

- c) What is the oxidation number of Cr in Cr^{3+} ?

This one is obvious: the oxidation number (charge on the atom) is +3.

Conclusion: The oxidation number of a monatomic ion is the charge on the ion.

- d) What is the oxidation number of S in SO_4^{2-} ?

$$\begin{array}{r} \text{S} \quad \text{O}_4 \quad 2^- \\ \text{individual charge for an atom} \longrightarrow x \quad -2 \\ \text{total charge (all atoms)} \longrightarrow x \quad -8 = -2 \end{array}$$

The ion has a 2- charge overall, requiring the solution of the equation:

$$x - 8 = -2, \text{ which gives } x = +6.$$

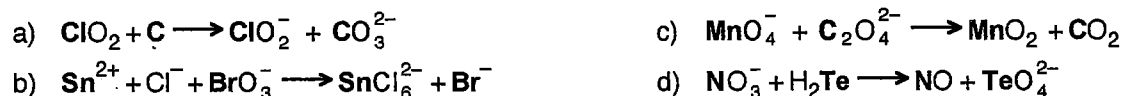
Therefore, the oxidation number of S is +6.

EXERCISES:

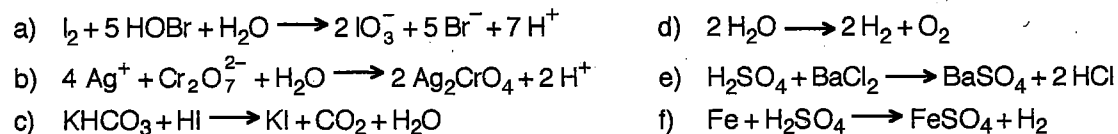
3. Calculate the oxidation number of the atom in **bold type**.

a) HNO_3	e) NH_4^+	i) Al(OH)_4^-	m) HClO_3	q) K_2UO_4
b) NO_2^-	f) N_3^-	j) S_2F_{10}	n) N_2H_5^+	r) $\text{C}_3\text{H}_6\text{O}$
c) CrO_4^{2-}	g) C_2H_6	k) N_2O_3	o) NH_2OH	s) S_8
d) $\text{Cr}_2\text{O}_7^{2-}$	h) C_3H_8	l) HClO_4	p) $\text{C}_2\text{O}_4^{2-}$	t) C_4H_6

4. Assign oxidation numbers to the **bold species** in each of the following unbalanced reaction equations. Then determine which species undergoes oxidation in each reaction.

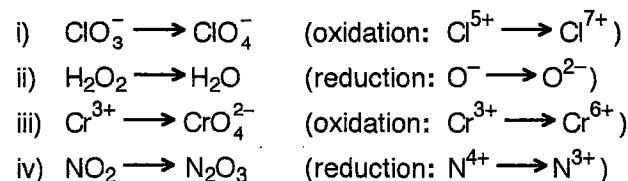


5. Which of the following are redox reactions?



SNEAKY TRICK!

You will sometimes find that the solution to a problem only requires you to determine which species have been oxidized and which have been reduced. Look at the following oxidations and reductions.



In each of these cases, **THE NUMBER OF ATTACHED OXYGEN ATOMS INCREASES DURING AN OXIDATION**, and **THE NUMBER OF ATTACHED OXYGENS DECREASES DURING A REDUCTION**. In the last example, (iv), the number of oxygens go from 2 O's per N-atom to 1.5 O's per N-atom.

