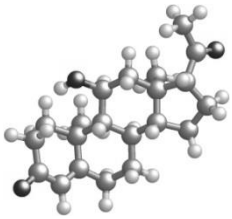


Chem!stry

Name: …… **( )**

Class: ……

Date: …… **/** …… **/** ……

Oxidation and Reduction – Redox Reactions – Macroconcept: Change – Answers

Activity 1:

Oxidation is the addition of *oxygen* to a substance or the removal of *hydrogen* from a substance.

Reduction is the addition of *hydrogen* to a substance or the removal of *oxygen* from a substance.

Activity 2:

Fe has *lost oxygen* and is therefore *reduced*.

$$Fe_2O_3(s) + 3CO(g) \rightarrow 2Fe(s) + 3CO_2(g)$$

C has *gained oxygen* and is therefore *oxidised*.

C has *lost hydrogen* and is therefore *oxidised*.

$$C_2H_6(g) \rightarrow C_2H_4(g) + H_2(g)$$

Cu has *lost oxygen* and is therefore *reduced*.

$$CuO(s) + H_2(g) \rightarrow Cu(s) + H_2O(l)$$

H has *gained oxygen* and is therefore *oxidised*.

C has *gained hydrogen* and is therefore *reduced*.

$$C_6H_6(l) + 3H_2(g) \rightarrow C_6H_{12}(l)$$

Activity 3:

This is up to you. Make sure that you know the answers to your own questions!

Activity 4:

Oxidation is the *removal* of *electrons* from a substance.

Reduction is the *addition* of *electrons* to a substance.

There is a simple mnemonic to help you remember this: ***OIL RIG***

O*xidation* ***I****s* ***L****oss* (of *electrons*).

R*eduction* ***I****s* ***G****ain* (of *electrons*).

Activity 5:

$2Mg(s) + O_2(g) \rightarrow 2MgO(s)$

becomes:

$2Mg(s) \rightarrow 2Mg^{2+}(s) + 4e^-$ The magnesium has *lost electrons* and is therefore *oxidised*.

$O_2(g) + 4e^- \rightarrow 2O^{2-}(s)$ The oxygen has *gained electrons* and is therefore *reduced*.

$CuSO_4(aq) + Zn(s) \rightarrow Cu(s) + ZnSO_4(aq)$

becomes:

$Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$ The copper has *gained electrons* and is therefore *reduced*.

$Zn(s) \rightarrow Zn^{2+}(aq) + 2e^-$ The zinc has *lost electrons* and is therefore *oxidised*.

Note: the sulfate ion SO_4^{2-} is chemically unchanged by the reaction and therefore not included in either of the ionic half-equations. The sulfate ion is said to be a *spectator ion*.

Activity 6:

This is also up to you. Once again, make sure that you know the answers to your own questions!

Activity 7:

Oxidation is an *increase* in oxidation state or oxidation state.

Reduction is a *decrease* in oxidation state or oxidation state.

Activity 8:

O$_2$ This is elemental oxygen, so the oxidation state of ***O* = 0**

ZnO Zn + O = 0 so Zn + (–2) = 0 so ***Zn* = +2**

NO_2 N + (2 × O) = 0 so N + (2 × –2) = 0 so N + (–4) = 0 so ***N* = +4**

CO_3^{2-} C + (3 × O) = –2 so C + (3 × –2) = –2 so C + (–6) = –2 so ***C* = +4**

Cu^{2+} ***Cu* = +2**

V$_2O_5$ (2 × V) + (5 × O) = 0 so (2 × V) + (5 × –2) = 0 so (2 × V) + (–10) = 0

so (2 × V) = +10 so V = +10 ÷ 2 so ***V* = +5**

Cr$_2O_7^{2-}$ (2 × Cr) + (7 × O) = –2 so (2 × Cr) + (7 × –2) = –2 so (2 × Cr) + (–14) = –2

so (2 × Cr) = +12 so Cr = +12 ÷ 2 so ***Cr* = +6**

FeCl_3 Fe + (3 × C*l*) = 0 so Fe + (3 × –1) = 0 so Fe + (–3) = 0 so ***Fe* = +3**

SO_2 S + (2 × O) = 0 so S + (2 × –2) = 0 so S + (–4) = 0 so ***S* = +4**

$\mathbf{S}O_3$ S + (3 × O) = 0 so S + (3 × –2) = 0 so S + (–6) = 0 so **S = +6**

