OXIDATION NUMBERS

Oxidation state (number) shows the total number of electrons which have been removed from an element (a positive oxidation state) or added to an element (a negative oxidation state) to get to its present state.

Oxidation involves an increase in oxidation number (state)
Reduction involves a decrease in oxidation number (state)

Recognising this simple pattern is the single most important thing about the concept of oxidation states (numbers). If you know how the oxidation state (number) of an element changes during a reaction, you can instantly tell whether it is being oxidised or reduced without having to work in terms of electron-half-equations and electron transfers.

Rule 1. **ELEMENTS ARE ASSIGNED AN OXIDATION NUMBER 0 (ZERO).**

Rule 2. **THE OXIDATION NUMBER OF A MONATOMIC ION IS THE CHARGE ON THE ION.**

Rule 3. **HYDROGEN HAS AN OXIDATION NUMBER +1 (EXCEPT IN METAL HYDRIDES WHERE APPLICATION OF RULE 2 REQUIRES IT TO BE –1).**

Rule 4. **OXYGEN HAS AN OXIDATION NUMBER OF –2 (EXCEPT IN PEROXIDES WHERE APPLICATION OF RULES 2 AND 3 REQUIRES IT TO BE –1).**

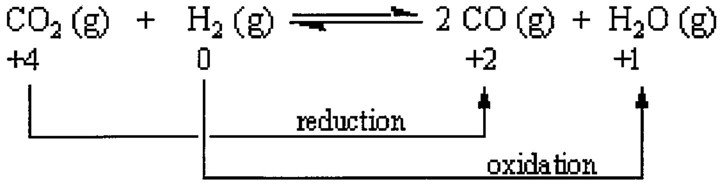
Rule 5. **IN NEUTRAL SPECIES, THE SUM OF THE OXIDATION NUMBERS OF ALL ATOMS PRESENT = 0 (ZERO).**

Rule 6. **IN POLYATOMIC AND COMPLEX IONS, THE SUM OF THE OXIDATION NUMBERS OF ALL ATOMS PRESENT = THE CHARGE ON THE ION.**

OXIDATION = INCREASE IN OXIDATION NUMBER.

REDUCTION = DECREASE IN OXIDATION NUMBER.

EXAMPLE



carbon is reduced (decrease in oxidation number)
hydrogen is oxidised (increase in oxidation number)

QUESTIONS on OXIDATION NUMBERS

Set 1:

Assign oxidation numbers for each element in the following chemical formulae:

1. Cl_2O_5 **each O has an oxidation number of −2, using Rule #4;**
   each Cl has an oxidation number of +5, using Rule #5.
2. $KBrO_4$ **K has an oxidation number of +1, using Rule #2;**
   each O has an oxidation number of −2, using Rule #4;
   Br has an oxidation number of +7, using Rule #5.
3. Ba^{2+} **this ion has a +2 oxidation number, using Rule #2.**
4. F_2 **each F has an oxidation number of 0, as this is the natural elemental form of fluorine, using Rule #1.**
5. $H_4P_2O_7$ **each H has an oxidation number of +1, using Rule #3;**
   each O has an oxidation number of −2, using Rule #4;
   each P has an oxidation number of +5, using Rule #5.
6. H_2S **each H has an oxidation number of +1, using Rule #3;**
   the S has an oxidation number of −2, using either Rule #5.
7. N_2O **the O has an oxidation number of −2, using Rule #4;**
   each N has an oxidation number of +1, using Rule #5.
8. $KHCO_3$ **K has an oxidation number of +1, using Rule #2;**
   H has an oxidation number of +1, using Rule #4;
   each O has an oxidation number of −2, using Rule #3;
   and C has an oxidation number of +4, using Rule #5.
9. PO_4^{3-} **each O has an oxidation number of −2, using Rule #4;**
   P has an oxidation number of +5, using Rule #6.
10. Cu **Cu has an oxidation number of 0, as this is the natural elemental form of copper, using Rule #1.**
11. $KMnO_4$ **K has an oxidation number of +1, using Rule #2;**
    each O has an oxidation number of −2, using Rule #4;
    Mn has an oxidation number of +7, using Rule #5.
12. $Ca_3(PO_4)_2$ **each Ca has an oxidation number of +2, using Rule #2;**
    each O has an oxidation number of −2, using Rule #4;
    each P has an oxidation number of +5, using Rule #5.
13. $Fe(NO_3)_2$ **Fe has an oxidation number of +2, using Rule #2 (based upon its ionic charge);**
    each O has an oxidation number of −2, using Rule #4;
    each N has an oxidation number of +5, using Rule #5.
14. $Au(OH)_3$ **Au has an oxidation number of +3, using Rule #2 (based upon its ionic charge);**
    each H has an oxidation number of +1, using Rule #3.
    each O has an oxidation number of −2, using Rule #4;
15. PF_3 **F always has an oxidation number of −1, in it's compounds (being the most electronegative element);**
    P has an oxidation number of +3, using Rule #5.
    NOTE: these answers could also have been obtained based upon the fact that F is more electronegative than P.
16. $CoCl_2$ **the Co has an oxidation number of +2 using Rule #2 (based upon its ionic charge);**
    each Cl has an oxidation number of −1, using Rule #5.

