

# Half Equations

1) a) Calculate the oxidation state of each underlined element in the following: [14]

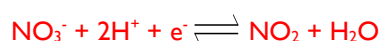
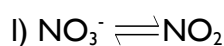
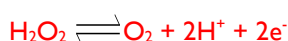
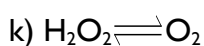
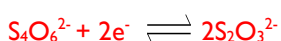
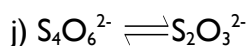
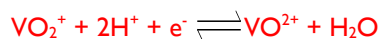
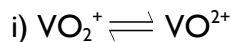
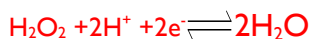
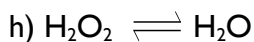
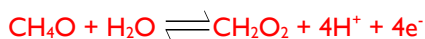
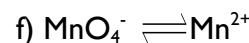
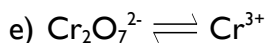
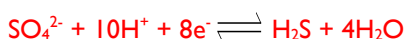
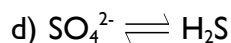
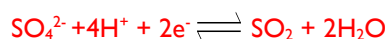
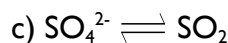
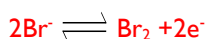
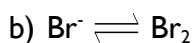
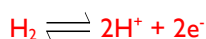
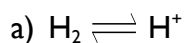
<u>S</u> O <sub>2</sub> +4	<u>S</u> O <sub>3</sub> +6	<u>S</u> O <sub>4</sub> <sup>2-</sup> +6	<u>Cr</u> <sub>2</sub> O <sub>3</sub> +3	<u>Cr</u> O <sub>3</sub> +6	<u>Mn</u> O <sub>4</sub> <sup>2-</sup> +6	<u>Mn</u> O <sub>4</sub> <sup>-</sup> +7
<u>Fe</u> Cl <sub>4</sub> <sup>2-</sup> +2	<u>Cu</u> <sub>2</sub> O +1	<u>Cu</u> O +2	<u>N</u> O <sub>3</sub> <sup>-</sup> +5	<u>C</u> <sub>2</sub> O <sub>4</sub> <sup>2-</sup> +3	<u>C</u> H <sub>4</sub> O <sub>2</sub> 0	<u>C</u> H <sub>4</sub> O -2

b) name the IONS in part (a) [4]

SO<sub>4</sub><sup>2-</sup> = sulphate (VI), MnO<sub>4</sub><sup>2-</sup> = manganate (VI),  
MnO<sub>4</sub><sup>-</sup> = manganate (VII), NO<sub>3</sub><sup>-</sup> = nitrate (V),

(FYI, FeCl<sub>4</sub><sup>2-</sup> is tetrachloroferrate (II) and C<sub>2</sub>O<sub>4</sub><sup>2-</sup> is ethandioate)

2) Write a half equation for each of the following conversions in acidic solution. [10]



3) Using your answers to Q2, combine them to create overall equations for the following reactions: (all in acidic conditions) [10]

a) Oxidation of Fe<sup>2+</sup> by MnO<sub>4</sub><sup>-</sup>

Half equations are Fe<sup>2+</sup> ⇌ Fe<sup>3+</sup> + e<sup>-</sup> and MnO<sub>4</sub><sup>-</sup> + 8H<sup>+</sup> + 5e<sup>-</sup> ⇌ Mn<sup>2+</sup> + 4H<sub>2</sub>O

So to make electrons cancel we need to multiply the Fe half equation by 5.

