Lesson 3 – an overall redox reaction from two half reactions (oxidation and reduction half reactions).

An overall balanced redox equation must balance for elements and charge. Electrons do not appear in an overall reaction. Number of electrons produced in oxidation equals the number of electrons used in reduction.

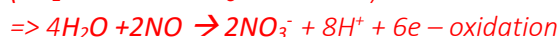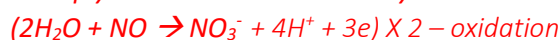Derive the balanced overall equation given the two conjugate pairs. (Make sure electrons balance)

Eg. $Cr_2O_7^{2-}$ (aq)/ Cr^{3+} (aq) and NO(aq) / NO_3^-(aq)

Step 1 write the balanced oxidation and reduction half equations

$6e + 14H^+ + Cr_2O_7^{2-} \rightarrow 2Cr^{3+} + 7H_2O$ -- *reduction*

$2H_2O + NO \rightarrow NO_3^- + 4H^+ + 3e$ – *oxidation*
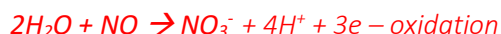
Step 2 Number of electrons produced in oxidation should equal the number of electrons used in reduction.

Multiply the oxidation reaction by 2
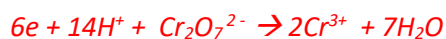
$(2H_2O + NO \rightarrow NO_3^- + 4H^+ + 3e) X 2$ – *oxidation*

$=> 4H_2O + 2NO \rightarrow 2NO_3^- + 8H^+ + 6e$ – *oxidation*

Step 3 Add the oxidation and reduction reactions

$4H_2O + 2NO \rightarrow 2NO_3^- + 8H^+ + 6e$

$+$

$6e + 14H^+ + Cr_2O_7^{2-} \rightarrow 2Cr^{3+} + 7H_2O$

$=> 6e + 14H^+ + Cr_2O_7^{2-} + 4H_2O + 2NO \rightarrow 2NO_3^- + 8H^+ + 6e + 2Cr^{3+} + 7H_2O$

Step 4 Eliminate electrons and species that appear on both sides.

$=> 6H^+(aq) + Cr_2O_7^{2-} (aq) + 2NO(aq) \rightarrow 2NO_3^-(aq) + 2Cr^{3+}(aq) + 3H_2O(l)$

a. MnO_4^-(aq) / MnO(s) and Cu(s) / Cu^{2+}(aq)

Step 1 write the balanced oxidation and reduction half equations

$3e + 6H^+(aq) + MnO_4^-(aq) \rightarrow MnO(s) + 3H_2O(l)$

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

Step 2 Balance for electrons

$(5e + 6H^+(aq) + MnO_4^-(aq) \rightarrow MnO(s) + 3H_2O(l)) X 2$

$(Cu(s) \rightarrow Cu^{2+}(aq) + 2e) X 5$

$10e + 12H^+(aq) + 2MnO_4^-(aq) \rightarrow 2MnO(s) + 6H_2O(l)$

$5Cu(s) \rightarrow 5Cu^{2+}(aq) + 10e$

Step 3 add the equations

$10e + 12H^+(aq) + 2MnO_4^-(aq) + 5Cu(s) \rightarrow 2MnO(s) + 6H_2O(l) + 5Cu^{2+}(aq) + 10e$

$=> 12H^+(aq) + 2MnO_4^-(aq) + 5Cu(s) \rightarrow 2MnO(s) + 6H_2O(l) + 5Cu^{2+}(aq)$
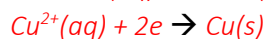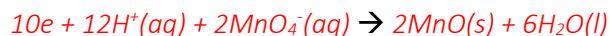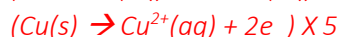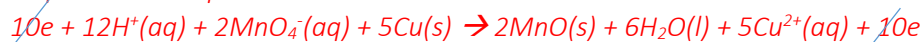
b. S(s) / H_2S(g) and Al(s) /Al^{3+}(aq)

