

# Chem!stry

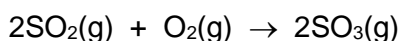
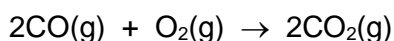
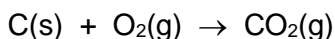
Name: ..... ( )

Class: .....

Date: ..... / ..... / .....

## Redox Reactions through Concept Development

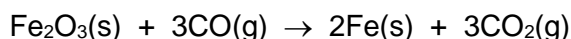
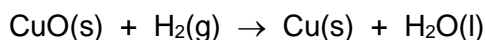
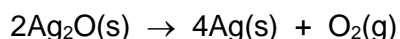
1. Study each of the following chemical reactions:



In these reactions, the carbon (C), carbon monoxide (CO) and sulfur dioxide (SO<sub>2</sub>) have all been *oxidised*. Based upon this information, define the term *oxidised / oxidation*.

.....  
.....  
.....

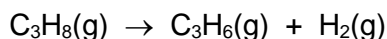
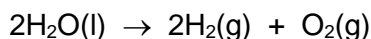
2. Study each of the following chemical reactions:



In these reactions, the silver in the silver oxide (Ag<sub>2</sub>O), the copper in the copper(II) oxide (CuO) and the iron in the iron(III) oxide (Fe<sub>2</sub>O<sub>3</sub>) have all been *reduced*. Based upon this information, define the term *reduced / reduction*.

.....  
.....  
.....

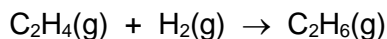
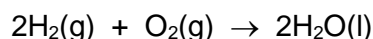
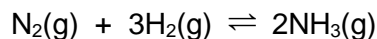
3. Study each of the following chemical reactions:



In these reactions, the oxygen in the water (H<sub>2</sub>O), the carbon in the propane (C<sub>3</sub>H<sub>8</sub>) and the carbon in the ethanol (CH<sub>3</sub>CH<sub>2</sub>OH) have all been *oxidised*. Based upon this information, define the term *oxidised / oxidation*.

.....  
.....  
.....

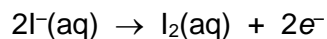
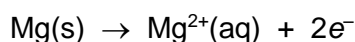
4. Study each of the following chemical reactions:



In these reactions, the nitrogen ( $\text{N}_2$ ), oxygen ( $\text{O}_2$ ) and ethene ( $\text{C}_2\text{H}_4$ ) have all been *reduced*. Based upon this information, define the term *reduced / reduction*.

.....  
.....  
.....

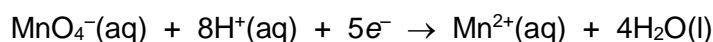
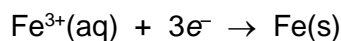
5. Study each of the following chemical reactions:



In these reactions, magnesium ( $\text{Mg}$ ), iodide ions ( $\text{I}^-$ ) and the carbon in ethanol ( $\text{CH}_3\text{CH}_2\text{OH}$ ) have all been *oxidised*. Based upon this information, define the term *oxidised / oxidation*.

.....  
.....  
.....

6. Study each of the following chemical reactions:



In these reactions, chlorine ( $\text{Cl}_2$ ), iron(III) ions ( $\text{Fe}^{3+}$ ) and the manganese in the manganate(VII) ion ( $\text{MnO}_4^-$ ) have all been *reduced*. Based upon this information, define the term *reduced / reduction*.

.....  
.....  
.....

**Note:** Students often use the mnemonic OIL RIG to help them remember the relationship between oxidation / reduction and the loss / gain of electrons.

• O..... I..... L..... of electrons.

• R..... I..... G..... of electrons.

## 7. Change in oxidation state.

### Part One – Inductive Reasoning

- The oxidation state (also referred to as the oxidation number) is an artificial construct invented by Chemists to help them understand redox better.
- The oxidation state is a number given to an **element**. This number is preceded by either a “+” sign or a “-” sign. In general, this number is the charge the atom of the element would have **if** it existed as an ion in the compound (even if the compound is a covalent compound).

