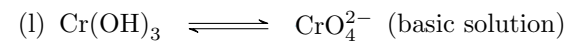
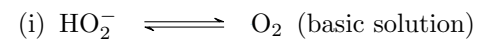
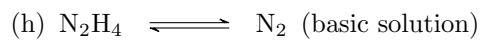
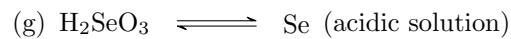
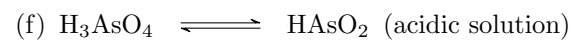
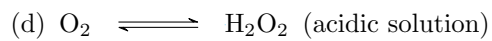
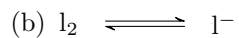
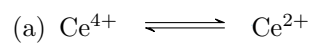


19. Balance the following half-reactions.



21. In the half-reaction $\text{MnO}_4^- \rightleftharpoons \text{MnO}_2$:

(a) calculate the oxidation numbers for Mn on both sides of the equation.

(b) calculate ΔON and assign a sign for the value of ΔON .

(c) balance the half-reaction in acid solution.

(d) look at the number of electrons involved and compare this to the value of ΔON . Is the half-reaction a reduction or oxidation?

22. Summarize the results of the above two exercises by completing the following sentence.
The OXIDATION NUMBER ? during a REDUCTION reaction and ? during an OXIDATION reaction.

23. For each of the half-reactions below
i) determine the change in oxidation number of the atom in bold type.
ii) state whether the half-reaction is an oxidation or a reduction.

