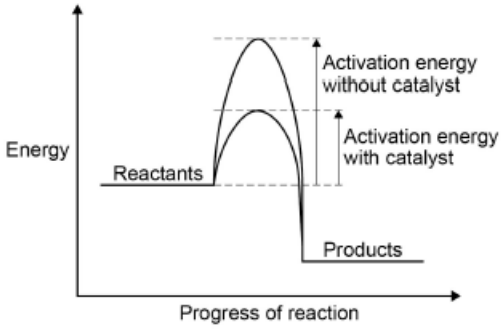
4.6. The rate and extent of chemical change – Knowledge organiser

4.6.1	Rate of reaction
4.6.1.1 Calculating rate of reaction	**Mean rate of reaction = <u>quantity of reactants used</u> / Time taken** **Mean rate of reaction = <u>quantity of product formed</u> / Time taken** The quantity of reactant or product can be measured by the mass in grams or by a volume in cm^3. The units of rate of reaction may be given as g/s or cm^3/s.
4.6.1.2 Factors which affect rate of reaction	Include **concentration, pressure** of gases, **surface area** of solids, **temperature** and **catalysts**. Recall the required practicals investigating effect of changing concentration by measuring gas produced and change in colour
4.6.1.3 Collision theory and activation energy	Chemical reactions only occur when **reacting particles collide** with each other and with **sufficient e**nergy. The minimum amount of energy that particles must have to react is called the **activation energy**. **Increasing** the **concentration** of reactants in solution, the pressure of reacting gases, and the surface area of solid reactants **increases the frequency of collisions** and so increases the rate of reaction. Increasing the temperature **increases the frequency of collisions** and makes the **collisions more energetic**, and so increases the rate of reaction.
4.6.1.4 catalysts	**Catalysts change the rate** of chemical reactions but are **not used up** during the reaction. Different reactions need different catalysts. **Enzymes** act as catalysts in biological systems. Catalysts increase the rate of reaction by providing a different pathway for the reaction that has a **lower activation energy**. 
4.6.2	Reversible reactions and dynamic equilibrium
4.6.2.1 reversible reactions	In some chemical reactions, the products of the reaction can react to produce the original reactants. Such reactions are called **reversible reactions** and are represented: $A + B \rightleftharpoons C + D$ The direction of reversible reactions can be changed by changing the conditions. ammonium chloride $\underset{\text{cool}}{\overset{\text{heat}}{\rightleftharpoons}}$ ammonia + hydrogen chloride

4.6.2.2 energy changes and reversible reactions	If a reversible reaction is exothermic in one direction, it is endothermic in the opposite direction. The same amount of energy is transferred in each case. For example: hydrated copper sulfate (blue) $\underset{\text{exothermic}}{\overset{\text{endothermic}}{\rightleftharpoons}}$ anhydrous copper sulfate (white) + water
4.6.2.3 equilibrium	When a reversible reaction occurs in apparatus which prevents the escape of reactants and products (a closed system), **equilibrium** is reached when the **forward and reverse reactions** occur at exactly the **same rate**.
4.6.2.4 The effect of changing conditions on equilibrium (HT)	The relative amounts of all the reactants and products at equilibrium depend on the conditions of the reaction. If a system is at equilibrium and a change is made to any of the conditions, then the system responds to counteract the change. The effects of changing conditions on a system at equilibrium can be predicted using Le Chatelier's Principle • If a dynamic equilibrium is disturbed by changing the conditions, the position of equilibrium moves to counteract the change.
4.6.2.5 The effect of changing concentration (HT)	If the concentration of one of the reactants or products is changed, the system is no longer at equilibrium and the concentrations of all the substances will change until equilibrium is reached again. If the concentration of a reactant is increased, more products will be formed until equilibrium is reached again. If the concentration of a product is decreased, more reactants will react until equilibrium is reached again.
4.6.2.6 The effect of changing temperature on equilibrium (HT)	If the **temperature** of a system at equilibrium is **increased**: • the relative amount of **products** at equilibrium **increases** for an **endothermic** reaction • the relative amount of products at equilibrium **decreases** for an **exothermic** reaction. If the **temperature** of a system at equilibrium is **decreased**: • the relative amount of **products** at equilibrium **decreases** for an **endothermic** reaction • the relative amount of products at equilibrium **increases** for an **exothermic** reaction.
4.6.2.7 The effect of pressure changes on equilibrium (HT)	For gaseous reactions at equilibrium: • an **increase in pressure** causes the equilibrium position to shift towards the side with the smaller number of molecules as shown by the symbol equation for that reaction • a **decrease in pressure** causes the equilibrium position to shift towards the side with the larger number of molecules as shown by the symbol equation for that reaction.