Balancing redox reactions

- **Introduction**

- **Balancing redox reaction (acid pH)**

  Example: $Cl^- + MnO_4^- \rightarrow Mn^{2+} + Cl_2$ **(acid pH)**

- **Balancing redox reactions (basic pH)**

  Example: $CrO_4^{2-} + Fe^{2+} \rightarrow Cr^{3+} + Fe^{3+}$ **(basic pH)**

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Redox reactions

- **Oxidation and reduction can't happen one without the other**

One of the chemicals will lose e^- (oxidation)

Another one will gain them (reduction)

OIL RIG: Oxidation is loss (of e^-), reduction is gain (of e^-)

In a redox reaction there is a transfer of e^- from one reactant to another

Redox reactions

- **Oxidation numbers can be used to recognise redox reactions**

$2Na + Cl_2 \rightarrow 2NaCl$

Na: 0 Cl: 0 → Na:+1 Cl: -1 (REDOX)

$NaOH + HCl \rightarrow NaCl + H_2O$

Na: -1 O: -2 H: +1 Cl: -1 → Na: -1 O: -2 H: +1 Cl: -1 (NON REDOX)

OXIDATION: loss of e^- **REDUCTION: gain of e^-**

OXIDISING AGENT: substance reduced

REDUCING AGENT: substance oxidised

Balancing redox equations (pH acid)

$$Cl^- + MnO_4^- \rightarrow Mn^{2+} + Cl_2$$

1. **Identify the atoms that are oxidised and reduced, using ox. no.**
2. **Write the half-reactions for oxidation and reduction processes**
3. **Balance mass, so that the number of atoms of each element oxidised/reduced is the same on both sides**

   If there is any O atoms present, balance them adding H_2O

   If there is H atoms present, balance them adding H^+

6. **Balance charges with e^-**
7. **Multiply the half-equations so that the number of e^- lost in one equation is equal to the e^- gained in the other**
8. **Add the two half-equation together and cancel out any substances that appear on both side**

$Cl^- + MnO_4^- \rightarrow Mn^{2+} + Cl_2$ (acid medium)

1. Identify atoms oxidised and reduced, using ox. no.

   Cl : -1 Mn : +7 O: -2 → Mn^{2+}: +2 Cl: 0

   Cl oxidises (goes from -1 to 0) Mn reduces (from +7 to +2)

2-4. Write the half-reactions. Balance mass, if necessary using H_2O (to add O) and/or H^+ (to add H)

   $2Cl^- \rightarrow Cl_2$ Oxidation (reducing agent)

   $8H^+ + MnO_4^- \rightarrow Mn^{2+} + 4H_2O$ Reduction (oxidising agent)

7. Balance the charges using electrons (e^-). Each e- adds a -1

   $2Cl^- \rightarrow Cl_2 + 2e^-$ -2 = 0 -2

   $8H^+ + MnO_4^- + 5e^- \rightarrow Mn^{2+} + 4H_2O$ +8 -1 -5 = +2 +0

$Cl^- + MnO_4^- \rightarrow Mn^{2+} + Cl_2$ (acid medium)

1. **Multiply the half-equations so e- lost in one = e- gained in the other**

$5x(2Cl^- \rightarrow Cl_2 + 2e^-)$

$2x(8H^+ + MnO_4^- + 5e^- \rightarrow Mn_2^+ + 4H_2O)$

4. **Add the two half-equation together and cancel out any substances that appear on both sides**

$$10Cl^- \rightarrow 5Cl_2 + 10e^-$$

$$+ \quad 16H^+ + 2MnO_4^- + 10e^- \rightarrow 2Mn^{2+} + 8H_2O)$$

$$10Cl^- + 16H^+ + 2MnO_4^- + \cancel{10e^-} \rightarrow 5Cl_2 + \cancel{10e^-} + 2Mn^{2+} + 8H_2O$$

Answer: $10Cl^- + 16H^+ + 2MnO_4^- \rightarrow 5Cl_2 + 2Mn^{2+} + 8H_2O$

There should be the same number/type of atoms in both sides. IF THAT'S NOT THE CASE, YOU'VE DONE SOMETHING WRONG!!!

Balancing redox equations (pH basic)

$$CrO_4^{2-} + Fe^{2+} \rightarrow Cr^{3+} + Fe^{3+}$$

1. **Identify the atoms that are oxidised and reduced, using ox. no.**
2. **Write the half reactions for oxidation and reduction processes**
3. **Balance mass, so that the number of atoms of each element oxidised/reduced is the same on both sides**

   If there is any O atoms present, balance them adding OH^- (double the number necessary)

   If there is H atoms present, balance them adding H_2O

6. **Balance charges with e^-**
7. **Multiply the half-equations so that the number of e^- lost in one equation is equal to the e^- gained in the other**
8. **Add the two half-equation together,cancel out any substances that appear on both side.**

$CrO_4^{2-} + Fe^{2+} \rightarrow Cr^{3+} + Fe^{3+}$ (basic pH)

1. **Identify the atoms oxidised and reduced, using ox. no.**

   Fe : +2 Cr : +6 O: -2 → Cr^{3+}: +3 Fe^{3+}: +3

   Fe oxidises (goes from +2 to +3) Cr reduces (goes from +6 to +3)

2-4. **Write the half-reactions. Balance mass, if necessary using OH^- (to add O, double the number needed) and/or H_2O (to add H)**

   $Fe^{2+} \rightarrow Fe^{3+}$ Oxidation (reducing agent)

   $4H_2O + CrO_4^{-2} \rightarrow Cr^{3+} + 8OH^-$ Reduction (oxidising agent)

7. **Balance the charges using electrons (e^-). Each e- adds a -1**

   $Fe^{2+} \rightarrow Fe^{3+} + 1\ e^-$ (+2 = +3 – 1)

   $4H_2O + CrO_4^{-2} + 3\ e^- \rightarrow Cr^{3+} + 8OH^-$ (0 -2 -3 = +3 -8)

$CrO_4^{2-} + Fe^{2+} \rightarrow Cr^{3+} + Fe^{3+}$

1. **Multiply the half-equations so that e- lost in one = e- gained in the other**

   $3x(Fe^{2+} \rightarrow Fe^{3+} + 1e^-)$

   $1x(4H_2O + CrO_4^{-2} + 3e^- \rightarrow Cr^{3+} + 8OH^-)$

4. **Add the two half-equation together and cancel out any substances that appear on both side**

$$3Fe^{2+} \rightarrow 3Fe^{3+} + 3e^-$$

$$+$$

$$4H_2O + CrO_4^{-2} + 3e^- \rightarrow Cr^{3+} + 8OH^-$$

$$3Fe^{2+} + 4H_2O + CrO_4^{-2} + \cancel{3e^-} \rightarrow 3Fe^{3+} + \cancel{3e^-} + Cr^{3+} + 8OH^-$$

Check there is the same number/type of atoms in both sides of the equation. IF THAT'S NOT THE CASE, YOU'VE DONE SOMETHING WRONG!!!