Chemical Reactions

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7.1:
Physical and Chemical changes

Physical changes are reversible, unlike chemical changes. We can further identify if a change is chemical through the formation of precipitate, change in color and pH.

7.2:
Rate of Reaction

Rate of reaction is generally defined as the speed of a reaction. However, a more accurate definition would be the rate of change of concentration/mass/volume of the reactants/product.

Factors that affect the rate of reaction:

1) Temperature: An increase in temperature will cause the reactants to have more kinetic energy. This hence causes the atoms to collide with each other more frequently. Not to mention, an increase in temperature will cause a greater proportion of the atoms to have energy higher than activation energy and hence, frequency of effective collisions increases.
2) Catalyst: Catalyst are substances that are not used up in a chemical reaction but instead, speeds it up. This is possible as catalyst finds an alternative pathway for the reactants to react that require lower activation energy. Hence, frequency of effective collisions also increases.
3) Surface area: An increase in surface area will expose a greater proportion if the reactants to each other and hence, frequency of collisions increases
4) Concentration: concentration is defined as amount of moles of a substance per unit volume. Hence, if concentration increases, there would be more moles of the substance per unit volume and hence, frequency of collisions increases.

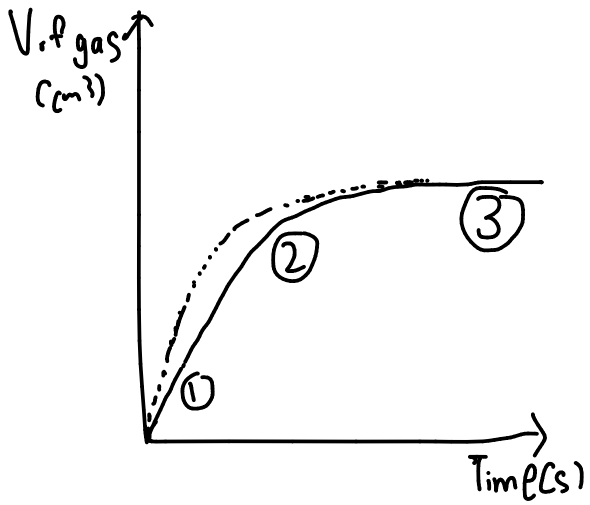
Key definitions to take note of:

1) Activation energy: Minimum amount of energy required for a reaction to start. Hence, if activation energy decreases, the reaction is more likely to occur
2) Frequency of effective collisions refer to the collisions that are successful. **It is different from** frequency of collisions. The latter refers to atoms colliding and there is not guarantee that this collision results in a chemical reaction.

With this factors taken into account, we can conclude very realistic real life scenarios. Explosions often occur in coal mines where methane builds up in very high concentrations. A small spark is all that is required to ignite the entire mine.

The rate of reaction can be measured in several ways. For reactions producing gas, we can measure the volume of gas produced with respect to time. On the other hand, if we do not wish to measure the volume of gas due to the technicality of the experiment, we measure the loss of mass with respect to time. **Take note that law of conservation of mass is still true.** It is just because the gas that has been produced has escaped and hence, mass decreases.

A graph can be produced such as that of the diagram below:



Take note of the gradient of the curve. If we divide volume by time, we obtain rate of reaction.

With this information, we can then conclude that the rate of reaction is always fastest when the reaction has just started. We can also conclude that at (3), the reaction has stopped.

A common mistake students commit is that they think a faster rate of reaction means that volume of gas will increase. This is false. Rate of reaction has nothing to do with yield but with speed. Hence, if rate of reaction increases, the curve will be steeper initially but converge at 3 as well, as seen from the dotted curve.

Photochemical reactions

Photochemical reactions are reactions that require the presence of light as light is absorbed for energy. The greater the intensity of light, the faster the rate of reaction.

Type of photochemical reactions:

1) Photosynthesis
2) Film Photography

When the shutter opens, light strikes the film and decomposes the AgBr

$$2Ag^+ + 2e^- \rightarrow 2Ag$$
$$2Br^- \rightarrow Br_2 + 2e^-$$

$$2AgBr \rightarrow 2Ag + Br_2$$

7.3:
Reversible reactions

A common misconception that students have is that when they classify a reaction as a chemical reaction, they assume it is irreversible. This is simply not true.

A common example would be the reaction of anhydrous copper sulfate with that of water.

$$CuSO_{4(s)} + 5H_2O \rightleftharpoons CuSO_4 \cdot 5H_2O$$

This reaction is commonly used to test for the presence of water. Anhydrous copper sulfate is white in color but turns blue in the presence of water.

Another salt that a similar usage is $CoCl_2$. In the presence of water, it is pink in color.

