

## SCH 4U

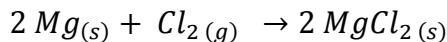
### PART 1: OXIDATION-REDUCTION REACTIONS

- OXIDATION REACTIONS – Formally known as reactions involving oxygen.
- REDUCTION REACTIONS – Formally known as a chemical process of extracting metals from their ores, thus reducing the mass of the material from which they came.

#### RECENT DEFINITIONS:

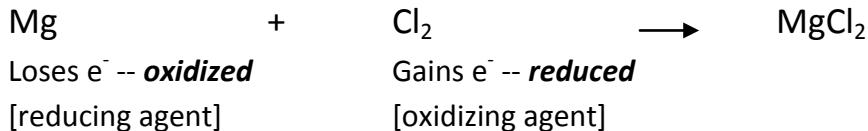
- OXIDATION: loss of electrons from one substance to another
- REDUCTION: substance that gains the electrons lost by another substance
- Oxidation and reduction must happen together – also known as **REDOX** reactions.

Consider the reaction of magnesium metal with chlorine gas:



- The substance that is oxidized is the **reducing agent**. A reducing agent causes reduction to occur in the other substance
- The substance that is reduced is the **oxidizing agent**.

In the reaction of magnesium and chlorine, since the magnesium loses electrons, it is being oxidized and is called the reducing agent as it causes the chlorine atom to be reduced. Each chlorine atom gains an electron, so it is being reduced and is called the oxidizing agent as it causes the sodium atom to be oxidized.



- A redox reaction is a chemical reaction in which changes in oxidation numbers (or oxidation states) occur.

Many REDOX reactions are already well-known to us.

- Organic reactions
- Synthesis and decomposition reactions
- Many double displacement reactions

NOT ALL reactions are REDOX reactions – increase/decrease of oxidation states do not always occur.

**EXAMPLE:** Identify the oxidizing and reducing agents in the reaction of iron and bromine, producing iron (III) bromide.

### SPONTANEITY of a REDOX REACTION:

- Will a reaction occur? – associated with single displacement reactions

#### *Recall the Metal Activity Series from Gr. 11 Chemistry:*

The metal activity series arranges metals in a column from most to least reactive, so that if a metal in the chart is located above the cation of a compound, the reaction will occur.

In tables of the Metal Activity Series, metals are often arranged from least reactive (weakest reducing agent) to most reactive (strongest reducing agent). The stronger the reducing agent, the greater the metal's ability to lose electrons to the other substance and form a new compound, or in other words, the greater the metal's ability to cause reduction (gain electrons) in the other substance, a reaction will occur. So when predicting if a REDOX reaction will occur, if the pure metal is located below the cation of the compound, a reaction will be spontaneous.

**EXAMPLE:** Which of the following reactions will proceed spontaneously?

If a reaction occurs, identify the oxidizing and reducing agents.

1. solid iron and aqueous tin (II) chloride

2. aqueous aluminum nitrate and copper metal

## **PART 2: OXIDATION NUMBERS**

### **RULES FOR ASSIGNING OXIDATION NUMBERS (O.N.):**

1. Oxidation number of a free element is zero:
2. Oxidation number of monoatomic ion is equal to the charge on the ion:

In compounds/polyatomic ions AND in the following order:

3. fluorine has oxidation number -1.
4. hydrogen has oxidation number of +1, with the exception of metal hydrides where it has O.N. of -1
5. oxygen has oxidation number of -2.
6. molecules not containing H or O → the more electronegative element is assigned an O.N. equal to the negative charge it usually has when in an ionic compound.

In general,

7. Sum of oxidation numbers in a molecule is 0.  
Sum of oxidation numbers in a polyatomic ion equals charge on particle.

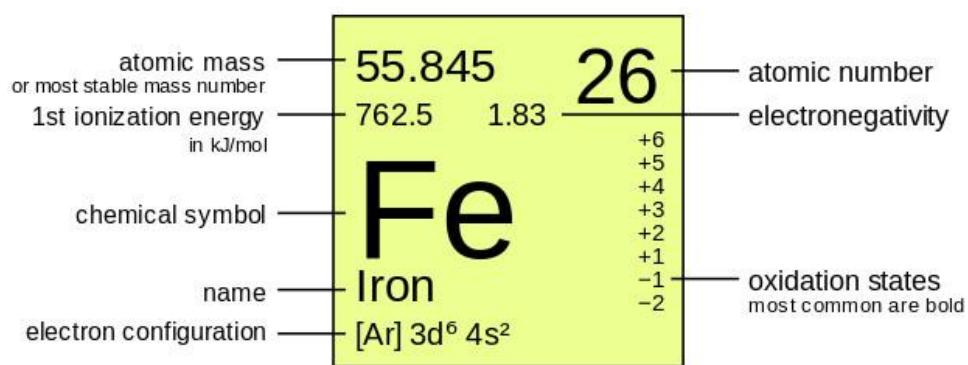
**EXAMPLES:** Determine the oxidation number of each element in the given substance.

