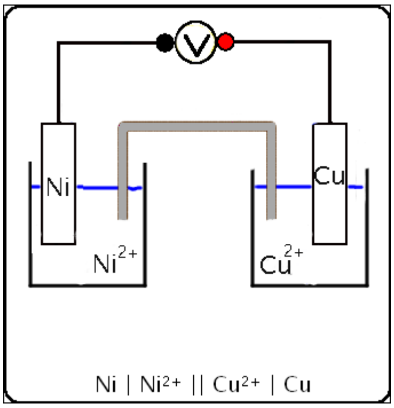
Writing Cell Diagrams

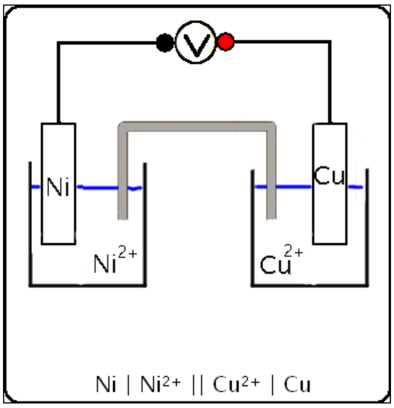


1. Representing the electrochemical cell
   a. Examples
      i. Ni | Ni^{2+} || Cu^{2+} | Cu
      ii. Fe | Fe^{2+} || V^{3+}, V^{2+} | Pt
      iii. Cu | Cu^{2+} || H^+, H_2 | Pt
      iv. Pt | H_2, H^+ || Cl_2, Cl^- | Pt
   b. Conclusions
      i. salt bridge (||), change of state (|), use of ...| Pt
      ii. RED | OX || OX | RED
      iii. standard electrode potentials
      iv. balancing electrons
2. More complicated half-equations written as half-cells
   a. Examples
      i. $O_2 + 2H_2O + 4e^- \rightleftharpoons 4OH^-$
      ii. $2H_2O + 2e^- \rightleftharpoons 2OH^- + H_2$
      iii. $MnO_4^{2-} + 2H_2O + 2e^- \rightleftharpoons MnO_2 + 4OH^-$
      iv. $VO^{2+} + 2H^+ + e^- \rightleftharpoons V^{3+} + H_2O$
   b. Conclusions
      i. use of [ ]
      ii. use of ,
3. Cell diagram for which E_{cell} is +ve
   a. Which is the right-hand electrode if E_{cell} is +ve?
   b. Example: Hydrogen-oxygen fuel cell
   c. Assessment:

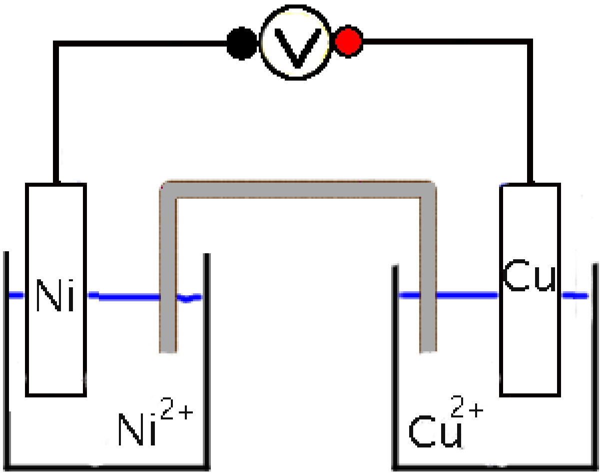
      $IO^-(aq) + H_2O(l) \rightleftharpoons I^-(aq) + 2OH^-(aq)$ $E^o = +0.49V$

      $CrO_4^{2-}(aq) + 4H_2O(l) \rightleftharpoons Cr(OH)_3(s) + 5OH^-(aq)$ $E^o = -0.13V$