Equilibrium

Equilibrium refers to **reversible chemical reactions only.** In a closed system, a reversible chemical reaction will reach dynamic equilibrium. The 2 conditions are:

1) Rate of forward reaction is equal to rate of backward reaction
2) Concentration is constant, **not equal**

The equilibrium can be shifted either to the reactant or product side. This suits something called Le Chatelier's principle. The statement is:

"If a dynamic equilibrium is disturbed by changing the conditions, the position of the equilibrium will change to counteract the change."

Simply said, this principle helps us understand how different conditions affect reversible reactions in dynamic equilibrium.

Let us take the Haber Process as an example. This reaction will be extensively studied in the future.

$$N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)} \qquad \Delta H(-)$$

The factors are:

1) Temperature: An increase in temperature will shift the equilibrium towards the endothermic side. In the example above, the forward reaction is exothermic as seen from the negative sign for enthalpy change. Hence, an increase in temperature would shift equilibrium to the left.
2) Pressure: Changes in pressure is only applicable if the reaction involves gasses. An increase in pressure would shift the equilibrium to the side with more moles of gas. In the example above, the reactant side has 4 moles of gas whereas the product has 2. Hence, an increase in pressure will shift equilibrium to the right
3) Concentration: Increasing concentration of one side would shift equilibrium to the other side of the reaction. Simply said, if concentration of reactants is increases, equilibrium will shift to the product.

Note that surface area and catalyst has no effect on equilibrium. **You must understand**

that rate of reaction, simply said, is the 'speed of the reaction' whereas factors affecting equilibrium does not affect speed but affects yield.

7.4:
Redox

Redox is short for reduction and oxidation. A chemical reaction is known as redox if reactants experiences both oxidation and reduction.

Criteria for oxidation and reduction

Oxidation	Reduction
Gains oxygen	Lose oxygen
Lose hydrogen	Gains hydrogen
Gains oxidation state	Loses oxidation state
Loses electrons	Gains electrons

OILRIG Oxidation is loss, reduction is gain

Oxidation state refers to the degree of oxidation of an atom. The more positive it is, the more oxidized the atom. Oxidation state of element and compounds = 0
Eg:

+1 is O.S

$$Li \rightarrow Li^{+} + \bar{e}$$

Here, we can see that in the reaction, electron is lost. This is already an indication of oxidation. Not to mention, the oxidation state has increases from 0 to +1.

Oxidizing and reducing agents:

When talking about redox, this 2 compounds are incredibly common. One is acidified potassium manganate and the other is acidified potassium dichromate. These 2 are common examples of oxidizing agents.

Oxidizing agents, are, despite their name, the species which gets reduced in the chemical reaction. In other words, it helps the other species get oxidized which means by default, it is reduced.

Reducing agents are then obviously the species in a chemical reaction that undergo oxidation.

Hence, in a chemical reaction, both acidified potassium manganate and dichromate will be reduced. A color change will be observed.

If $KMnO_4$ is reduced(oxidizing agent), it will turn from purple to colorless.
If $K_2Cr_2O_7$ is reduced(oxidizing agent), it will turn from orange to green.
If KI is oxidized(reducing agent), it will turn from colorless to reddish brown.

If given a chemical reaction, we can see which species is reduced or oxidized by calculating their oxidation number.
Eg:

$$Mg + Cl_2 \rightarrow MgCl_2$$

O.S $\quad$ O.S $\quad$ O.S

$0 \quad 0 \quad \downarrow$

$$Mg^{2+} + Cl^-$$

$Mg \rightarrow$ From $0 \rightarrow 2^+$ (Reducing agent)

$Cl_2 \rightarrow$ from $0 \rightarrow 1^-$ (oxidizing agent)

With this example, we can also conclude that generally, group 1 and 2 metals are reducing agents. The further down the group, the stronger it is due to their reactivity. Not to mention, group 7(Halogens) would be oxidizing agents. The more reactive, the stronger it is as an oxidizing agent.

This equation is more complicated. However, the steps to identify each respective species is still the same.

$$MnO_4^- + 5Fe^{2+} + 8H^+ \rightarrow Mn^{2+} + 5Fe^{3+} + 4H_2O$$

$$\begin{array}{cccccc}
\downarrow & \downarrow & \downarrow & \downarrow & \downarrow & \downarrow \\
0 & 2+ & 1+ & 2^+ & 3^+ & 0 \\
Mn \quad O_4 & & & & & H_2 \quad O
\end{array}$$

O is always 2^-
unless seen
with H_2O_2
↳
Hence,

$-2 \times 4 + [Mn]^x = -1$

$x = 7+$

$2+$ $\quad$ 2^-

H

$1+$

$Mn^{7+} \longrightarrow Mn^{2+}$ (reduced) ∴ oxidizing agent

$Fe^{2+} \longrightarrow Fe^{3+}$ (oxidized) ∴ reducing agent

$H^+ \longrightarrow H^+$

$O^{2-} \longrightarrow O^{2-}$