SUVA SANGAM COLLEGE
YEAR 12
CHEMISTRY

Week 1: 05/07/21- 09/07/21
Strand 3: reactions
Sub strand 2: redox reactions.
Achievement indicator: students should be able to:

- *Distinguish between oxidation and reduction reactions.*
- *Distinguish between some common oxidizing and reducing agent*

Oxidation-Reduction Terminology

Term	Transfer of atoms	Transfer of electrons	Change in oxidation number
Oxidation	Gain of oxygen or loss of hydrogen	Loss of electrons	Increase in oxidation number
Reduction	Loss of oxygen or gain of hydrogen	Gain of electrons	Decrease in oxidation number
Oxidant (Oxidising agent)	Substance that loses oxygen or gains hydrogen	Substance that gains electron or an electron acceptor	Substance whose oxidation number has decreased
Reductant (Reducing Agent)	Substance that gains oxygen or loses hydrogen	Substance that loses electron or an electron donor	Substance whose oxidation number has increased

- **Redox reaction**

Reaction where both oxidation and reduction occur together. The reason is that electrons lost by one should be gained by another.

Transfer of atoms

Examples

REDUCTION (LOSS OF O_2)

a) $PbO + C \rightarrow Pb + CO$

OXIDATION (GAIN OF O_2)

Therefore - Pb is an oxidant - C is a reductant

Transfer of electrons

REDUCTION (GAIN OF e^-)

a) $Cu^{2+}SO_4^{2-} + Fe' \rightarrow Cu' + Fe^{2+}SO_4^{2-}$

OXIDATION (LOSS OF e^-)

$Cu^{2+} + 2e^- \rightarrow Cu$ $Fe \rightarrow Fe^{2+} + 2e^-$

Therefore Cu^{2+} is an oxidising agent (gains e^-) and Fe is a reducing agent (loses e^-)
Oxidation → increase in O.N.
Reduction → decrease in O.N.

E.g.

REDUCTION – O.N. DECREASES

$$\overset{0}{Fe} + \overset{+2\ +6\ -2}{CuSO_4} \rightarrow \overset{0}{Cu} + \overset{+2\ +6\ -2}{FeSO_4}$$

OXIDATION – O.N. INCREASES

Fe – reducing agent (O.N. increases) & Cu^{2+} is an oxidising agent (O.N. decreases)

For more examples of oxidizing agents and reducing agents students can refer to the table in their text book. **(Ref: Chemistry for year 12 pg. 70-71)**

Exercise 1;

1. For the following equation, identify whether the reaction is oxidation or reduction.

   i. $Al \rightarrow Al^{3+}$

   ____

   ii. $Cu^{2+} \rightarrow Cu$

   ____

2. **2.** Determine the oxidising and reducing agent for the equation given below.

   i. $Mg \rightarrow Mg^{2+}$

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   ii. $O_2 \rightarrow O^{2-}$

   ____

3. In the reaction represented by the equation: $CuO + H_2 \rightarrow Cu + H_2O$

   Determine the oxidant and reductant.

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Week 2 -12/07/21-16/07/21
Strand 3: reactions
Sub strand 2: redox reactions.

Achievement indicator: students should be able to:
-calculate the oxidation number of an element.

Oxidation number (Nox)
Describes the degree to which an element is oxidized or reduced.

Rules for Determining Oxidation Numbers

1. Oxidation number for free elements is zero (0)
   E.g. Mg, Zn, S, H_2, N_2, Cl_2, O_2, O etc

2. Oxidation number of an atom on a monoatomic ion is equal to the charge on the ion
   E.g. Cu^{2+} = +2, Al^{3+} = +3, S^{2-} = -2, Cl^- = -1, Na^+ = +1

3. Oxidation number of O_2 in a compound is -2 (except in perodixes when it is -1,
   E.g. H_2O_2, Na_2O_2, K_2O_2)

4. Oxidation number of H_2 in a compound is +1 (except in metal hydrides when it is -1
   E.g. NaH, LiH etc)

5. The sum of the oxidation numbers in a polyatomic ion is equal to the charge on the polyatomic ion.

Calculating oxidation number

RULES	EXAMPLES
N_{ox} of elements is zero	Na , C , O , Cl , etc.
N_{ox} of ions is equal to their charge	Na^+ (+1) . O^{2-}(-2),CO_3^{2-} (-2) ,etc.
N_{ox} of molecules is zero	CO_2 (0) , H_2O(0) ,etc.
N_{ox} of H in compounds is +1 but in metal hydride it is -1	in H_2O (+1) , NaH (-1),etc.
N_{Ox} of O in compounds is -2 but in H_2O_2 it is -1	In H_2O (-2) , CO_2(-2),etc.