1. $Cl_2O$	2. $Cl_2O_7$	3. $HOCl$
4. $Mg_3(PO_4)_2$	5. $NCl_3$	6. $HSO_4^-$

# Periodic Table of the Elements

1 IA 1A	2 IIA 2A	<table style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="text-align: center;">Atomic Number</th><th style="text-align: center;">Oxidation States*</th></tr> </thead> <tbody> <tr> <td style="text-align: center;">Symbol</td><td></td></tr> <tr> <td style="text-align: center;">Name</td><td></td></tr> <tr> <td style="text-align: center;">Atomic Mass</td><td></td></tr> </tbody> </table>	Atomic Number	Oxidation States*	Symbol		Name		Atomic Mass		18 VIIA 8A						
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1 H Hydrogen 1.008	2 Be Beryllium 9.012	<table style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="text-align: center;">Atomic Number</th><th style="text-align: center;">Oxidation States*</th></tr> </thead> <tbody> <tr> <td style="text-align: center;">Symbol</td><td></td></tr> <tr> <td style="text-align: center;">Name</td><td></td></tr> <tr> <td style="text-align: center;">Atomic Mass</td><td></td></tr> </tbody> </table>	Atomic Number	Oxidation States*	Symbol		Name		Atomic Mass		18 VIIA 8A						
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3 Li Lithium 6.941	4 Be Beryllium 9.012	<table style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="text-align: center;">Atomic Number</th><th style="text-align: center;">Oxidation States*</th></tr> </thead> <tbody> <tr> <td style="text-align: center;">Symbol</td><td></td></tr> <tr> <td style="text-align: center;">Name</td><td></td></tr> <tr> <td style="text-align: center;">Atomic Mass</td><td></td></tr> </tbody> </table>	Atomic Number	Oxidation States*	Symbol		Name		Atomic Mass		18 VIIA 8A						
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11 Na Sodium 22.990	12 Mg Magnesium 24.305	<table style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="text-align: center;">Atomic Number</th><th style="text-align: center;">Oxidation States*</th></tr> </thead> <tbody> <tr> <td style="text-align: center;">Symbol</td><td></td></tr> <tr> <td style="text-align: center;">Name</td><td></td></tr> <tr> <td style="text-align: center;">Atomic Mass</td><td></td></tr> </tbody> </table>	Atomic Number	Oxidation States*	Symbol		Name		Atomic Mass		18 VIIA 8A						
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19 K Potassium 38.988	20 Ca Calcium 40.078	21 Sc Scandium 44.956	22 Ti Titanium 47.88	23 V Vanadium 50.942	24 Cr Chromium 51.999	25 Mn Manganese 54.938	26 Fe Iron 55.893	27 Co Cobalt 58.933	28 Ni Nickel 58.993	29 Cu Copper 63.548	30 Zn Zinc 65.39	31 Ga Gallium 69.726	32 Ge Germanium 71.922	33 As Arsenic 74.922	34 Se Selenium 78.972	35 Br Bromine 79.904	36 Kr Krypton 84.80
37 Rb Rubidium 84.469	38 Sr Strontium 87.62	39 Y Yttrium 87.926	40 Zr Zirconium 91.226	41 Nb Niobium 92.909	42 Mo Molybdenum 95.95	43 Tc Technetium 98.907	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.908	46 Pd Palladium 102.908	47 Ag Silver 107.898	48 Cd Cadmium 112.411	49 In Indium 114.818	50 Sn Antimony 118.71	51 Sb Antimony 121.785	52 Te Tellurium 127.6	53 I Iodine 126.904	54 Xe Xenon 131.29
55 Cs Cesium 132.905	56 Ba Barium 137.327	57-71	72 Hf Hafnium 178.49	73 Ta Tantalum 180.948	74 W Tungsten 183.85	75 Re Rhenium 186.207	76 Os Osmium 190.227	77 Ir Iridium 192.22	78 Pt Platinum 195.087	79 Au Gold 196.967	80 Hg Mercury 200.59	81 Tl Thallium 204.983	82 Pb Lead 207.2	83 Bi Bismuth 208.989	84 Po Polonium 209.922	85 At Astatine 209.877	86 Rn Radium 222.016
87 Fr Francium 223.025	88 Ra Radium 226.025	89-103	104 Rf Rutherfordium 261	105 Db Dubnium 262	106 Sg Seaborgium 265	107 Bh Bohrium 264	108 Hs Hassium 266	109 Mt Methmerium 268	110 Ds Darmstadtium 281	111 Rg Roentgenium 272	112 Cn Copernicium 277	113 Uut Ununtrium unknown	114 Fl Flerovium 288	115 Uup Ununpentium 289	116 Lv Livermorium 291	117 Uus Ununoctium unknown	118 Uuo Ununseptium unknown

Lanthanide Series	57 La Lanthanum 138.905	58 Ce Cerium 140.115	59 Pr Praseodymium 140.903	60 Nd Neodymium 144.24	61 Pm Promethium 144.913	62 Sm Samarium 151.985	63 Eu Europium 151.985	64 Gd Gadolinium 157.25	65 Tb Terbium 158.925	66 Dy Dysprosium 161.20	67 Ho Holmium 164.930	68 Er Erbium 169.934	69 Tm Thulium 173.04	70 Yb Ytterbium 174.907	71 Lu Lutetium 174.907
Actinide Series	89 Ac Actinium 227.028	90 Th Thorium 232.038	91 Pa Protactinium 231.039	92 U Uranium 238.029	93 Np Neptunium 237.048	94 Pu Plutonium 244.064	95 Am Americium 243.081	96 Cm Curium 247.070	97 Bk Berkelium 247.070	98 Cf Californium 251.060	99 Es Einsteinium 254.000	100 Fm Fermium 257.095	101 Md Mendelevium 258.1	102 No Nobelium 259.101	103 Lr Lawrencium 259.101



## Common Oxidation States of Nonmetals

Group 14	carbon	-4, +2, +4
Group 15	nitrogen	-3, +1, +2, +3, +4, +5
	phosphorus	-3, +3, +5
Group 16	sulfur	-2, +4, +6
Group 17	chlorine	-1, +1, +3, +5, +7
	bromine	-1, +1, +3, +5, +7
	iodine	-1, +1, +3, +5, +7

In addition to the values shown, atoms of each element in its pure state are assigned an oxidation number of zero.