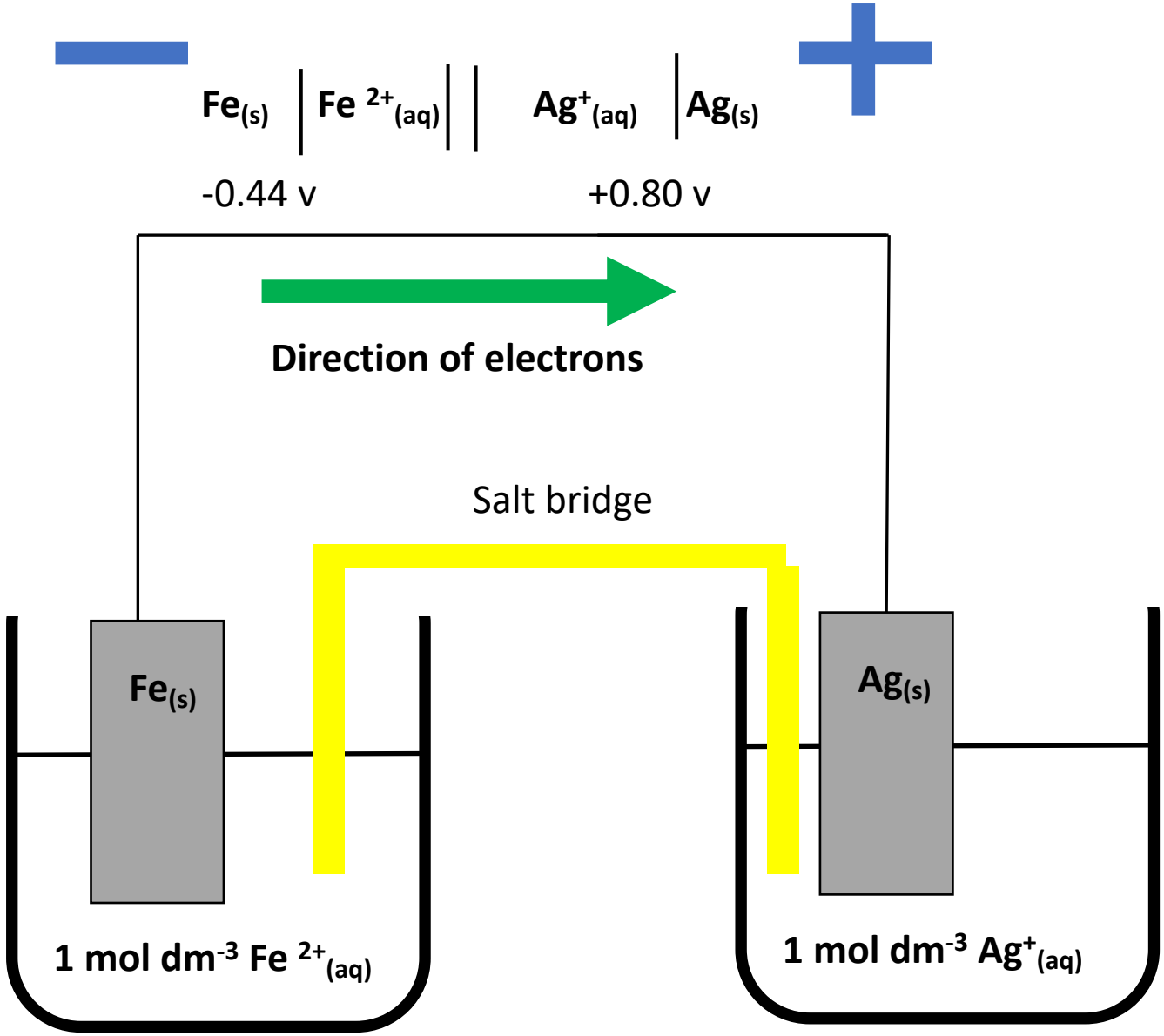
We have created a 1.24 v battery



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