Examples

SO_4^{2-} = -2
S + (-2 x 4) = -2
S + (-8) = -2

S = +6

NO_3^- = -1
N + (-2 x 3) = -1
N + (-6) = -1

N = +5

CO_3^{2-} = -2
C + (-2 x
C + (-6) =

C = +4

Exercise 2:

1. Find the oxidation number of chromium (Cr) in:

   a. $K_2Cr_2O_7$

   ____

   ____

   ____

   ____

   b. $Cr_2O_7^{2-}$

   ____

   ____

   ____

   ____\

2. Find the oxidation number of carbon in:

   a. CO_2

   ____

   ____

   ____

3. Find the oxidation number of hydrogen in:

   a. H_2O

   ____

   ____

   ____

   ____

   b. H_2O_2

   ____

   ____

   ____

   ____

Week 3 -19/07/21-23/07/21
Strand 3: reactions
Sub strand 2: redox reactions.

Achivement indicator: students should be able to:

- *Balance half equations.*

Balancing half equations ;

Step 1:
Balance all atoms except O & H.

Step 2:
Balance O by adding water on the opposite side.

Step 3:
Balance H by adding H+ to the opposite side

Step 4:
Balance charges by adding electrons on one of the sides

Example:

$Cr_2O_7^{2-} \rightarrow Cr^{3+}$

Balancing all atoms except O/H

$Cr_2O_7^{2-} \rightarrow 2Cr^{3+}$

Balancing O by adding H_2O

$Cr_2O_7^{2-} \rightarrow 2Cr^{3+} + 7H_2O$

Balancing H by adding H^+

$Cr_2O_7^{2-} + 14H^+ \rightarrow 2Cr^{3+} + 7H_2O$

Balance the charges by adding e^-

$Cr_2O_7^{2-} + 14H^+ + 6e^- \rightarrow 2Cr^{3+} + 7H_2O$

Exercise 3:

Balance the following:

1. $Fe_2O_3 \rightarrow Fe$

2. $Cl^{-} \rightarrow Cl_2$

3. $MnO_4^{-} \rightarrow MnO_2$

Week 4 – 26/07/21-30/07/21
Strand 3: reactions
Sub strand 2: redox reactions.

<u>Achivement indicators :</u> students should be able to:
-Balance redox reactions.

<u>Steps in balancing redox equations.</u>

Balance
$SO_2 + Cr_2O_7^{2-} \rightarrow Cr^{3+} + SO_4^{2-}$

<u>Step 1</u>
Break the equation into half equation

<u>Step 2</u>
Balance each half equation separately

<u>Step 3</u>
Combine the 2 half equations, ensuring that the electrons get cancelled out.
If electrons can't cancel out, multiply the equation by a factor.

<u>Example:</u>
When SO_2 gas is passed through orange potassium dichromate solution, it turns green.
Half reactions:

$Cr_2O_7^{2-} \rightarrow Cr^{3+}$ $\qquad$ $SO_2 \rightarrow SO_4^{2-}$

Balancing all atoms except O/H

$Cr_2O_7^{2-} \rightarrow 2Cr^{3+}$ $\qquad$ $SO_2 \rightarrow SO_4^{2-}$

Balancing O by adding H_2O

$Cr_2O_7^{2-} \rightarrow 2Cr^{3+} + 7H_2O$ $\qquad$ $SO_2 + 2H_2O \rightarrow SO_4^{2-}$

Balancing H by adding H^+

$Cr_2O_7^{2-} + 14H^+ \rightarrow 2Cr^{3+} + 7H_2O$ $\qquad$ $SO_2 + 2H_2O \rightarrow SO_4^{2-} + 4H^+$

Balance the charges by adding e^-

$Cr_2O_7^{2-} + 14H^+ + 6e^- \rightarrow 2Cr^{3+} + 7H_2O$ $\qquad$ $SO_2 + 2H_2O \rightarrow SO_4^{2-} + 4H^+ + 2e^-$

*Note: before adding the two half equations together the number of electrons must be balanced (therefore in this example multiply the SO_2 equation by 3)

$Cr_2O_7^{2-} + 14H^+ + 6e^- \rightarrow Cr^{3+} + 7H_2O$ $\qquad$ $3SO_2 + 6H_2O \rightarrow 3SO_4^{2-} + 12H^+ + 6e^-$

Combine and balance the equation

$Cr_2O_7^{2-} + \cancel{14H^+} + \cancel{6e^-} \rightarrow 2Cr^{3+} + \cancel{7H_2O}$

2H+ $\qquad$ H2O

$3SO_2 + \cancel{6H_2O} \rightarrow SO_4^{2-} + \cancel{12H^+} + \cancel{6e^-}$

$Cr_2O_7^{2-} + 2H^+ + 3SO_2 \rightarrow 2Cr^{3+} + 3SO_4^{2-} + H_2O$

(For **more examples and reference, students can refer to the year 12 chemistry textbook on pg. 74-75)**

Exercise 4;

Balance the following equations. In each case, give the balanced half-equations and combine the balanced half-equations to give the overall reaction equation.