Writing Cell Diagrams



1. Representing the electrochemical cell
    a. Examples
        i. Ni | Ni^{2+} || Cu^{2+} | Cu
        ii. Fe | Fe^{2+} || V^{3+}, V^{2+} | Pt
        iii. Cu | Cu^{2+} || H^{+}, H_2 | Pt
        iv. Pt | H_2, H^{+} || Cl_2, Cl^{-} | Pt
    b. Conclusions
        i. salt bridge (||), change of state (|), ...| Pt
        ii. RED | OX || OX | RED
        iii. standard electrode potentials
        iv. balancing electrons
2. More complicated half-equations written as half-cells
3. Cell diagram for which E_{cell} is +ve



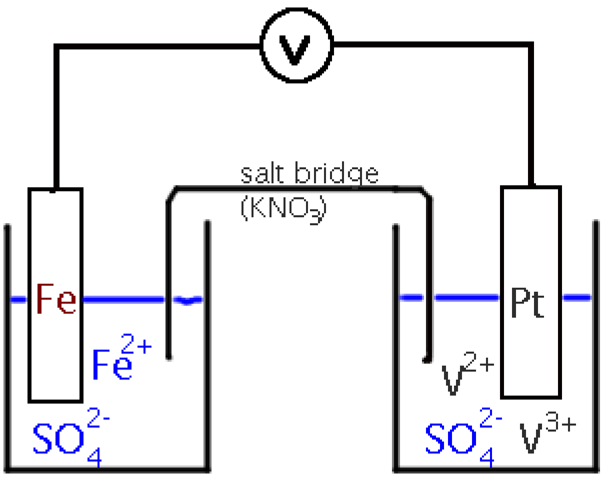
Ni | Ni^{2+} || Cu^{2+} | Cu

metal

metal ion

metal ion

metal



Fe | Fe^{2+} || V^{3+}, V^{2+} | Pt

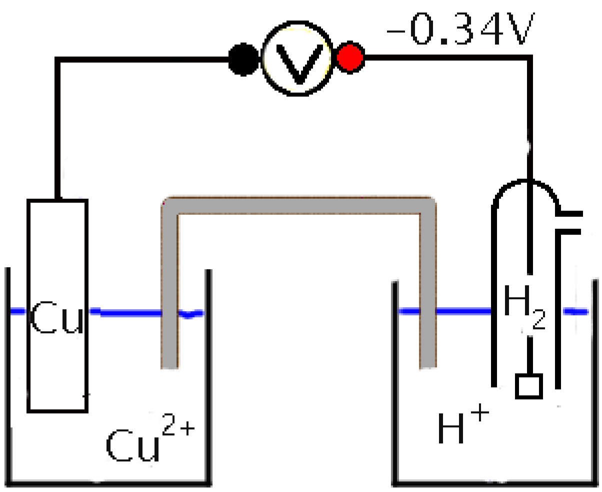
RED

OX

OX

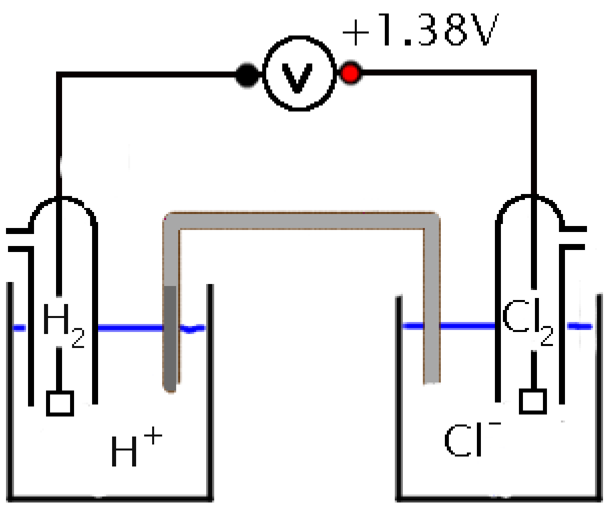
RED

watch a video tutorial about this at www.chemistry.jamesmungall.co.uk



Cu | Cu^{2+} || $2H^+$, H_2 | Pt

