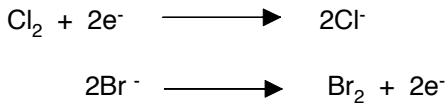
REDOX EQUATIONS

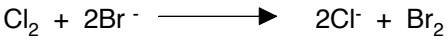
1. a) The reaction between chlorine gas and bromide ions:



$$Cl_2 + 2e^- \longrightarrow 2Cl^-$$

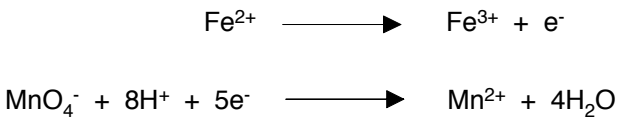
$$2Br^- \longrightarrow Br_2 + 2e^-$$

This is easy because two electrons are involved in both half-equations. All you need to do is add the two equations together to give



$$Cl_2 + 2Br^- \longrightarrow 2Cl^- + Br_2$$

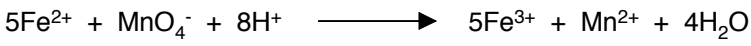
b) The reaction between iron(II) ions and acidified potassium manganate(VII) solution:



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

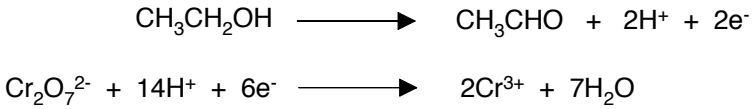
$$MnO_4^- + 8H^+ + 5e^- \longrightarrow Mn^{2+} + 4H_2O$$

This time, you would need to multiply the iron half-reaction by 5 in order to produce the 5 electrons needed by the second half-reaction. Then add them together to give



$$5Fe^{2+} + MnO_4^- + 8H^+ \longrightarrow 5Fe^{3+} + Mn^{2+} + 4H_2O$$

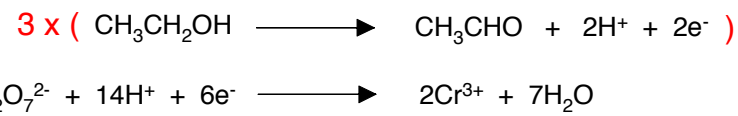
c) The reaction between ethanol and acidified potassium dichromate(VI) solution to give ethanal:



$$CH_3CH_2OH \longrightarrow CH_3CHO + 2H^+ + 2e^-$$

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

To get the 6 electrons needed for the second half-reaction, you would need to multiply the first one by 3. Then add them together:



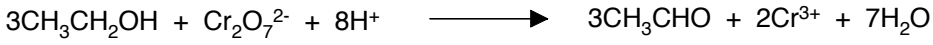
$$3 \times (CH_3CH_2OH \longrightarrow CH_3CHO + 2H^+ + 2e^-)$$

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

That leaves you with:

$$3CH_3CH_2OH + Cr_2O_7^{2-} + 14H^+ \longrightarrow 3CH_3CHO + 6H^+ + 2Cr^{3+} + 7H_2O$$

. . . but there are hydrogen ions on both sides of the equation. Simplify it to give



$$3CH_3CH_2OH + Cr_2O_7^{2-} + 8H^+ \longrightarrow 3CH_3CHO + 2Cr^{3+} + 7H_2O$$

d) The reaction between copper and moderately concentrated nitric acid to give nitrogen monoxide:

$$Cu \longrightarrow Cu^{2+} + 2e^-$$

$$NO_3^- + 4H^+ + 3e^- \longrightarrow NO + 2H_2O$$

You will need to multiply the first half-reaction by 3, and the second by 2 in order to transfer 6 electrons.

$$3 \times (Cu \longrightarrow Cu^{2+} + 2e^-)$$

$$2 \times (NO_3^- + 4H^+ + 3e^- \longrightarrow NO + 2H_2O)$$

Add them together to give:

$$3Cu + 2NO_3^- + 8H^+ \longrightarrow 3Cu^{2+} + 2NO + 4H_2O$$

e) The reaction between copper and concentrated nitric acid to give nitrogen dioxide:

$$Cu \longrightarrow Cu^{2+} + 2e^-$$

$$NO_3^- + 2H^+ + e^- \longrightarrow NO_2 + H_2O$$

This is a simple one to finish with. You need to multiply the second half-reaction by 2 in order to transfer 2 electrons. Then add them up.

$$Cu + 2NO_3^- + 4H^+ \longrightarrow Cu^{2+} + 2NO_2 + 2H_2O$$

2. a) The oxidation of sulphite ions, SO_3^{2-}, to sulphate ions, SO_4^{2-}.

Start with what you know:

$$SO_3^{2-} \longrightarrow SO_4^{2-}$$

You need an extra oxygen, so add a water to the left-hand side:

$$SO_3^{2-} + H_2O \longrightarrow SO_4^{2-}$$

To balance the extra hydrogens, you need 2 hydrogen ions on the right.

$$SO_3^{2-} + H_2O \longrightarrow SO_4^{2-} + 2H^+$$

And to balance the charges, you will need 2 electrons also on the right-hand side.

$$SO_3^{2-} + H_2O \longrightarrow SO_4^{2-} + 2H^+ + 2e^-$$

b) The reduction of chlorate(V) ions, ClO_3^-, to chlorine gas, Cl_2.

Start from what you know:

$$ClO_3^- \longrightarrow Cl_2$$

This time it is important to remember to balance the chlorines before you do anything else.

$$2ClO_3^- \longrightarrow Cl_2$$

Now add water to balance the oxygen . . .

$$2ClO_3^- \longrightarrow Cl_2 + 6H_2O$$

. . . and then hydrogen ions to balance the hydrogens:

$$2ClO_3^- + 12H^+ \longrightarrow Cl_2 + 6H_2O$$

Finally, balance the charges:

$$2ClO_3^- + 12H^+ + 10e^- \longrightarrow Cl_2 + 6H_2O$$

c) The reduction of manganese(IV) oxide, MnO_2, to manganese(II) ions, Mn^{2+}.

Work it out in these stages:

$$MnO_2 \longrightarrow Mn^{2+}$$

$$MnO_2 \longrightarrow Mn^{2+} + 2H_2O$$

$$MnO_2 + 4H^+ \longrightarrow Mn^{2+} + 2H_2O$$

$$MnO_2 + 4H^+ + 2e^- \longrightarrow Mn^{2+} + 2H_2O$$

d) The reduction of xenon(VI) oxide, XeO_3, to xenon gas, Xe.

$$XeO_3 \longrightarrow Xe$$

$$XeO_3 \longrightarrow Xe + 3H_2O$$

$$XeO_3 + 6H^+ \longrightarrow Xe + 3H_2O$$

$$XeO_3 + 6H^+ + 6e^- \longrightarrow Xe + 3H_2O$$

e) The oxidation of hydrogen sulphide, H_2S, to sulphur, S.

$$H_2S \longrightarrow S$$

$$H_2S \longrightarrow S + 2H^+$$

$$H_2S \longrightarrow S + 2H^+ + 2e^-$$