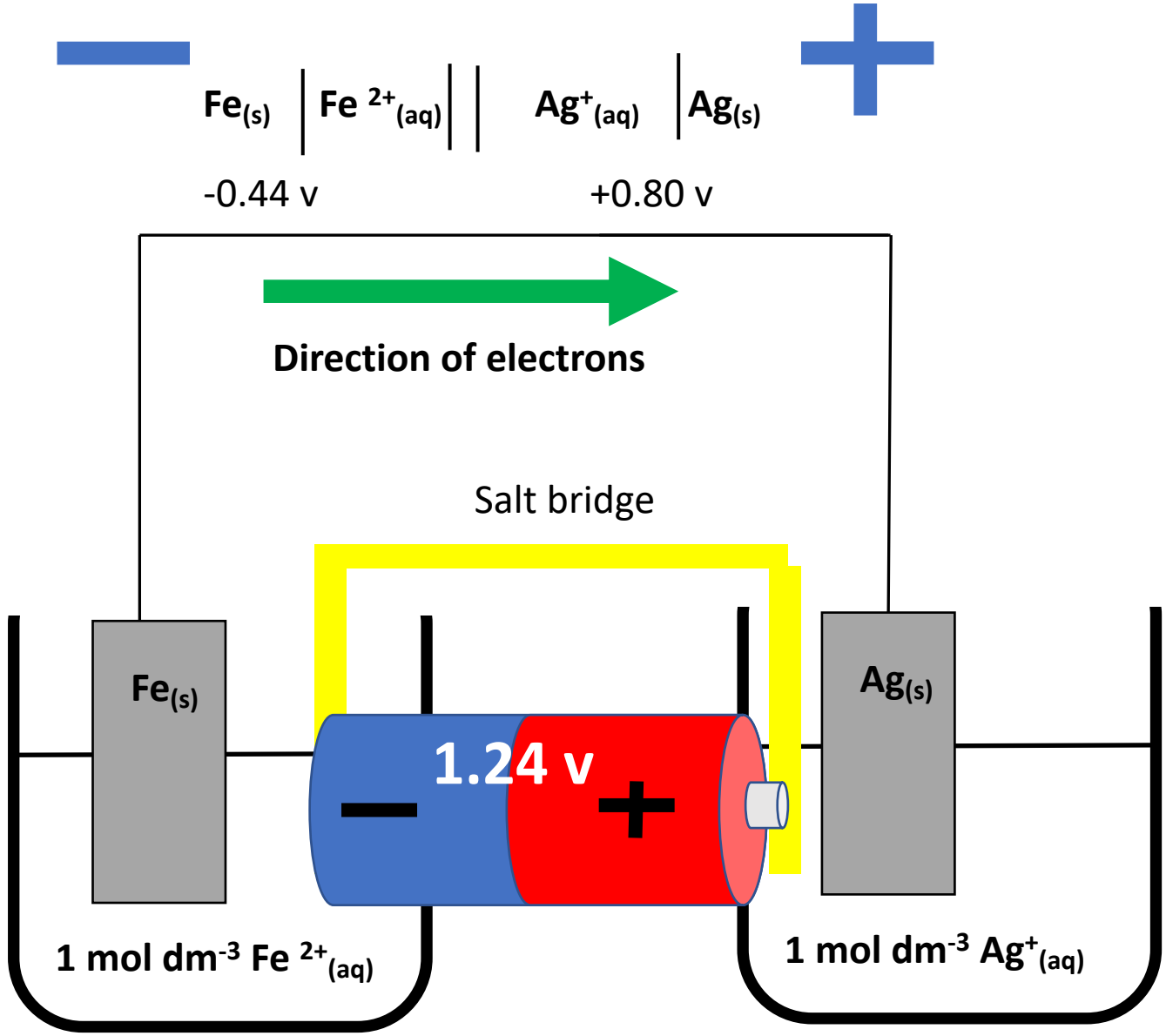

Online Teaching and Learning Resources for Chemistry Students

ChemistryTuition.Net