AQA Rate and Extent of Chemical Change Journey of Knowledge

Context and introduction to the unit: Chemical reactions can occur at vastly different rates. Whilst the reactivity of chemicals is a significant factor in how fast chemical reactions proceed, there are many variables that can be manipulated in order to speed them up or slow them down. Chemical reactions may also be reversible and therefore the effect of different variables needs to be established in order to identify how to maximise the yield of desired product. Understanding energy changes that accompany chemical reactions is important for this process. In industry, chemists and chemical engineers determine the effect of different variables on reaction rate and yield of product. Whilst there may be compromises to be made, they carry out optimisation processes to ensure that enough product is produced within a sufficient time, and in an energy-efficient way. **KS3:** ***Pupils studies chemical reactions in Year 8 as well as energy stores in Year 7 which links to the energy involved in reactions. Pupils will have also experienced making up different concentrations in the acids and alkalis topic in Year 8.***

CORE KNOWLEDGE

5.6.1.1 Calculating rates of reactions- The rate of a chemical reaction can be found by measuring the quantity of a reactant used or the quantity of product formed over time: *mean rate of reaction = quantity of reactant used / time taken* OR *mean rate of reaction = quantity of products formed / time taken*. The quantity of reactant or product can be measured by the mass in grams or by a volume in cm3 . The units of rate of reaction may be given as g/s or cm3 /s. For the Higher Tier, students are also required to use quantity of reactants in terms of moles and units for rate of reaction in mol/s.

5.6.1.2 Factors which affect the rates of chemical reactions - Factors which affect the rates of chemical reactions include: the concentrations of reactants in solution, the pressure of reacting gases, the surface area of solid reactants, the temperature and the presence of catalysts.

5.6.1.3 Collision theory and activation energy - Collision theory explains how various factors affect rates of reactions. According to this theory, chemical reactions can occur only when reacting particles collide with each other and with sufficient energy. 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.
Volume of gas can be measured using a gas syringe, fitted with a delivery tube and fixed with a clamp or, using an upturned measuring cylinder in a water trough, with a delivery tube feeding gas into the tube. Turbidity refers to the cloudiness or haziness of a liquid, particularly water, caused by the presence of suspended particles. This is measured by timing how long it takes for a cross to no longer be visible when placed underneath a reacting mixture, using a stopclock.

5.6.1.4 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.

5.6.2.1 Reversible reaction - 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: $A + B \rightleftharpoons C + D$.

5.6.2.2 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

5.6.2.3 Equilibrium - When a reversible reaction occurs in apparatus which prevents the escape of reactants and products, equilibrium is reached when the forward and reverse reactions occur at exactly the same rate.

I am practically investigating a reversible reaction using hydrous and anhydrous copper sulphate.

Hydrous refers to 'with water', anhydrous refers to 'without water'. Tongs should be used to hold the test tube in place over the Bunsen flame. Squeezing of these tongs actually releases the grip on the test tube, this warning should be given.

Disciplinary knowledge

Required practical activity 11: investigate how changes in concentration affect the rates of reactions by a method involving measuring the volume of a gas produced and a method involving a change in colour or turbidity. This should be an investigation involving developing a hypothesis. AT skills covered by this practical activity: chemistry AT 1, 3, 5 and 6.

Vocabulary

Rate, equilibrium, reversible, reactant, product, catalyst, collisions, temperature, concentration, surface area, mean, closed system, endothermic, exothermic.

CORE KNOWLEDGE

5.6.2.4 The effect of changing conditions on equilibrium (HT only) - 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.

5.6.2.5 The effect of changing concentration (HT only) - 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.

5.6.2.6 The effect of temperature changes on equilibrium (HT only) - 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.**

5.6.2.7 The effect of pressure changes on equilibrium (HT only) - 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.**

Reading is Power

Where next?

If pupils go on to study AS Chemistry they will develop their knowledge of rates of reaction in Physical Chemistry: 3.1.9 Rate Equations as well as 3.1.10 Equilibrium constant.