ANSWERS TO UNIT V : ELECTROCHEMISTRY

1. (a) $\text{Mn} \longrightarrow \text{Mn}^{2+} + 2\text{e}^-$; Mn is oxidized and is the reducing agent.
 $\text{Hg}^{2+} + 2\text{e}^- \longrightarrow \text{Hg}$; Hg^{2+} is reduced and is the oxidizing agent.
 - (b) $\text{H}_2 \longrightarrow 2\text{H}^+ + 2\text{e}^-$; H_2 is oxidized and is the reducing agent.
 $\text{Sn}^{4+} + 2\text{e}^- \longrightarrow \text{Sn}^{2+}$; Sn^{4+} is reduced and is the oxidizing agent.
 - (c) $\text{Li} \longrightarrow \text{Li}^+ + \text{e}^-$; Li is oxidized and is the reducing agent.
 $\text{F}_2 + 2\text{e}^- \longrightarrow 2\text{F}^-$; F_2 is reduced and is the oxidizing agent.
 - (d) $\text{Cr}^{2+} \longrightarrow \text{Cr}^{3+} + \text{e}^-$; Cr^{2+} is oxidized and is the reducing agent.
 $\text{Br}_2 + 2\text{e}^- \longrightarrow 2\text{Br}^-$; Br_2 is reduced and is the oxidizing agent.
 - (e) $\text{Fe}^{2+} \longrightarrow \text{Fe}^{3+} + \text{e}^-$; Fe^{2+} is oxidized and is the reducing agent.
 $\text{Sn}^{4+} + 2\text{e}^- \longrightarrow \text{Sn}^{2+}$; Sn^{4+} is reduced and is the oxidizing agent.
2. (a) $2\text{Cs} + \text{Cl}_2 \longrightarrow 2\text{CsCl}$
 - (b) $\text{Cs} \longrightarrow \text{Cs}^+ + \text{e}^-$ (oxidation) $\text{Cl}_2 + 2\text{e}^- \longrightarrow 2\text{Cl}^-$ (reduction)
 - (c) Cs is the reducing agent; Cl_2 is the oxidizing agent.
3. (a) +5 (d) +6 (g) -3 (j) +5 (m) +5 (o) -1 (q) +6 (s) 0
 (b) +3 (e) -3 (h) -8/3 (k) +3 (n) -2 (p) +3 (r) -4/3 (t) -3/2
 (c) +6 (f) -1/3 (i) +3 (l) +7
4. (a) $\text{ClO}_2 + \text{C} \longrightarrow \text{ClO}_2^- + \text{CO}_3^{2-}$; C is oxidized
 +4 0 +3 +4
 - (b) $\text{Sn}^{2+} + \text{Cl}^- + \text{BrO}_3^- \longrightarrow \text{SnCl}_6^{2-} + \text{Br}^-$; Sn is oxidized
 +2 +5 +4 -1
 - (c) $\text{MnO}_4^- + \text{C}_2\text{O}_4^{2-} \longrightarrow \text{MnO}_2 + \text{CO}_2$; C is oxidized
 +7 +3 +4 +4
 - (d) $\text{NO}_3^- + \text{H}_2\text{Te} \longrightarrow \text{NO} + \text{TeO}_4^{2-}$; Te is oxidized
 +5 -2 +2 +6
5. Equations a, d and f
 6. (a) $\text{Cl}_2, \text{Cl}^-, \text{Cl}_2\text{O}$ (b) $\text{NO}_3^-, \text{NO}_2^-, \text{N}_2\text{O}_3$
7. (a) Na^+ can only be reduced (g) Fe^{2+} can be either reduced or oxidized
 (b) I^- can only be oxidized (h) Co^{2+} can only be reduced
 (c) Cu^+ can be either reduced or oxidized (i) Se(s) cannot react at all (needs H^+ to react)
 (d) Sn^{4+} can only be reduced (j) Sn^{2+} can be either reduced or oxidized
 (e) NO_3^- cannot react at all (needs H^+ to react) (k) Al(s) can only be oxidized
 (f) Hg(l) can only be oxidized (l) acidic $\text{Cr}_2\text{O}_7^{2-}$ can only be reduced
8. (a) no reaction; the species to be reduced (Ni^{2+}) is below the species to be oxidized (Ag) on the Table.
 (b) spontaneous: $2\text{Li} + \text{Zn}^{2+} \longrightarrow 2\text{Li}^+ + \text{Zn}$.
 (c) no reaction; both species can only be oxidized.
 (d) no reaction; the species to be reduced (H^+) is below the species to be oxidized (Cu) on the Table.
 (e) spontaneous: $2\text{H}^+ + \text{Fe} \longrightarrow \text{H}_2 + \text{Fe}^{2+}$.