19. Balance the following half-reactions.

(a) $Ce^{4+} \rightleftharpoons Ce^{2+}$

(b) $l_2 \rightleftharpoons l^-$

(c) $Mn^{2+} \rightleftharpoons MnO_2$ (acidic solution)

(d) $O_2 \rightleftharpoons H_2O_2$ (acidic solution)

(e) $S_2O_8^{2-} \rightleftharpoons HSO_4^-$ (acidic solution)

(f) $H_3AsO_4 \rightleftharpoons HAsO_2$ (acidic solution)

(g) $H_2SeO_3 \rightleftharpoons Se$ (acidic solution)

(h) $N_2H_4 \rightleftharpoons N_2$ (basic solution)

(i) $HO_2^- \rightleftharpoons O_2$ (basic solution)

(j) $HXeO_4^- \rightleftharpoons HXeO_6^{3-}$ (basic solution)

(k) $HC_2H_3O_2 \rightleftharpoons C_2H_5OH$ (acidic solution)

(l) $Cr(OH)_3 \rightleftharpoons CrO_4^{2-}$ (basic solution)

(m) $CH_3CHO \rightleftharpoons CH_2CH_2$ (acidic solution)

20. In the half-reaction $NO_2^- \rightleftharpoons NO_3^-$:

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

(b) calculate "ΔON" (the "change in Oxidation Number"), and decide on a sign for the value of ΔON. (Hint: the change equals the oxidation number of the nitrogen on the product side minus the oxidation number of the nitrogen on the reactant side.)

(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?

21. In the half-reaction $MnO_4^- \rightleftharpoons MnO_2$:

(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.

(a) $\mathrm{Te} \rightleftharpoons \mathrm{TeO_4^-}$

(b) $\mathrm{ClO_3^-} \rightleftharpoons \mathrm{Cl^-}$

(c) $\mathrm{U^{4+}} \rightleftharpoons \mathrm{UO_2^{2+}}$

(d) $\mathrm{C_2H_5OH} \rightleftharpoons \mathrm{CH_3COOH}$(treat both carbons in CH.COOH identicaly)

(e) $\mathrm{PO_4^{3-}} \rightleftharpoons \mathrm{HPO_3^{2-}}$