Name:

Rates of Reaction	**Objectives**
16. Rates of Reaction	-define rate of reaction -define catalysis -monitor the rate of production of oxygen from hydrogen peroxide, using manganese dioxide as a catalyst -plot reaction rate graphs -interpret reaction rate graphs -explain what is meant by the nature of reactants -describe and explain how concentration, particle size, temperature, nature of reactants, and the presence of a catalyst effects the rate of reaction -describe how to investigate the effect of (i) particle size and (ii) catalysts on reaction rate -explain why dust explosions occur -identify two examples of catalysts produced by living cells (enzymes) -describe catalytic converters in terms of; nature of catalysts, reactions catalysed, environmental benefits and catalyst poisons -investigate the effects on the reaction rate of (i) concentration and (ii) temperature, using sodium thiosulfate solution and hydrochloric acid -describe and explain an experiment to show the oxidation of methanol (methyl alcohol) using a hot platinum or nichrome catalyst -define activation energy -describe and explain the influence of temperature change to changes in reaction rate

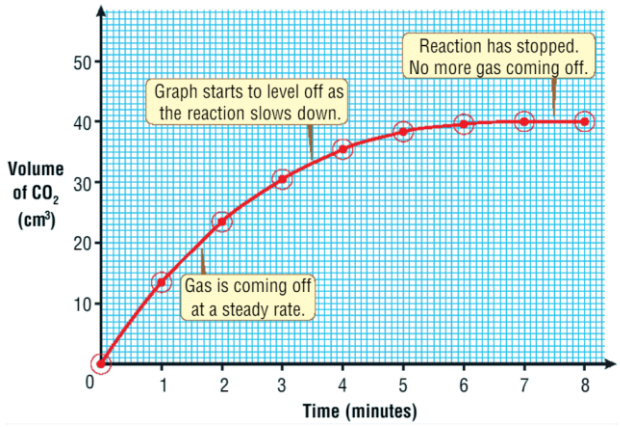
Def^n: The **rate of reaction** is the change in concentration of any one reactant or product in unit time. (THINK SPEED)

EXPERIMENT:

When monitoring the production of oxygen gas from the decomposition of hydrogen peroxide using a manganese (IV) oxide as a catalyst, the following reaction occurs:

$$H_2O_2 \rightarrow H_2O + \tfrac{1}{2} O_2$$

If the volume of oxygen gas produced is measured until the reaction stops, a similar graph to this is obtained:



$$\text{Average Rate} = \frac{\text{Total Gas Produced}}{\text{Total Time Taken}}$$

$$= \frac{40}{7}$$

$$= 5.71\ cm^3/min$$

FACTORS AFFECTING REACTION RATE:

For particles to react, they need to collide with a certain amount of energy.
Def$^{n:}$ An **effective collision** is a collision between particles that has enough energy for a reaction to occur.

1. **Nature of the Reactants:**
   If the reactants are ionic compounds, they have fast reactions. This is because when ionic compounds are dissolved in water, their ionic bonds are already broken, and new bonds can quickly form.
   If the reactants are covalent compounds, they will react slowly. This is because the covalent bonds in the reactants need to be broken beofre the new bonds can be formed.

2. **Particle Size:**
   Smaller particle size means faster reactions because the particles have a higher surface area and will collide more often. This is why powdered chemicals react more quickly than large chips of the same substance.
   Dust Explosion: Needs combustible dust, confined area, air, source of ignition.

3. **Concentration:**
   As the concentration of a reactant increases, so does the rate. This is because the number of collisions between the particles increases. This relationship is directly proportional, i.e., if the concentration is doubled, they rate is also doubled. (See Mandatory Experiment 14A)

4. **Temperature:**
   As temperature of a reaction mixture increases, so does its rate. This relationship is exponential, not directly proportional. (See Mandatory Experiment 14B) This is because increasing the temperature increases both the number of collisions, and the amount of energy in each collision (most significant factor as more collisions will be effective).