step 1 Write the half equations

$2e + 2H^+(aq) + S (s) \rightarrow H_2S(g)$

$Al(s) \rightarrow Al^{3+}(aq) + 3e$

Step 2 Balance for electrons

$(2e + 2H^+(aq) + S (s) \rightarrow H_2S(g)) X 3$

$(Al(s) \rightarrow Al^{3+}(aq) + 3e) X 2$

Step 3 add the equations

$6e + 6H^+(aq) + 3S (s) \rightarrow 3H_2S(g)$

$2Al(s) \rightarrow 2Al^{3+}(aq) + 6e$

$2Al(s) + 6H^+(aq) + 3S(s) \rightarrow 3H_2S (g) + 2Al^{3+}(aq)$
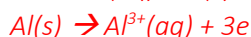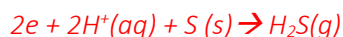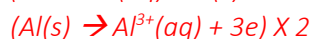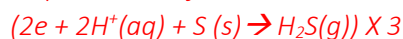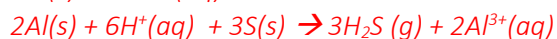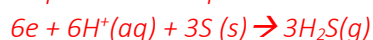
c. K(s)/K$^+$(aq) and Cl$_2$ (g)/Cl$^-$(aq)

step 1 Write the half equations

K(s) → K$^+$(aq) + e

Cl$_2$(g) +2e → 2Cl$^-$(aq)

Step 2 Balance for electrons

(K(s) → K$^+$(aq) + e) X 2

Cl$_2$(g) +2e → 2Cl$^-$(aq)

Step 3 add the equations

2K(s) → 2K$^+$(aq) + 2e

Cl$_2$(g) +2e → 2Cl$^-$(aq)

2K(s) +Cl$_2$(g) → 2K$^+$(aq) + 2Cl$^-$(aq)
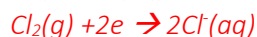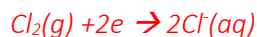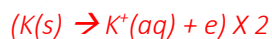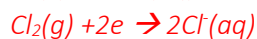
d. Cr$_2$O$_7^{2-}$(aq) / Cr^{3+}(aq) and CH$_3$OH (aq) / COOH(aq)

step 1 Write the half equations

6e + 14H$^+$(aq) + Cr$_2$O$_7^{2-}$(aq) → 2Cr^{3+}(aq) + 7H$_2$O(l)

H$_2$O(l) + CH$_3$OH (aq) → COOH(aq) + 5H$^+$(aq) + 5e

Step 2 Balance for electrons

(6e + 14H$^+$(aq) + Cr$_2$O$_7^{2-}$(aq) → 2Cr^{3+}(aq) + 7H$_2$O(l)) X 5

(H$_2$O(l) + CH$_3$OH (aq) → COOH(aq) + 5H$^+$(aq) + 5e) X 6

Step 3 add the equations

30e + 70H$^+$(aq) + 5Cr$_2$O$_7^{2-}$(aq) → 10Cr^{3+}(aq) + 35H$_2$O(l)

6H$_2$O(l) + 6CH$_3$OH (aq) → 6COOH(aq) + 30H$^+$(aq) + 30e

40H$^+$(aq) +5Cr$_2$O$_7^{2-}$(aq) + 6CH$_3$OH (aq) → 29H$_2$O(l) + 6COOH(aq) +10Cr^{3+}(aq)
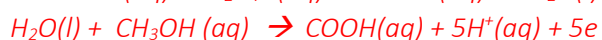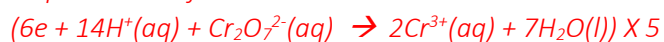
e. H$^+$(aq) /H$_2$(g) and Al(s) / Al^{3+}(aq)

step 1 Write the half equations

2H$^+$(aq) + 2e → H$_2$(g)

Al(s) → Al^{3+}(aq) + 3e

Step 2 Balance for electrons

(2H$^+$(aq) + 2e → H$_2$(g)) X 3

(Al(s) → Al^{3+}(aq) + 3e) X 2

Step 3 add the equations

6H$^+$(aq) + 6e → 3H$_2$(g)

2Al(s) → 2Al^{3+}(aq) +63e

6H$^+$(aq) + 2Al(s) → 2Al^{3+}(aq) + 3H$_2$(g)