RED OX OX RED



Pt | H_2, $2H^+$ || ½ Cl_2, Cl^- | Pt

RED OX OX RED

watch a video tutorial about this at www.chemistry.jamesmungall.co.uk

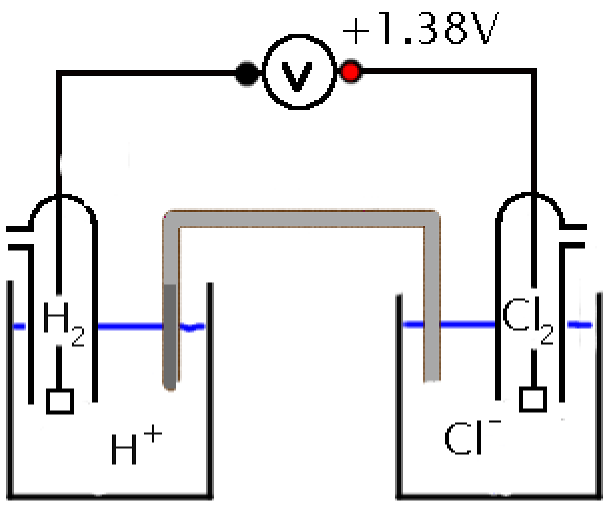
Conclusions

i. salt bridge (||), change of state (|), use of ...| Pt

ii. RED | OX || OX | RED

iii. standard electrode potentials

iv. balancing atoms and electrons



Pt | H_2, $2H^+$ || ½ Cl_2, Cl^- | Pt

Writing Cell Diagrams

1. Representing the electrochemical cell
2. More complicated half-equations written as half-cells
    a. Examples
        i. $O_2 + 2H_2O + 4e^- \rightleftharpoons 4OH^-$
        ii. $2H_2O + 2e^- \rightleftharpoons 2OH^- + H_2$
        iii. $MnO_4^{2-} + 2H_2O + 2e^- \rightleftharpoons MnO_2 + 4OH^-$
        iv. $VO^{2+} + 2H^+ + e^- \rightleftharpoons V^{3+} + H_2O$
    b. Conclusions
        i. use of [ ]
        ii. use of ,
3. Cell diagram for which E_{cell} is +ve

