Chemical Reactions and Equations

Consider the following processes and think about the reactions taking

- coal is burnt.
- food gets digested in our body.
- iron nail is exposed to humid atmosphere for a longtime.
- we respire.
- milk is converted into curd.
- water is added to quicklime.
- crackers are burnt.

• Are they physical changes or chemical changes?

• Are they temporary changes or permanent changes?

In all the above processes, the nature of original substance would be changed. If new substances are formed with properties completely unlike those of the original substances, we say a chemical change has taken place.

- Take about 1 g of quick lime (calcium oxide) in a beaker. Add 10 ml of
- water to this. Touch the beaker with your finger.
- Do you notice that the beaker is hot when you touch it. The reason is

that the calcium oxide (quick lime) reacts with water and in that processheat energy is released. Calcium oxide dissolves in water producing colourless solution. Test the nature of solution with litmus paper.

- What is the nature of the solution?

A red litmus paper turns blue when dipped in the above solution. This

solution is a **basic** solution

calcium oxide + water ⟶ calcium hydroxide

- **reactants,** are written on the **left side** of arrow and the final substances, or
- **products** are written on the **right side** of the arrow. The arrow head point towards the product shows the direction of the reaction.
- If there is more than one reactant or product involved in the reaction,
- they are indic
- CaO + H2O Ca (OH)2

- Is the number of atoms of each element on both sides equal?
- Observe the following reactions and their chemical equations. Zinc
- metal reacts with dilute HC*l* to yield ZnC*l*2 and liberates Hydrogen gas.
- Zn + HC*l* $\longrightarrow$ ZnC*l*2+ H2
- Sodium sulphate reacts with barium chloride to give white precipitate, barium sulphate.
- Na2SO4 + BaC*l*2 $\longrightarrow$ BaSO4 + NaC*l*

Do the atoms of each element on left side equal to the atoms of the

- element on the right side of the equation?

- **Balancing Chemical Equations**

- All the chemical equations must balance, because atoms are neither created nor destroyed in chemical reactions.

A chemical equation in which the numbers of atoms of different elements on the reactants side (left side) are same as those on product side (right side) is called a *balanced reaction*.

- **Combustion of propane (C3H8)**
- Propane, C 3 H8 is a colourless, odourless gas often used as a heating
- and cooking fuel. Write the chemical equation for the combustion reaction
- of propane. The reactants are propane and oxygen and the products are
- carbon dioxide and water.
- Write the reaction in terms of symbols and formulae of the substances
- involved and follow the four steps described in previous discussion.
- **Step 1:** Write the unbalanced equation using correct chemical formulae
- for all substances.
- $C3H8 + O2 \longrightarrow CO2 + H2O$

- **Element No of atoms**

LHS	**RHS**
C 3(inC3H8)	1 (inCO2)
H 8 (inC3H8)	2(inH2O)
O 2 (inO2)	3 (inCO2H2O)

Note: Unbalanced chemical equation

- **Step 2:** Compare number of atoms of
- each element on both sides.

- **Making Chemical Equations more informative:**
- following characteristics of the reactants and products.
  - i. Physical state
  - ii. Heat changes (exothermic or endothermic change)
  - iii. Gas evolved (if any)
  - iv. Precipitate formed (if any)
- **i. Expressing the physical state:**

  Gaseous -g , liquid -l , solid - s

  If the substance is present as a solution in water, the word ‘aqueous’ - aq

  $Fe_2O_3(s) + 2Al(s) \xrightarrow{\Delta} 2Fe(s) + Al_2O_3(s)$ Δ - heating.
- **ii. Expressing the heat changes:**

  Heat is liberated in <u>exothermic</u>

  reactions and heat is absorbed in <u>endothermic</u> reactions.