Which gives 5Fe<sup>2+</sup> + MnO<sub>4</sub><sup>-</sup> + 8H<sup>+</sup> → 5Fe<sup>3+</sup> + Mn<sup>2+</sup> + 4H<sub>2</sub>O

b) Oxidation of Fe<sup>2+</sup> by O<sub>2</sub> 2Fe<sup>2+</sup> + O<sub>2</sub> + 2H<sup>+</sup> → 2Fe<sup>3+</sup> + H<sub>2</sub>O<sub>2</sub> (using half equation (k) going from right to left)

c) Oxidation of H<sub>2</sub>O<sub>2</sub> by MnO<sub>4</sub><sup>-</sup>

Combining the two half equations gives 2MnO<sub>4</sub><sup>-</sup> + 16H<sup>+</sup> + 5H<sub>2</sub>O<sub>2</sub> → 2Mn<sup>2+</sup> + 8H<sub>2</sub>O + 5O<sub>2</sub> + 10H<sup>+</sup>

Since both sides have H<sup>+</sup> we can cancel them down and give 2MnO<sub>4</sub><sup>-</sup> + 6H<sup>+</sup> + 5H<sub>2</sub>O<sub>2</sub> → 2Mn<sup>2+</sup> + 8H<sub>2</sub>O + 5O<sub>2</sub>

d) Reduction of Br<sub>2</sub> by Fe<sup>2+</sup>



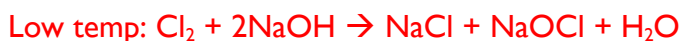
e) Reduction of Cr<sub>2</sub>O<sub>7</sub><sup>2-</sup> by CH<sub>4</sub>O



4) Chlorine reacts differently with sodium hydroxide depending on temperature. [5]

At high temp it forms NaCl and NaClO<sub>3</sub> but at low temperatures it forms NaCl and NaOCl.

By considering the oxidation states involved, create balanced equations for both reactions.



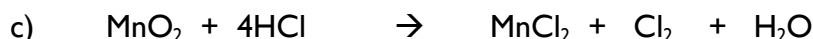
5) State whether the following are redox reactions or not, by showing the oxidation numbers of each of the elements involved. If the reaction is a redox reaction state which species have been oxidized and reduced during the reaction.



Yes, Zn oxidised, H reduced.



No



Yes Cl oxidised, Mn reduced



Yes Cl oxidised, Cl reduced

[14]

6) A solution of the NO<sub>2</sub><sup>-</sup> ion can be reduced to the ion, N<sub>2</sub>O<sub>2</sub><sup>2-</sup>. This ion is a strong reducing agent which reacts with MnO<sub>4</sub><sup>-</sup> in acidic conditions to form Mn<sup>2+</sup> ions and a second product that could be NO, NO<sub>3</sub><sup>-</sup>, NO<sub>2</sub><sup>-</sup>, N<sub>2</sub>O or NO<sub>2</sub>.

a) State the oxidation number of nitrogen in NO, NO<sub>3</sub><sup>-</sup>, NO<sub>2</sub><sup>-</sup>, N<sub>2</sub>O, NO<sub>2</sub> and N<sub>2</sub>O<sub>2</sub><sup>2-</sup>. [6]  
+2, +5, +3, +1, +4, +1

b) 8 mole of MnO<sub>4</sub><sup>-</sup> react with 5 moles of N<sub>2</sub>O<sub>2</sub><sup>2-</sup>.

i) Use this information to identify the second product of the reaction. [2]

MnO<sub>4</sub><sup>-</sup> to Mn<sup>2+</sup> is a change of 5 electrons, so if we have 8 moles of MnO<sub>4</sub><sup>-</sup> we have 40e<sup>-</sup>

5 moles of N<sub>2</sub>O<sub>2</sub><sup>2-</sup> contains 10 moles of N. So each N changes by 4e<sup>-</sup> (to get to 40e<sup>-</sup>)

So new ox state of N is +5, so NO<sub>3</sub><sup>-</sup> is other product

ii) Write a balanced equation for the reaction of 8 mole of MnO<sub>4</sub><sup>-</sup> react with 5 moles of N<sub>2</sub>O<sub>2</sub><sup>2-</sup>. [3]



7) Use oxidation states to create half equations for each of these reactions and use them to help balance the following reactions all in acidic solution [20]