5. **Presence of a Catalyst:**
   Def^{n}: A **catalyst** is a substance that alters the rate of a chemical reaction but is not consumed in the reaction. This works by reducing the amount of energy that particles need to collide with in order to react.

PROPERTIES OF CATALYSTS:

1. Catalysts are specific – Each catalyst only acts on one type of reaction.
   Enzymes (biological catalysts made by living cells) show this specificity. The enzyme *catalase* only breaks down hydrogen peroxide. The enzyme *lysozyme* only breaks down the cells walls of bacteria.
2. Only needed in very small amounts.
3. If reactions are reversible, the catalysts alters both the forward reaction rate and the reverse reaction rate the by the same amount.
4. Can be poisoned by certain substances (lead poisons the catalysts in a catalytic converter in a car).

TYPES OF CATALYSIS:

1. **Homogeneous Catalysis:**

Def^n: **Homogeneous catalysis** is catalsis in which both the reactants and the catalyst are in the same phase (no boundary between them).

Example:
Oxidation of Potassium Sodium Tartrate (formula and equations not needed) using hydrogen peroxide and a Cobalt (II) catalyst.

1. Potassium sodium tartrate and cobalt (II) catalyst mixed together. Solution is pink due to cobalt (II).

2. Hydrogen peroxide is added. Fizzing is seen and the solution turns green. Fizzing is due to the fast reaction taking place and the green colour is due to the formation of cobalt (III), which is our intermediate.

3. Fizzing stops and solution turns pink again. This is due to the fact that our products are now formed and our cobalt (II) catalyst has been regenerated.

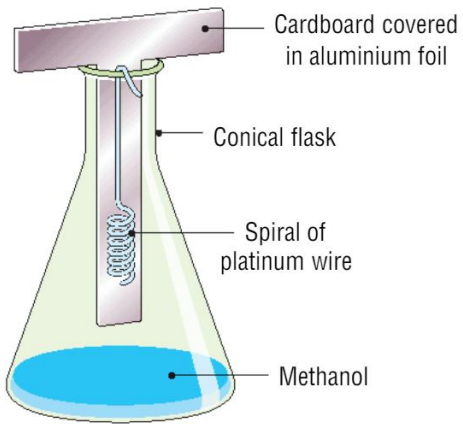
2. **Heterogeneous Catalysis:**

Def^n: **Heterogeneous catalysis** is catalsis in which the reactants and the catalyst are in different phases (there is a boundary between them).

In the following examples, because the reactants are gases, and the catalysts are solids, there is a boundary. Therefore we have heterogeneous catalysis.

Example 1:
Hydrogen gas and oxygen gas react quickly to form water vapour on the surface of a platinum catalyst.

$$2\,H_2 + O_2 \xrightarrow{Pt} 2H_2O$$



Example 2:

Methanol is heated and some vapourises. Red hot platinum wire catalyst inserted. Methanol vapours are oxidised to form methanal, hydrogen gas and carbon monoxide. Carbon monoxide temporarily poisons the catalyst, letting it cool. When catalyst is no longer poisoned, reaction begins again, heating the catalyst to become red hot. Cycle continues until methanol is used up. Also note that the hydrogen produced gets ignited by the hot wire, producing “pops”. Carboard in foil used as a chimney to allow air in and waste gases out.

Example 3:
A catalytic converter is a device in the exhaust system of vehicles that uses catalysts to convert harmful gases to less harmful gases. They have a honeycomb structure inside to give it a very high surface area. The interior is coated in **Platinum, Palladium and Rhodium** catalysts. Hot, harmful carbon monoxide and nitrogen monoxide pass over the catalysts and are converted to the less harmful substances, carbon dioxide and nitrogen gas. The main reaction is: (we normally show the catalyst above the arrow, as it is not used up or formed in the reaction)

$$2CO + 2NO \xrightarrow{Pt/Pd/Rh} 2CO_2 + N_2$$

Lead (Pb) is a catalyst poison, and bonds with the catalyst very strongly. This stops the catalyst working as it blocks the active sites. This is one of the reasons petrol is now “unleaded” i.e. lead is no longer added to increase its octane rating.