#### Definition of Oxidation and Reduction:

An atom / element is **oxidised** when its oxidation state **increases**, and it is **reduced** when its oxidation state **decreases**.

- By examining the oxidation numbers of the different elements in the following substances or ions, derive the underlying rules that govern the assignment of oxidation numbers.

Substance or Ion	Element	Oxidation State of the Element
Magnesium metal, Mg	Magnesium	0
Chlorine gas, Cl <sub>2</sub>	Chlorine	0
Graphite, C	Carbon	0
Iron(II) ion, Fe <sup>2+</sup>	Iron	+2
Chloride ion, Cl <sup>-</sup>	Chlorine	-1
Magnesium chloride, MgCl <sub>2</sub>	Magnesium	+2
	Chlorine	-1
Lead(II) oxide, PbO	Lead	+2
	Oxygen	-2
Sodium carbonate, Na <sub>2</sub> CO <sub>3</sub>	Sodium	+1
	Carbon	+4
	Oxygen	-2
Nitric acid, HNO <sub>3</sub>	Hydrogen	+1
	Nitrogen	+5
	Oxygen	-2
Manganate(VII) ion, MnO <sub>4</sub> <sup>-</sup>	Manganese	+7
	Oxygen	-2

Substance or Ion	Element	Oxidation State of the Element
Potassium sulfate, $K_2SO_4$	Potassium	+1
	Sulfur	+6
	Oxygen	-2
Carbon monoxide, CO	Carbon	+2
	Oxygen	-2
Ammonium ion, $NH_4^+$	Nitrogen	-3
	Hydrogen	+1
Aluminium hydroxide, $Al(OH)_3$	Aluminium	+3
	Oxygen	-2
	Hydrogen	+1
Hydrogen peroxide, $H_2O_2$	Hydrogen	+1
	Oxygen	-1
Sodium hydride, NaH	Sodium	+1
	Hydrogen	-1
Potassium dichromate(VI), $K_2Cr_2O_7$	Potassium	+1
	Chromium	+6
	Oxygen	-2

### Assigning Oxidation Numbers

**Rule 1:** A pure element that is uncombined with other elements is assigned an oxidation state of .....

**Rule 2:** For simple ions, the oxidation state is simply the ..... on the ion.

**Rule 3:** In complex ions, the sum of the oxidation states .....

**Rule 4:** The oxidation state of hydrogen in all compounds is ....., except in metal hydrides where its oxidation state is .....

**Rule 5:** The oxidation state of oxygen in all compounds is ....., except in peroxides where its oxidation state is .....

**Rule 6:** The oxidation number of Group I elements (e.g. sodium) in their compounds is ....., for Group II elements (e.g. magnesium) in their compounds it is ....., and for aluminium in its compounds it is .....

**Rule 7:** There are many oxidation numbers for Group VII elements in their compounds, but the most common one is .....

**Rule 8:** .....

## Part Two – Practice Questions

1) Write down the oxidation state of the named element in the following substances:

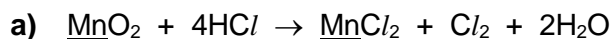
- |  |   |
|--|---|
| <p>a) Manganese in Mn .....</p> <p>c) Manganese in MnO<sub>2</sub> .....</p> <p>e) Oxygen in H<sub>2</sub>O<sub>2</sub> .....</p> <p>g) Chromium in K<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub> .....</p> <p>i) Sulfur in SO<sub>2</sub> .....</p> <p>k) Nitrogen in NH<sub>4</sub><sup>+</sup> .....</p> <p>m) Nitrogen in Zn(NO<sub>3</sub>)<sub>2</sub> .....</p> <p>o) Vanadium in V<sub>2</sub>O<sub>5</sub> .....</p> <p>q) Carbon in CO<sub>2</sub> .....</p> <p>s) Chlorine in HOCl .....</p> <p>u) Phosphorus in P<sub>4</sub> .....</p> <p>w) Chlorine in ClO<sub>3</sub><sup>-</sup> .....</p> | <p>b) Manganese in Mn<sup>2+</sup> .....</p> <p>d) Manganese in NH<sub>4</sub>MnO<sub>4</sub> .....</p> <p>f) Chromium in CrCl<sub>3</sub> .....</p> <p>h) Sulfur in SO<sub>3</sub><sup>2-</sup> .....</p> <p>j) Sulfur in (NH<sub>4</sub>)<sub>2</sub>SO<sub>4</sub> .....</p> <p>l) Nitrogen in NO<sub>3</sub><sup>-</sup> .....</p> <p>n) Iron in Fe<sub>2</sub>O<sub>3</sub> .....</p> <p>p) Hydrogen in NaH .....</p> <p>r) Bromine in Br<sub>2</sub> .....</p> <p>t) Phosphorus in H<sub>3</sub>PO<sub>4</sub> .....</p> <p>v) Iron in Fe(OH)<sub>3</sub> .....</p> <p>x) Chromium in CrO<sub>3</sub> .....</p> |
|--|---|

2) Name the following substances using oxidation states by filling in the brackets or writing down the name.

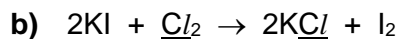
Example: MnO<sub>2</sub> Manganese(IV) oxide.

- a) SO<sub>2</sub> Sulfur( ) oxide.
- b) SO<sub>3</sub> Sulfur( ) oxide.
- c) CuSO<sub>4</sub> Copper( ) sulphate.
- d) FeCl<sub>3</sub> Iron( ) chloride.
- e) KMnO<sub>4</sub> Potassium manganate( ).
- f) N<sub>2</sub>O Nitrogen( ) oxide.
- g) PbSO<sub>3</sub> Lead( ) sulfate( ).
- h) FeSO<sub>4</sub> Iron( ) sulfate( ).

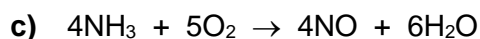
3) Calculate the oxidation state of the element that is underlined at the start of the reaction and at the end of the reaction. Identify how the oxidation state of the element has changed during the reaction and hence state whether the element has been oxidised or reduced.



.....



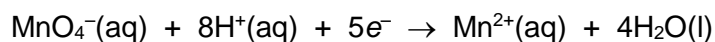
.....



.....

8. Oxidising agents and reducing agents.

- Notes on oxidising agents, e.g. acidified potassium manganate(VII):



→ Questions to consider:

- a)** Why is the potassium cation,  $\text{K}^+$ , not included in this ionic half-equation?

.....

- b)** What colour change would you observe during this reaction?

.....

- c)** What evidence is there that the acidified potassium manganate(VII) is an oxidising agent?

.....

.....

- d)** Is the manganese (Mn) oxidised or reduced during this reaction? What is your evidence?

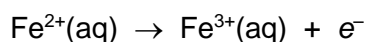
.....

.....

- e)** Why must the potassium manganate(VII) be acidified?

.....

- Notes on reducing agents, e.g. iron(II) sulfate:



→ Questions to consider:

- a)** Why is the sulfate anion,  $\text{SO}_4^{2-}$ , not included in this ionic half-equation?

.....

- b)** What colour change would you observe during this reaction?

.....

- c)** What evidence is there that the iron(II) cation is a reducing agent?

.....

.....

- d)** Is the iron(II) cation oxidised or reduced during this reaction? What is your evidence?

.....

.....

- Using the information provided, write the overall ionic equation for the reaction between acidified potassium manganate(VII) and iron(II) sulfate:

.....

- Scan the QR code below for the answers to this assignment.



[http://www.chemist.sg/redox/redox\\_worksheet\\_concept\\_ans.pdf](http://www.chemist.sg/redox/redox_worksheet_concept_ans.pdf)