  $C(s) + O_2(g) \rightarrow CO_2(g) + Q$ (exothermic reaction)

  $N_2(g) + O_2(g) \rightarrow 2NO(g) - Q$ (endothermic reaction)
- $6CO_2(g) + 6H_2O(l) \xrightarrow{\text{Chlorophyll}} C_6H_{12}O_6(s) + 6O_2(g)$ glucose
- **Interpreting a balanced chemical equation**

- **iii. Expressing the gas evolved:** gas is evolved in a reaction, it is denoted by an upward arrow or(g) ↑

Eg: $Zn\ (s) + H_2SO_4\ (aq) \rightarrow ZnSO_4\ (aq) + H_2\ (g)\uparrow$

iv. Expressing precipitate formed: If a **precipitate** is formed in the reactions it is denoted by a downward arrow. ↓

$AgNO_3\ (aq) + NaCl\ (aq) \rightarrow AgCl\ (s)\downarrow + NaNO_3\ (aq)$

Sometimes the reaction conditions such as temperature, pressure, catalyst, etc are indicated above and/or below the arrow in the equation. For example,

sunlight

$2AgCl\ (s) \xrightarrow{\text{Sunlight}} 2\ Ag\ (s) + Cl_2\ (g)$

- **Eg-1:** Al (s) + Fe2O3 (s) □ Al2O3 (s) + Fe (s)
- (atomic masses of Al = 27U, Fe = 56U, and O = 16U)

2Al (s) + Fe2O3 (s) ⟶ Al2O3 (s) + 2Fe (s) , is a balanced equation.

(2x27)U + (2x56+3x16)U ⟶ (2x27+3x16)U + (2x56)U

54 U + 160 U ⟶ 102 U + 112 U

or 2 mol + 1 mol ⟶ 1 mol + 2 mol

54 g + 160 g ⟶ 102 g + 112 g

Suppose that your are asked to calculate the amount of aluminium,

required to get 1120 kg of iron by the above reaction.

Solution: As per the balanced equation

Aluminium □ Iron

54 g - 112 g

X - (1120 x 1000)g

= 540000 g or 540 kg

∴ to get 1120 kg of iron we have to use 540 kg of aluminium.

Eg-2: Calculate the volume, mass and number of molecules of hydrogen liberated when 230 g of sodium reacts with excess of water at STP.(atomic masses of Na = 23U, O = 16U, and H = 1U)

The balanced equation for the above reaction is,

$2Na\ (s) + 2H_2O\ (l) = 2NaOH\ (aq) + H_2\ (g)$

$(2x23)U + 2(2x1+1x16)U = 2(23+16+1)U + (2x1)U$

46 U + 36 U = 80 U + 2 U

or 46 g + 36 g = 80 g + 2 g

Solution: As per the balanced equation:

46 g of Na gives 2g of hydrogen

230g of Na gives _____? g of hydrogen.

230 g x 2g

1 gram molar mass of any gas at STP i.e, standard temperature 273K and standard pressure 1 bar, occupies 22.4 litres known as *gram molar volume*.

∴ 2.0g of hydrogen occupies 22.4 litres at STP.

10.0g of hydrogen occupies .....? litres at STP.

- 10.0g x 22.4 litres
  ——————————— = 112 litres
  2.0g
- 2 g of hydrogen i.e, 1 mole of H2 contains 6.02x1023 (NO) molecules
- 10 g of hydrogen contain .....?
- 10.0g x 6.02x1023 molecules
- ———————————————
- 2.0g
- = 30.10 x 1023 molecules
- = 3.01 x 1024 molecules

- **Chemical Combination**
- - Take a small piece (about 3 cm long) of magnesium ribbon.
- - Rub the magnesium ribbon with sand paper.
- - Hold it with a pair of tongs.
- - Burn it with a spirit lamp or burner.
- Magnesium burns in oxygen by producing dazzling
- white flame and changes into white powder. The white
- powder is magnesium oxide.
- 2Mg(s) + O2 (g) = 2MgO (s) ..... (18)
- Magnesium Oxygen Magnesium oxide
- In this reaction magnesium and oxygen combine to
- form a new substance magnesium oxide. A reaction in
- which single product is formed from two or more
- reactants is known as *chemical combination reaction*.