1. $Fe^{2+} + MnO_4^- \rightarrow Fe^{3+} + Mn^{2+}$

2. $H_2S + SO_2 \rightarrow S + H_2O$

3. $Cu + NO_3^- \rightarrow NO_2 + Cu^{2+}$

Week 5 – 2/08/21-6/08/21
Strand 3: reactions
Sub strand 2: redox reactions.

Achievement indicator:
- *Describe and explain the electrolytic processes in the production of aluminum and copper metal*

<u>Industrial application of redox reactions.</u>

<u>Production of aluminium</u>

- 3rd most abundant element
- Found in clays, rocks & minerals
- Main ore is bauxite (red colored clay containing impure form of Al_2O_3(alumina) , Fe_2O_3 and SiO_2)

<u>Extraction of Al</u>

1. mining the aluminium ore
2. Purification of bauxite (Bayer process)
3. electrolysis of alumina (Hall – Heroult process)

➢ alumina (Al_2O_3) is dissolved in molten cryolite (Na_3AlF_6) to :

- ❖ lower the melting point of the electrolyte (from 1200^0C to 970^0C)
- ❖ increase conductivity of the electrolyte

➢ Electrolysis takes place in large steel pots using carbon electrodes.

- ❖ Anode reaction (oxidation) : $2O^{2-} \rightarrow O_2 + 4e^-$

The O_2 reacts with the carbon: $O_2 + C \rightarrow CO_2$ and that's why carbon rods have to be replaced frequently.

- ❖ Cathode reaction (reduction) : $Al^{3+} + 3e^- \rightarrow Al$

(refer to the diagram in the textbook of year 12 chemistry pg 7)

Industrial application of redox.

Purication of Copper

Uses of copper

- Electrical wiring
- Car radiators
- Plumbing industry & fittings
- Tubing in air conditioners &refrigerators
- Coins

EXTRACTION OF COPPER

STEP 1: EXTRACTION

Copper ores are sulphide ores commonly known as:

- Chalcopyrite
- Copper pyrite ($CuFeS_2$)
- Chalcocite (Cu_2S)
- Malachite ($CuCO_3.Cu(OH)_2$)
- Cuprite (Cu_2O)
- Azurite ($CuCO_3.Cu(OH)_2$)

The ore is crushed, mixed with water and then finely grounded. The powder is mixed with water and useful minerals are removed by froth flotation.

STEP 2: FROTH FLOTATION

In water, the air bubbles rise to the surface while the more dense particles of minerals and unwanted material (gangue) sink to the bottom.

The concentrated mineral contains 30% Cu as $CuFeS_2$

STEP 3: SMELTING

In this process. High temperatures is used to remove further impurities.

STEP 4: ROASTING

High temperature and air is used to remove S as SO_2 and iron impurities to iron oxide.

$$2CuFeS_{2(s)} + 4O_{2(g)} \rightarrow Cu_2S_{(s)} + 3SO_{2(g)} + 2FeO_{(s)}$$

Further heating occurs with sand (silica –SiO_2) in the absence of air. The sand reacts with iron oxide impurities to form a molten material called **slag**.

$$FeO_{(s)} + SiO_{2(s)} \rightarrow \underbrace{FeSiO_{3(l)}}_{\text{Slag}}$$

The remaining material is called matte which contains 60% Cu as Cu_2S
Further heating of the matte with silica removes FeS.

STEP 5: CONVERSION

Air is blasted in the hot matte.Reductio of Cu_2S occurs.

$Cu_2S_{(l)} + O_{2(g)} \rightarrow 2Cu_{(l)} + SO_{2(g)}$

The SO_2 gas that form causes bubbles in the molten copper and copper forms a blistered appearance.Blistered copper is 98% Cu metal.

STEP 6: ELECTROLYSIS

By this method 99.9% Cu can be obtained.

- $CuSO_4$ is the electrolyte
- Blistered Cu is the anode (oxidation occurs)

- Pure Cu sheet is the cathode (reduction occurs)

(Refer to the diagram in the year 12 chemistry textbook pg. 79)

The voltage used is chosen is carefully so that only copper is oxidized on the anode. Silver and gold metals (which are impurities) are not oxidized so they fall at the bottom of the electrolytic tank as anode sludge and are later removed.

Anode: $Cu \rightarrow Cu^{2+} + 2e^-$

Cathode: $Cu^{2+} + 2e^- \rightarrow Cu$

EXERCISE 5

1. Briefly explain why alumina (Al_2O_3) is dissolved in molten cryolite (Na_3AlF_6).

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2. What is another name of alumina?

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3. In the purification of alumina, why the graphite (carbon) anode is usually replaced from time to time.

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4. Briefly describe the process(s) which occurs during the electrolysis of molten alumina (Al_2O_3)?