$O_2(g) + 2H_2O(l) + 4e^- \rightleftharpoons 4OH^-(aq)$

OXIDISED SPECIES REDUCED SPECIES

$[O_2(g) + 2H_2O(l)],\ 4OH^-(aq)\ |\ Pt$

OX RED

AS A RIGHT−HAND HALF−CELL

$Pt\ |\ 4OH^-(aq),\ [O_2(g) + 2H_2O(l)]$

RED OX

AS A LEFT−HAND HALF−CELL

$2H_2O(l) + 2e^- \rightleftharpoons 2OH^-(aq) + H_2(g)$

OXIDISED SPECIES REDUCED SPECIES

$2H_2O(l),\ [2OH^-(aq) + H_2(g)]\ |\ Pt$

OX RED

AS A RIGHT−HAND HALF−CELL

$Pt\ |\ [2OH^-(aq) + H_2(g)],\ 2H_2O$

RED OX

AS A LEFT−HAND HALF−CELL

$$MnO_4^{2-} + 2H_2O + 2e^- \rightleftharpoons MnO_2 + 4OH^-$$

OXIDISED SPECIES REDUCED SPECIES

$$[MnO_4^{2-} + 2H_2O],\ [MnO_2 + 4OH^-] | \ Pt$$

OX RED

AS A RIGHT−HAND HALF−CELL

$$Pt \ | \ [MnO_2 + 4OH^-],\ [MnO_4^{2-} + 2H_2O]$$

RED OX

AS A LEFT−HAND HALF−CELL

$$VO^{2+} + 2H^+ + e^- \rightleftharpoons V^{3+} + H_2O$$

OXIDISED SPECIES REDUCED SPECIES

$$[VO^{2+} + 2H^+],\ [V^{3+} + H_2O] | \ Pt$$

OX RED

AS A RIGHT−HAND HALF−CELL

$$Pt \ | [V^{3+} + H_2O],\ [VO^{2+} + 2H^+]$$

RED OX

AS A LEFT−HAND HALF−CELL

watch a video tutorial about this at www.chemistry.jamesmungall.co.uk

Conclusion: Use of [ ] and ,

$$A(g) + B(l) + e^- \rightleftharpoons C(aq)$$

OXIDISED SPECIES REDUCED SPECIES

LH ELECTRODE

Pt | C(aq), [A(g) + B(l)]

RED OX

RH ELECTRODE

[A(g) + B(l)], C(aq) | Pt

OX RED

Writing Cell Diagrams

1. Representing the electrochemical cell
2. More complicated half-equations written as half-cells
3. Cell diagram for which E_{cell} is +ve
    a. Which is the right-hand electrode if E_{cell} is +ve?
    b. Example: Hydrogen-oxygen fuel cell
    c. Assessment:

$IO^-(aq) + H_2O(l) \rightleftharpoons I^-(aq) + 2OH^-(aq)$ E^o = +0.49V

$CrO_4^{2-}(aq) + 4H_2O(l) \rightleftharpoons Cr(OH)_3(s) + 5OH^-(aq)$ E^o = −0.13V

Which is the right-hand electrode if E_{cell} is +ve?

the more **Positive** electrode will proceed in the **Forward** direction

this is **Reduction** and goes on the **Right** in the cell diagram

Example: Hydrogen-oxygen fuel cell

$O_2(g) + 2H_2O(l) + 4e^- \rightleftharpoons 4OH^-(aq)$ +0.40V

OXIDISED SPECIES | REDUCED SPECIES

$2H_2O(l) + 2e^- \rightleftharpoons 2OH^-(aq) + H_2(g)$ -0.83V

OXIDISED SPECIES | REDUCED SPECIES

the more **Positive** electrode will proceed in the **Forward** direction

this is **Reduction** and goes on the **Right** in the cell diagram

LHS (-0.83V) RHS (+0.40V)

$Pt|\ [2OH^-(aq) + H_2(g)],\ 2H_2O(l)\ ||[O_2(g) + 2H_2O(l)],\ 4OH^-(aq)|\ Pt$

RED OX OX RED

watch a video tutorial about this at www.chemistry.jamesmungall.co.uk

Assessment

What would the cell diagram be for the cell with e.m.f. +0.62V which would occur if these two half cells were joined under standard conditions?

$IO^-(aq) + H_2O(l) \rightleftharpoons I^-(aq) + 2OH^-(aq)$ $E^o = +0.49V$

$CrO_4^{2-}(aq) + 4H_2O(l) \rightleftharpoons Cr(OH)_3(s) + 5OH^-(aq)$ $E^o = -0.13V$

A Pt | $[CrO_4^{2-}(aq) + 4H_2O(l)], [Cr(OH)_3(s) + 5OH^-(aq)]$ || $[I^-(aq) + 2OH^-(aq)], [IO^-(aq) + H_2O(l)]$ | Pt

B Pt | $[CrO_4^{2-}(aq) + 4H_2O(l)], [Cr(OH)_3(s) + 5OH^-(aq)]$ || $[IO^-(aq) + H_2O(l)], [I^-(aq) + 2OH^-(aq)]$ | Pt

C Pt | $[Cr(OH)_3(s) + 5OH^-(aq)], [CrO_4^{2-}(aq) + 4H_2O(l)]$ || $[I^-(aq) + 2OH^-(aq)], [IO^-(aq) + H_2O(l)]$ | Pt

D Pt | $[Cr(OH)_3(s) + 5OH^-(aq)], [CrO_4^{2-}(aq) + 4H_2O(l)]$ || $[IO^-(aq) + H_2O(l)], [I^-(aq) + 2OH^-(aq)]$ | Pt

ANSWER: D