Burning of Coal: When coal is burnt in oxygen, carbon dioxide is produced.

C (s) + O2 (g) = CO2 (g) + Q (heat energy) .....(19)

Slaked lime is prepared by adding water to quick lime.

Ca O (s) + H20 (l) = Ca (OH) 2 (aq) + Q (heat energy).....(20)

- **Displacement reaction**
- Take a small quantity of zinc dust in a conical flask.
- - Add dilute hydrochloric acid slowly.
- - Now take a balloon and tie it to the mouth of the conical flask.
- - Closely observe the changes in the conical flask and balloon.
- - What do you notice?
- You can see the gas bubbles coming out from the solution and the
- balloon bulges out (figure 10b). Zinc pieces react with dilute hydrochloric
- acid and liberate hydrogen gas as shown below.
- $Zn\ (s) + 2HCl\ (aq) = ZnCl_2(aq) + H_2\ (g)$
- In reaction (25) the element zinc has displaced hydrogen from
- hydrochloric acid. This is displacement reaction

- **Decompostion Reaction**
- In the above activity, on heating calcium carbonate decomposes to
- calcium oxide and carbon dioxide.
- Heat
- $CaCO_3 (s) \xrightarrow{\Delta} CaO(s) + CO_2 (g)$ ..... (21)
- Lime stone quick lime
- It is a thermal decomposition reaction. When a decomposition reaction
- is carried out by heating, it is called *thermal decomposition reaction*.

Double displacement reaction

Take a pinch of lead nitrate and dissolve in 5.0ml of distilled water in a test tube.

- Take a pinch of potassium iodide in a test tube and dissolve in distilled water.
- Mix lead nitrate solution with potassium iodide solution.
- What do you observe?

A yellow coloured substance which is insoluble in water, is formed as **precipitate**. The precipitate is lead iodide.

$Pb(NO_3)_{2(aq)} + 2KI_{(aq)} = PbI_{2(s)} + 2KNO_{3(aq)}$ .....(29)

lead nitrate potassium Iodide lead iodide potassium nitrate

- **Oxidation and Reduction**
- ‘Oxidation’ is a reaction that involves the addition of oxygen or removal
- of hydrogen.
- ‘Reduction’ is a reaction that involves the addition of hydrogen or
- removal of oxygen.
- **Corrosion:**
- You must have observed that a freshly cut apple turns brown after some
- time. The shining iron articles gradually become reddish brown when left
- for some time. Burning of crackers produce dazzling light with white
- fumes.

Oxidation is the reaction of oxygen
molecules with different substances
starting from metal to living tissue which
may come in contact with it.

**Apples pears, bananas, potatoes etc.,
contain enzyme called polyphenol
oxidase or tyrosinase, which reacts with
oxygen and changes the colour on the cut
surface of the fruit.**

**The browning of iron, when left for
sometime in moist air, is a process
commonly known as rusting of iron. This
process is basically oxidation reaction which requires both oxygen and
water. Rusting does not occur in oxygen free water or dry air.**

Burning of crackers is also oxidation process of variety of chemicals.