Set 2:

Q1. Assign oxidation numbers to each atom in

$NiCl_2$ Mg_2TiO_4 $K_2Cr_2O_7$ SO_3^{2-} $Ca(VO_3)_2$ CO_2

MnO_2 MoS_2 CH_4 $SnCl_4$ CaH_2 $Na_3Co(NO_2)_6$

Q2. Calculate the oxidation number of the underlined element in each of the following species

$H_2\underline{S}$ $H_3\underline{P}O_4$ $H\underline{S}^-$ $\underline{N}H_3$ $H_2\underline{S}O_4$ $\underline{N}H_2^-$

$H\underline{Cl}$; $H\underline{N}O_3$ $H\underline{C}O_3^-$ $H_2\underline{P}O_4^-$ $\underline{C}O_3^{2-}$ $Na_2\underline{B_4}O_7$

$\underline{N}H_4^+$ $\underline{P}O_4^{3-}$ $K_2\underline{Cr}O_4$ $\underline{S}O_4^{2-}$ $\underline{Cr_2}O_7^{2-}$ $Li\underline{Al}H_4$

$\underline{Cl}O_4^-$ $\underline{Cr}Cl_3$ $\underline{Sn}S_2$ $\underline{Au}(NO_3)_3$ $Zn_3(\underline{P}O_4)_2$ $Na\underline{N}O_2$

Q3. Calculate the oxidation number of the underlined element in each of the following species

$\underline{B}F_3$ $\underline{Ti}Cl_4$ $H_3\underline{P}O_4$ $\underline{Mn}O_4^-$ $\underline{Cr}O_4^{2-}$ $H\underline{Cl}O_3$

$\underline{Mn}O_2$ $\underline{Al}F_6^{3-}$ $H\underline{N}O_2$ $\underline{S}O_3^{2-}$ $\underline{S}O_4^{2-}$ $HO\underline{I}$

$\underline{Pb}O_2$ $\underline{S_2}O_3^{2-}$ $[\underline{Al}(OH)_4]^-$ $[\underline{Cu}Cl_4]^{2-}$ $\underline{N}H_4NO_3$ $\underline{Fe_3}O_4$

$\underline{Sn}Br_2$ $H\underline{Sb}O_2$ $Mg(\underline{Mn}O_4)_2$ $NH_4\underline{N}O_3$ $\underline{C}H_2O$ $Ba\underline{O_2}$

Q4. In each of the following compounds, calculate the oxidation number of

A. chromium in $CrSO_4$ Cr_2O_3 CrO_2^- CrO_4^{2-}

B. manganese in $MnSO_4$ $Mn(OH)_3$ MnO_2 K_2MnO_4 $KMnO_4$

C. nitrogen in NH_3 N_2H_4 N_2O NO N_2O_3 NO_2 N_2O_4 N_2O_5

Q5. Give systematic names for the following anions:

ClO^- ClO_2^- ClO_3^- ClO_4^- BrO^- BrO_3^-

IO_3^- IO_4^- MnO_4^{2-} MnO_4^- SO_3^{2-} SO_4^{2-}

AsO_2^- AsO_4^{3-} SnO_2^{2-} SnO_3^{2-} NO_2^- NO_3^-

Q6. Write formulae for the following compounds.

A. potassium chlorate(III) B. sodium chlorate(V)

C. iron(III) hydroxide D. copper(II) nitrate(V)

Q7. Name the following ionic compounds.

A. $Fe(NO_3)_3$ B. $SrCO_3$ C. Na_2SO_3 D. $Ca(ClO)_2$

Answers:

Set 2:

Q1.	Ni(+2)Cl(−1)	Mg(+2)Ti(+4)O(−2)	K(+1)Cr(+6)O(−2)	S(+4)O(−2)
	Ca(+2)V(+5)O(−2)	C(+4)O(−2)	Mn(+4)O(−2)	Mo(+4)S(−2)
	C(−4)H(+1)	Sn(+4)Cl(−1)	Ca(+2)H(−1)	Na(+1)Co(+3)N(+3)O(−2)

Q2.	−2	+5	−2	−3	+6	−3
	−1	+5	+4	+5	+4	+3
	−3	+5	+6	+6	+6	+3
	+7	+3	+4	+3	+5	+3

Q3.	+3	+4	+5	+7	+6	+5
	+4	+3	+3	+4	+6	+1
	+4	+2	+3	+2	−3	2 x Fe +3 and 1 x Fe +2 (oxidation states are whole numbers)
	+2	+3	+7	+5	0	−1

Q4.	A.	+2	+3	+3	+6				
	B.	+2	+3	+4	+6	+7			
	C.	−3	−2	+1	+2	+3	+4	+4	+5

Q5.	chlorate(I)	chlorate(III)	chlorate(V)	chlorate(VII)	bromate(I)	bromate(V)
	iodate(V)	iodate(VII)	manganate(VI)	manganate(VII)	sulfate(IV)	sulfate(VI)
	arsenate(III)	arsenate(V)	stannate(II)	stannate(IV)	nitrate(III)	nitrate(V)

Q6. A. $KClO_2$ B. $NaClO_3$ C. $Fe(OH)_3$ D. $Cu(NO_3)_2$

Q7.	A.	iron(III) nitrate(V)	B.	strontium carbonate
	C.	sodium sulfate((IV)	D.	calcium chlorate(I)