$H_2\mathbf{S}$ S + (2 × H) = 0 so S + (2 × +1) = 0 so S + (+2) = 0 so **S = –2**

$\mathbf{Cr}O_4^{2-}$ Cr + (4 × O) = –2 so Cr + (4 × –2) = –2 so Cr + (–8) = –2 so **Cr = +6**

$\mathbf{S}O_3^{2-}$ S + (3 × O) = –2 so S + (3 × –2) = –2 so S + (–6) = –2 so **S = +4**

$\mathbf{I}O_4^-$ I + (4 × O) = –1 so I + (4 × –2) = –1 so I + (–8) = –1 so **I = +7**

$\mathbf{P}O_4^{3-}$ P + (4 × O) = –3 so P + (4 × –2) = –3 so P + (–8) = –3 so **P = +5**

$H\mathbf{N}O_3$ N + H + (3 × O) = 0 so N + (+1) + (3 × –2) = 0 so N + (+1) + (–6) = 0 so **N = +5**

Activity 9:

a) $\mathbf{Fe}_2O_3(s) + 3\mathbf{C}O(g) \rightarrow 2\mathbf{Fe}(s) + 3\mathbf{C}O_2(g)$

The iron changes its oxidation state from +3 to 0 and is therefore *reduced*.

The carbon changes its oxidation state from +2 to +4 and is therefore *oxidised*.

b) $\mathbf{Mg}(s) + \mathbf{H}_2SO_4(aq) \rightarrow \mathbf{Mg}SO_4(aq) + \mathbf{H}_2(g)$

The magnesium changes its oxidation state from 0 to +2 and is therefore *oxidised*.

The hydrogen changes its oxidation state from +1 to 0 and is therefore *reduced*.

c) $\mathbf{Zn}(s) + \mathbf{Cu}SO_4(aq) \rightarrow \mathbf{Zn}SO_4(aq) + \mathbf{Cu}(s)$

The zinc changes oxidation state from 0 to +2 and is therefore *oxidised*.

The copper changes its oxidation state from +2 to 0 and is therefore *reduced*.

d) $\mathbf{Mn}O_2(s) + 4HCl(aq) \rightarrow \mathbf{Mn}Cl_2(aq) + 2H_2O(l) + Cl_2(g)$

The manganese changes oxidation state from +4 to +2 and is therefore *reduced*.

e) $\mathbf{Cr}_2O_7^{2-}(aq) + 14H^+(aq) + 6e^- \rightarrow 2\mathbf{Cr}^{3+}(aq) + 7H_2O(l)$

The chromium changes oxidation state from +6 to +3 and is therefore *reduced*.

f) $2\mathbf{S}_2O_3^{2-}(aq) + I_2(aq) \rightarrow \mathbf{S}_4O_6^{2-}(aq) + 2I^-(aq)$

The sulfur changes its oxidation state from +2 to +2.5 and so it is *oxidised*.

g) $5\mathbf{Fe}^{2+}(aq) + \mathbf{Mn}O_4^-(aq) + 8H^+(aq) \rightarrow 5\mathbf{Fe}^{3+}(aq) + \mathbf{Mn}^{2+}(aq) + 4H_2O(l)$

The iron changes its oxidation state from +2 to +3 and is therefore *oxidised*.

The manganese changes its oxidation state from +7 to +2 and is therefore *reduced*.

h) $Na_2\mathbf{S}_2O_3(aq) + 2HCl(aq) \rightarrow 2NaCl(aq) + \mathbf{S}O_2(g) + \mathbf{S}(s) + H_2O(l)$

The sulfur changes its oxidation states from +2 to +4 (SO_2) and 0 (S) and so it is both *oxidised* and *reduced*.

Activity 10:

$MnO_4^-(aq) + 8H^+(aq) + 5e^- \rightarrow Mn^{2+}(aq) + 4H_2O(l)$

The manganate(VII) ion is gaining electrons. These electrons have been removed from another chemical which has consequently been oxidised. The manganate(VII) ion is therefore behaving as an oxidising agent by removing electrons from another chemical.

Activity 11:

$MnO_4^-(aq) + 8H^+(aq) + 5e^- \rightarrow Mn^{2+}(aq) + 4H_2O(l)$

The manganese changes its oxidation state from +7 to +2 and is therefore *reduced*.

An oxidising agent will oxidise another chemical by removing electrons from it, causing the other chemical's oxidation state to increase.

The oxidising agent itself is *reduced* because it *gains electrons* and consequently its *oxidation state decreases*.