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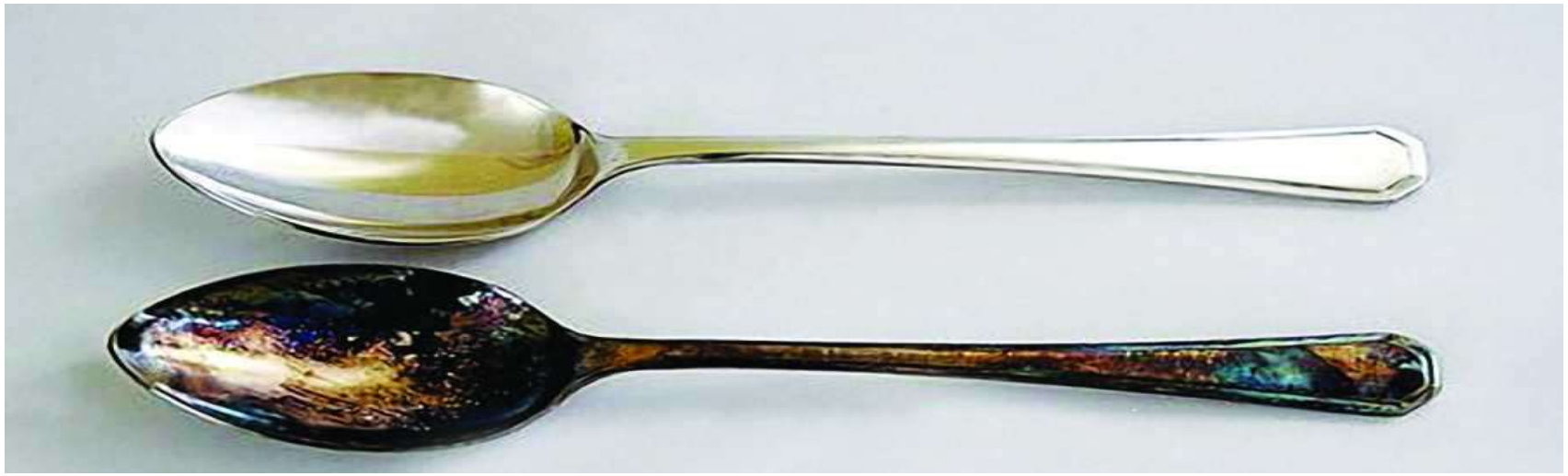
- The black coatings on silver
- $4Ag + 2H_2S + O_2 = 2Ag_2S + 2H_2O$



Green coating on copper

$2Cu + O2 = 2CuO$

- Corrosion causes damage to car bodies, bridges, iron railings, ships etc., and to all other objects that are made of metals. Especially corrosion of iron is a serious problem.
- Corrosion can be prevented or at least minimized by shielding the metal surface from oxygen and moisture. It can be prevented by painting, oiling, greasing, galvanizing, chrome plating or making alloys.

Galvanizing is a method of protecting iron from rusting by coating them a thin layer of Zinc.

- *Alloying* is also a very good method of improving properties of metal. Generally pure form of iron is very soft and stretches easily when hot. Iron is mixed with carbon, nickel and chromium to get an alloy stainless steel. The stainless steel is hard and does not rust.
- A metallic substance made by mixing and fusing two or more metals, or a metal and a nonmetal, to obtain desirable qualities such as hardness, lightness, and strength is known as *alloy*.

- **Some more effects of oxidation on everyday life**
- • Combustion is the most common example for oxidation reactions.
- For example: burning of wood involves release of carbon dioxide, water
- vapour along with huge amount of energy.
- Rising of dough with yeast depends on oxidation of sugars to carbon dioxide and water.
- • Bleaching of coloured objects using moist chlorine

  $Cl2 + H2O = HOCl + HCl$

  $HOCl = HCl + (O)$

  Coloured object + (O) = Colourless object.
- Some times during rainy season **the power supply** to our home from the electric pole will be interrupted due to formation of **the metal oxide** layer on the **electric wire**. This metal oxide is an electrical insulator. On removing the **metal oxide layer formed on the wire with a sand paper**, supply of electricity can be restored.

- **Rancidity**
- Tasted or smelt the fat/oil containing food materials left for a long time?
- When fats and oils are oxidized they become rancid. Their smell and taste change.
- Thus we can say that oxidation reactions in food material that were left for a long period are responsible for spoiling of food.
- Rancidity is an oxidation reaction.
- The spoilage of food can be prevented by adding preservatives like

Vitamin C and Vitamin E.

Usually substances which prevent oxidation (Antioxidants) are added to food containing fats and oil. Keeping food in air tight containers helps to slow down oxidation process.

- Do you know that manufacturers of potato chips flush bags of chips with nitrogen gas to prevent the chips from getting oxidized