Half Equations

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

SO_2 +4	SO_3 +6	SO_4^{2-} +6	Cr_2O_3 +3	CrO_3 +6	MnO_4^{2-} +6	MnO_4^- +7
$FeCl_4^{2-}$ +2	Cu_2O +1	CuO +2	NO_3^- +5	$C_2O_4^{2-}$ +3	CH_4O_2 0	CH_4O -2

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

SO_4^{2-} = sulphate (VI), MnO_4^{2-} = manganate (VI),

MnO_4^- = manganate (VII) NO_3^- = nitrate (V),

(FYI, $FeCl_4^{2-}$ is tetrachloroferrate (II) and $C_2O_4^{2-}$ is ethandioate)

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

a) $H_2 \rightleftharpoons H^+$

$H_2 \rightleftharpoons 2H^+ + 2e^-$

b) $Br^- \rightleftharpoons Br_2$

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

c) $SO_4^{2-} \rightleftharpoons SO_2$

$SO_4^{2-} + 4H^+ + 2e^- \rightleftharpoons SO_2 + 2H_2O$

d) $SO_4^{2-} \rightleftharpoons H_2S$

$SO_4^{2-} + 10H^+ + 8e^- \rightleftharpoons H_2S + 4H_2O$

e) $Cr_2O_7^{2-} \rightleftharpoons Cr^{3+}$

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

f) $MnO_4^- \rightleftharpoons Mn^{2+}$

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

g) $CH_4O \rightleftharpoons CH_2O_2$

$CH_4O + H_2O \rightleftharpoons CH_2O_2 + 4H^+ + 4e^-$

h) $H_2O_2 \rightleftharpoons H_2O$

$H_2O_2 + 2H^+ + 2e^- \rightleftharpoons 2H_2O$

i) $VO_2^+ \rightleftharpoons VO^{2+}$

$VO_2^+ + 2H^+ + e^- \rightleftharpoons VO^{2+} + H_2O$

j) $S_4O_6^{2-} \rightleftharpoons S_2O_3^{2-}$

$S_4O_6^{2-} + 2e^- \rightleftharpoons 2S_2O_3^{2-}$

k) $H_2O_2 \rightleftharpoons O_2$

$H_2O_2 \rightleftharpoons O_2 + 2H^+ + 2e^-$

l) $NO_3^- \rightleftharpoons NO_2$

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

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^{2+} by MnO_4^-

Half equations are $Fe^{2+} \rightleftharpoons Fe^{3+} + e^-$ and $MnO_4^- + 8H^+ + 5e^- \rightleftharpoons Mn^{2+} + 4H_2O$

So to make electrons cancel we need to multiply the Fe half equation by 5.
Which gives $5Fe^{2+} + MnO_4^- + 8H^+ \rightarrow 5Fe^{3+} + Mn^{2+} + 4H_2O$

b) Oxidation of Fe^{2+} by O_2 $2Fe^{2+} + O_2 + 2H^+ \rightarrow 2Fe^{3+} + H_2O_2$ (using half equation (k) going from right to left)

c) Oxidation of H_2O_2 by MnO_4^-

Combining the two half equations gives $2MnO_4^- + 16H^+ + 5H_2O_2 \rightarrow 2Mn^{2+} + 8H_2O + 5O_2 + 10H^+$

Since both sides have H^+ we can cancel them down and give $2MnO_4^- + 6H^+ + 5H_2O_2 \rightarrow 2Mn^{2+} + 8H_2O + 5O_2$

d) Reduction of Br_2 by Fe^{2+}

$Br_2 + 2Fe^{2+} \rightarrow 2Br^- + 2Fe^{3+}$

e) Reduction of $Cr_2O_7^{2-}$ by CH_4O

$2Cr_2O_7^{2-} + 16H^+ + 3CH_4O \rightarrow 4Cr^{3+} + 11H_2O + 3CH_2O_2$

4) Chlorine reacts differently with sodium hydroxide depending on temperature. [5]
At high temp it forms NaCl and $NaClO_3$ but at low temperatures it forms NaCl and NaOCl.
By considering the oxidation states involved, create balanced equations for both reactions.

