

OXIDATION STATES OF SELECTED ELEMENTS

Chemistry BC2001x

NITROGEN (Group VA or 15) Maximum (highest) oxidation state: +5 Minimum: -3

| | | |
|----|------------------------|---|
| +5 | NO_3^- | Nitrate ion. A strong oxidizing agent in acid solution. |
| +4 | NO_2 | Nitrogen dioxide, a reddish-brown gas. (Dimerizes to colorless N_2O_4 .) NO_2 is the principal product of the reduction of <i>concentrated</i> HNO_3 . |
| +3 | NO_2^- | Nitrite ion (in basic solution). |
| | HNO_2 | Nitrous acid (in acidic solution). |
| +2 | NO | Nitric oxide, a colorless gas. Reacts rapidly with O_2 to form NO_2 . NO is the principal product of the reduction of <i>dilute</i> HNO_3 . |
| +1 | N_2O | Nitrous oxide (laughing gas). Seldom formed in oxidation-reduction reactions. |
| 0 | N_2 | Nitrogen gas. (Also called dinitrogen.) Very stable and unreactive. |
| -1 | HONH_2 | Hydroxylamine. A weak base. |
| -2 | N_2H_4 | Hydrazine. A weak base. |
| -3 | NH_3 | Ammonia (in basic solution). A colorless gas, very soluble in water. |
| | NH_4^+ | Ammonium ion (in acidic solution). |

SULFUR (Group VIA or 16) Maximum (highest) oxidation state: +6 Minimum: -2

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| +6 | SO_3 | Sulfur trioxide. Dissolves in water to form the strong acid H_2SO_4 . |
| | SO_4^{2-} | Sulfate ion. |
| +4 | SO_3^{2-} | Sulfite ion. Easily oxidized to sulfate ion. |
| | SO_2 | Sulfur dioxide. Dissolves in water to form the weak acid H_2SO_3 . |
| 0 | S | Elemental sulfur. Actually exists as 8-membered rings $\text{S}_8(\text{s})$. |
| -2 | S^{2-} | Sulfide ion (in basic solution). |
| | H_2S | Hydrogen sulfide (in acidic solution). A gas, soluble 0.1 M in H_2O . |

CHLORINE (Group VIIA or 17) Maximum (highest) oxidation state: +7 Minimum: -1

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| +7 | ClO_4^- | Perchlorate ion. A powerful oxidizing agent. |
| +5 | ClO_3^- | Chlorate ion. A strong oxidizing agent. |
| +4 | ClO_2 | Chlorine dioxide. A yellow-orange gas. Uncommon. Formed when ClO_3^- reacts with certain reducing agents. |
| +3 | ClO_2^- | Chlorite ion (in basic solution). In acidic solution, HClO_2 disproportionates to $\text{ClO}_2(\text{g})$ and Cl^- . |
| | ClF_3 | A reactive gas. |
| +1 | ClO^- | Hypochlorite ion (in basic solution). An oxidizing agent. |
| | HOCl | Hypochlorous acid (in acidic solution). An oxidizing agent. |
| 0 | Cl_2 | Chlorine gas. A good oxidizing agent. |
| -1 | Cl^- | Chloride ion. A moderately good reducing agent. |

OXIDATION STATES OF SELECTED ELEMENTS: EXAMPLES

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CHROMIUM (Group VIB or 6) Maximum (highest) oxidation state: +6 Minimum: 0

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| +6 | CrO ₃ | Chromium trioxide or chromium(VI) oxide. Dissolves in H ₂ O to form strongly acidic solutions: $2 \text{CrO}_3(\text{s}) + \text{H}_2\text{O} \rightarrow \text{Cr}_2\text{O}_7^{2-}(\text{aq}) + 2\text{H}^+(\text{aq})$ |
| | Cr ₂ O ₇ ²⁻ | Dichromate ion. Orange-red. Stable in acidic solution. A strong oxidizing agent; usually reduced to Cr ³⁺ . |
| | CrO ₄ ²⁻ | Chromate ion. Yellow. Stable in basic solution. Dimerizes in acid: $2 \text{CrO}_4^{2-}(\text{aq}) + 2 \text{H}^+(\text{aq}) \rightarrow \text{Cr}_2\text{O}_7^{2-}(\text{aq}) + \text{H}_2\text{O}$ |
| +3 | Cr ³⁺ | Chromic ion. The usual reduction product of Cr ₂ O ₇ ²⁻ in acid solution. |
| | Cr(OH) ₃ | Chromic hydroxide. Amphoteric (both acidic and basic). |
| | Cr(OH) ₄ ⁻ | Chromite ion. Green. Formed from Cr(OH) ₃ in strong base. |
| +2 | Cr ²⁺ | Chromous ion. Blue. Easily oxidized to Cr ³⁺ . |
| 0 | Cr | Chromium metal. Elemental chromium. |

MANGANESE (Group VIIB or 7) Maximum (highest) oxidation state: +7 Minimum: 0

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|----|--------------------------------|---|
| +7 | MnO ₄ ⁻ | Permanganate ion. Dark purple. A powerful oxidizing agent. Usually reduced to Mn ²⁺ in acidic solution, to MnO ₂ in basic solution. |
| +6 | MnO ₄ ²⁻ | Manganate ion. Green. Stable only in very basic solution. |
| +4 | MnO ₂ | Manganese dioxide. Black or brown. Insoluble in water. |
| +3 | Mn ³⁺ | Manganic ion. Disproportionates to Mn ²⁺ and MnO ₂ in acid. |
| +2 | Mn ²⁺ | Manganous ion. Pale pink. Stable in acid solution. |
| 0 | Mn | Manganese metal. Elemental manganese. |

MERCURY (Group IIB or 12) Maximum (highest) oxidation state: +2 Minimum: 0

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|----|---------------------------------|---|
| +2 | Hg ²⁺ | Mercuric ion. |
| | HgCl ₄ ²⁻ | Tetrachloromercurate(II) ion. Formed in concentrated HCl. |
| +1 | Hg ₂ ²⁺ | Mercurous ion. Note that Hg(I) exists only as a <i>diatomic</i> cation. |
| 0 | Hg | Mercury metal. This element is liquid at room temperature. |

TIN (Group IVA or 14) Maximum (highest) oxidation state: +4 Minimum: 0

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|----|-----------------------------------|---|
| +4 | SnO ₂ | Stannic oxide. |
| | Sn(OH) ₆ ²⁻ | Stannate ion. Formed in strongly basic solution. |
| | SnCl ₆ ²⁻ | Hexachlorostannate(IV) ion. Formed in concentrated HCl. |
| +2 | Sn ²⁺ | Stannous ion. |
| 0 | Sn | Tin metal. Elemental tin. |