Activity 12:

The following ionic half-equations need to be combined together:

$$Cr_2O_7^{2-}(aq) + 14H^+(aq) + 6e^- \rightarrow 2Cr^{3+}(aq) + 7H_2O(l) \qquad \text{Equation 4.}$$

$$Fe^{2+}(aq) \rightarrow Fe^{3+}(aq) + e^- \qquad \text{Equation 5.}$$

Equation 5 must be multiplied by 6 because Equation 4 requires 6 moles of electrons, but Equation 5 only provides 1 mole of electrons.

$Fe^{2+}(aq) - e^- \rightarrow Fe^{3+}(aq)$ multiplied by 6 becomes:

$$6Fe^{2+}(aq) \rightarrow 6Fe^{3+}(aq) + 6e^- \qquad \text{Equation 6.}$$

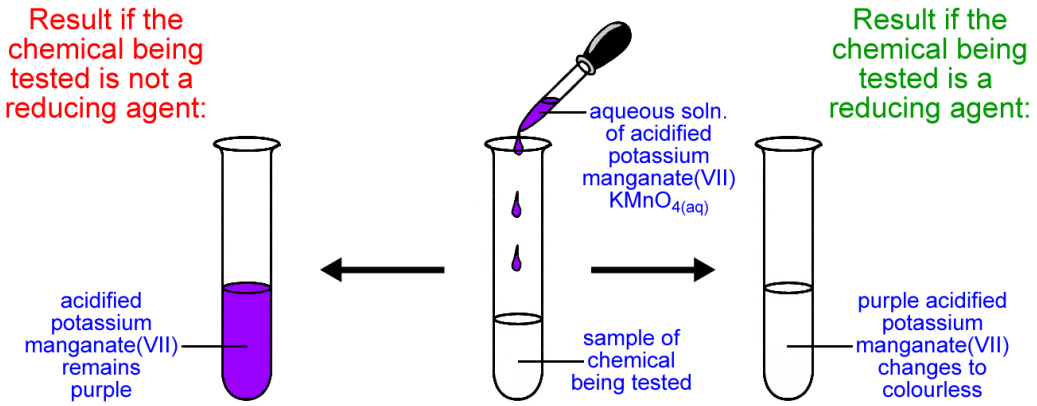
Combining together ionic half-equations (4) and (6) gives:

$$Cr_2O_7^{2-}(aq) + 14H^+(aq) + 6e^- + 6Fe^{2+}(aq) \rightarrow 2Cr^{3+}(aq) + 7H_2O(l) + 6Fe^{3+}(aq) + 6e^-$$

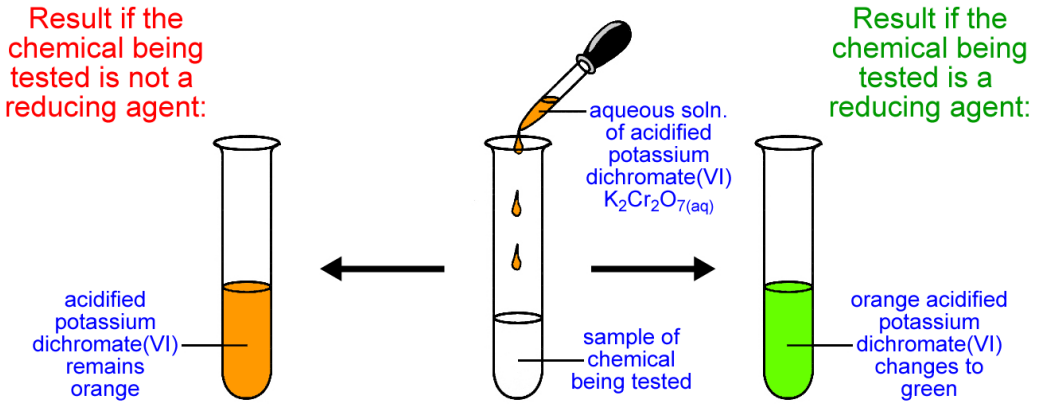
Cancelling out the $6e^-$ on either side of the equation gives:

$$Cr_2O_7^{2-}(aq) + 14H^+(aq) + 6Fe^{2+}(aq) \rightarrow 2Cr^{3+}(aq) + 7H_2O(l) + 6Fe^{3+}(aq)$$