Low temp: $Cl_2 + 2NaOH \rightarrow NaCl + NaOCl + H_2O$

High temp: $3Cl_2 + 6NaOH \rightarrow 5NaCl + NaClO_3 + 3H_2O$

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.

a) $Zn + 2HCl \rightarrow ZnCl_2 + H_2$

Yes, Zn oxidised, H reduced.

b) $CuO + 2HCl \rightarrow CuCl_2 + H_2O$

No

c) $MnO_2 + 4HCl \rightarrow MnCl_2 + Cl_2 + H_2O$

Yes Cl oxidised, Mn reduced

d) $Cl_2 + H_2O \rightarrow HCl + HClO$ [14]

Yes Cl oxidised, Cl reduced

6) A solution of the NO_2^- ion can be reduced to the ion, $N_2O_2^{2-}$. This ion is a strong reducing agent which reacts with MnO_4^- in acidic conditions to form Mn^{2+} ions and a second product that could be NO, NO_3^-, NO_2^-, N_2O or NO_2.

a) State the oxidation number of nitrogen in NO, NO_3^-, NO_2^-, N_2O, NO_2 and $N_2O_2^{2-}$. [6]

+2, +5, +3, +1, +4, +1

b) 8 mole of MnO_4^- react with 5 moles of $N_2O_2^{2-}$.

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

MnO_4^- to Mn^{2+} is a change of 5 electrons, so if we have 8 moles of MnO_4^- we have $40e^-$

5 moles of $N_2O_2^{2-}$ contains 10 moles of N. So each N changes by $4e^-$ (to get to $40e^-$)

So new ox state of N is +5, so NO_3^- is other product

ii) Write a balanced equation for the reaction of 8 mole of MnO_4^- react with 5 moles of $N_2O_2^{2-}$. [3]

$8MnO_4^- + 64H^+ + 40e^- \rightarrow 8Mn^{2+} + 32H_2O$

$5N_2O_2^{2-} + 20H_2O \rightarrow 10NO_3^- + 40H^+ + 40e^-$

Overall: $8MnO_4^- + 24H^+ + 5N_2O_2^{-2} \rightarrow 8Mn^{2+} + 12H_2O + 10NO_3^-$

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]

a) $Zn + NO_3^- + H^+ \rightarrow Zn^{2+} + NH_4^+ + H_2O$
b) $UO^{2+} + Cr_2O_7^{2-} \rightarrow UO_2^{2+} + Cr^{3+}$
c) $Mn^{2+} + BiO_3^- \rightarrow MnO_4^- + Bi^{3+}$
d) $Cl^- + Sn + NO_3^- \rightarrow SnCl_6^{2-} + NO_2(g) + H_2O$
e) $MnO_4^- + I^- \rightarrow Mn^{2+} + I_2$
f) $MnO_2 + Cl^- \rightarrow MnCl_2 + Cl_2$
g) $MnO_4^{2-} \rightarrow MnO_4^- + MnO_2$
h) $VO_2^+ + Zn \rightarrow VO^{2+} + Zn^{2+}$
i) $MnO_4^- + Ni \rightarrow Mn^{2+} + Ni^{2+}$
j) $CrO_4^{2-} + Cr^{2+} \rightarrow Cr^{3+}$

a) $4Zn + NO_3^- + 10H^+ \rightarrow 4Zn^{2+} + NH_4^+ + 3H_2O$

b) $6UO^{2+} + Cr_2O_7^{2-} + 2H^+ \rightarrow 6UO_2^{2+} + 2Cr^{3+} + H_2O$

c) $2Mn^{2+} + 5BiO_3^- + 14H^+ \rightarrow 2MnO_4^- + 5Bi^{3+} + 7H_2O$

d) $6Cl^- + Sn + 4NO_3^- + 8H^+ \rightarrow SnCl_6^{2-} + 4NO_2(g) + 4H_2O$

e) $2MnO_4^- + 16H^+ + 10I^- \rightarrow 2Mn^{2+} + 5I_2 + 8H_2O$

f) $MnO_2 + 4Cl^- + 4H^+ \rightarrow MnCl_2 + 2H_2O + Cl_2$

g) $3MnO_4^{2-} + 4H^+ \rightarrow 2MnO_4^- + MnO_2 + 2H_2O$

h) $2VO_2^+ + Zn + 4H^+ \rightarrow 2VO^{2+} + Zn^{2+} + 2H_2O$

i) $2MnO_4^- + 5Ni + 16H^+ \rightarrow 2Mn^{2+} + 5Ni^{2+} + 8H_2O$

j) $CrO_4^{2-} + 3Cr^{2+} + 8H^+ \rightarrow 4Cr^{3+} + 4H_2O$