Oxidation Number

Chemists have devised a useful "accountancy" tool to help keep track of electrons in compounds and reactions. This is particularly important in **redox reactions** where some atoms **lose** (are *oxidised*) and others gain (are *reduced*) electrons.

Each atom in a molecule is assigned an **oxidation number** (sometimes called **oxidation state**). This is the positive or negative charge the atom would have if the molecule was ionic.

Rules for working out oxidation numbers (O.N.)

The rules should be used in this order – the higher the rule, the higher its priority.

1. An atom in its elemental form (e.g. Fe, Cl_2, graphite etc) has O.N. = 0
2. The sum of the O.N. of all the atoms in a molecule equals zero.
3. The sum of the O.N. of all the atoms in an ion equals the charge of the ion.
4. The O.N. of fluorine is -1 (except in F_2 where it is 0 [rule 1]).
5. The O.N. of group 1 elements is +1.
6. The O.N. of group 2 elements is +2
7. The O.N. of oxygen is -2, except peroxides where it is -1.
8. The O.N. of halogens is usually -1.
9. The O.N. of hydrogen is +1 when bonded to non-metals and -1 when bonded to metals.

Examples

(a) AlF_3 F has O.N. = -1 (rule 4)
Al must have O.N. = +3 so that overall charge is zero: $(+3) + (3\times-1) = 0$

(b) NH_3 H is attached to a non-metal so O.N. = +1 (rule 9)
N must be -3 so that overall charge is zero: $(-3) + (3\times+1) = 0$

(c) NH_4^+ H is attached to a non-metal so O.N. = +1 (rule 9)
Ion has charge of +1.
N must be -3 so that overall charge is +1: $(-3) + (4\times+1) = +1$

(d) NH_2^- H is attached to a non-metal so O.N. = +1 (rule 9)
Ion has charge of -1.
N must be -3 so that overall charge is -1: $(-3) + (2\times+1) = -1$

(e) Cl_2 Elemental chlorine so O.N. = 0 (rule 1)

(f) ClF_3 F has O.N. = -1 (rule 4)
Cl must have O.N. = +3 so that overall charge is zero: $(+3) + (3\times-1) = 0$
(Note that rule 4 has higher priority than rule 8)

(g) ClF_4^+ F has O.N. = -1 (rule 4)
Ion has charge of +1.
Cl must have O.N. = +5 so that overall charge is +1: $(+5) + (4\times-1) = +1$

(g) ClF_4^- F has O.N. = -1 (rule 4)
Ion has charge of -1.
Cl must have O.N. = +3 so that overall charge is -1: $(+3) + (4\times-1) = -1$

Nitrogen Compounds

- **HNO_3** O has O.N. = -2 (rule 7)
  H is attached to a non-metal so O.N. = +1 (rule 9)
  N must have O.N. = +5 so that overall charge is zero: $(+1) + (+5) + (3\times-2) = 0$

- **NO_3^-** O has O.N. = -2 (rule 7)
  Ion has charge of -1.
  N must have O.N. = +5 so that overall charge is -1: $(+5) + (3\times-2) = -1$

- **NO_2** O has O.N. = -2 (rule 7)
  N must have O.N. = +4 so that overall charge is zero: $(+4) + (2\times-2) = 0$

- **N_2O_4** O has O.N. = -2 (rule 7)
  N must have O.N. = +4 so that overall charge is zero: $(2\times+4) + (2\times-2) = 0$

- **HNO_2** O has O.N. = -2 (rule 7)
  H is attached to a non-metal so O.N. = +1 (rule 9)
  N must have O.N. = +3 so that overall charge is zero: $(+1) + (+3) + (2\times-2) = 0$

- **NO_2^-** O has O.N. = -2 (rule 7)
  Ion has charge of -1.
  N must have O.N. = +3 so that overall charge is -1: $(+3) + (2\times-2) = -1$

- **NO** O has O.N. = -2 (rule 7)
  N must have O.N. = +2 so that overall charge is zero: $(+2) + (-2) = 0$

- **N_2O** O has O.N. = -2 (rule 7)
  N must have O.N. = +1 so that overall charge is zero: $(2\times+1) + (-2) = 0$

- **N_2** N must have O.N. = 0 as its in elemental form) = 0

- **NH_2OH** O has O.N. = -2 (rule 7)
  Each H is attached to a non-metal so O.N. = +1 (rule 9)
  N must have O.N. = -1 so that overall charge is zero: $(-1) + (2\times+1) + (-2) + (+1) = 0$

- **N_2H_4** H is attached to a non-metal so O.N. = +1 (rule 9)
  N must have O.N. = -2 so that overall charge is zero: $(2\times-2) + (4\times+1) = 0$

- **NH_3** H is attached to a non-metal so O.N. = +1 (rule 9)
  N must have O.N. = -3 so that overall charge is zero: $(-3) + (3\times+1) = 0$

- **NH_4^+** H is attached to a non-metal so O.N. = +1 (rule 9)
  Ion has charge of -1
  N must have O.N. = -3 so that overall charge is +1: $(-3) + (4\times+1) = +1$