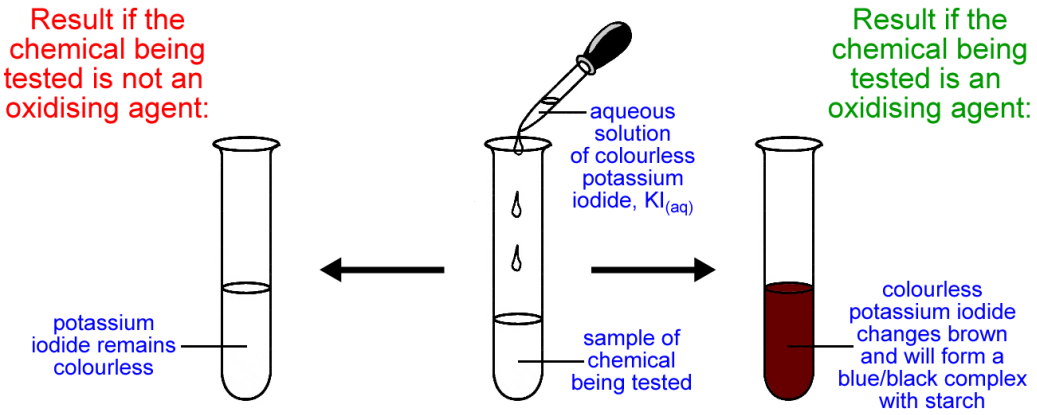
Activity 13:



Activity 14:



Activity 15:



Activity 16 (Enrichment):

$2H_2O_2(l) \rightarrow 2H_2O(l) + O_2(g)$

The oxygen changes its oxidation state from –1 (oxygen has an oxidation state of –1 in peroxides) to –2 (H_2O) and 0 (O_2). The oxidation state of the oxygen has both *decreased* ($-1 \rightarrow -2$) and *increased* ($-1 \rightarrow 0$), and so the oxygen has both been *reduced* and *oxidised*.

Activity 17 (Enrichment):

$Cu_2O(s) + H_2SO_4(aq) \rightarrow Cu(s) + CuSO_4(aq) + H_2O(l)$

The copper changes its oxidation state from +1 (Cu_2O) to 0 (Cu) and +2 ($CuSO_4$). The oxidation state of the copper has both *decreased* (+1 → 0) and *increased* (+1 → +2), and so the copper has both been *reduced* and *oxidised*.

Activity 18 (Enrichment):

A disproportionation reaction is a chemical reaction in which the same element is both oxidised and reduced.

Activity 19 (Enrichment):

$$C_6H_8O_6 \rightarrow C_6H_6O_6 + 2H^+ + 2e^-$$

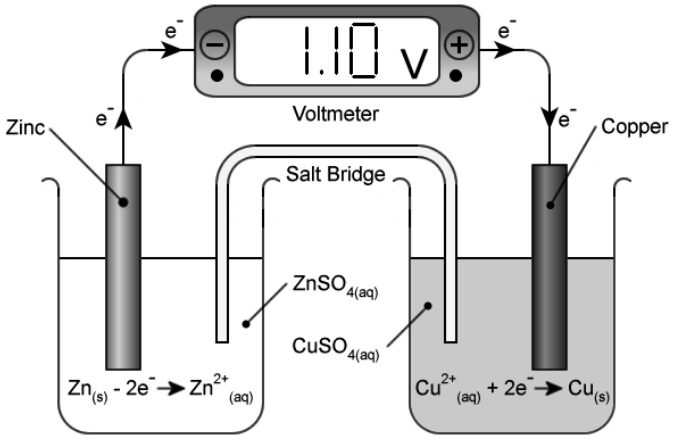
Activity 20 (Enrichment):

$$Zn(s) \rightarrow Zn^{2+}(aq) + 2e^-$$

$$Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$$

Activity 21 (Enrichment):

From the answer to **Activity Seventeen** it can be seen that there is transfer of electrons from the zinc to the copper. The zinc is oxidised and the copper is reduced. If the chemical reaction for the zinc and the chemical reaction for the copper are isolated from each other in two separate beakers, then the electrons that are transferred from the zinc to the copper must pass from one half of the reaction to the other through electrical wires. This results in the formation of a simple electrochemical cell or battery in which the zinc is the negative electrode and the copper is the positive electrode. The voltage of this particular battery is 1.10V.



Note: A simple salt bridge can be made by soaking a piece of filter paper in a saturated solution of potassium chloride. The function of the salt bridge is to complete the ionic circuit between the reactions that are taking place in the two beakers.