Beatty Secondary School
Science Department (Chemistry Unit)
Chemistry 6092

Name: _____ ( ) Date: _____

Class: 4E___

TOPIC: SPEED / RATE OF REACTION (WORKSHEET 1) – FACTORS

Learning Objectives:

(a) Describe the effect of concentration, pressure, particle size and temperature on the speeds of reactions and explain these effects in terms of collisions between reacting particles.

(b) Define the term catalyst and describe the effect of catalysts (including enzymes) on the speeds of reactions.

(c) Explain how pathways with lower activation energies account for the increase in speeds of reactions.

(d) State that some compounds act as catalysts in a range of industrial processes and that enzymes are biological catalysts.

Multiple-Choice Questions

1 Which factor does **not** affect the speed of a chemical reaction?

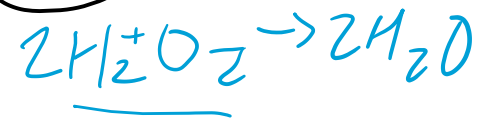
A concentration of reactant **B** colour of reactant
C surface area of reactant **D** temperature of reactant (**B**)

2 Which solution would react the fastest if added to the same amount of magnesium?

A 4 g of acid in 50 cm^3 of water **B** 10 g of acid in 100 cm^3 of water
C 40 g of acid in 250 cm^3 of water **D** 100 g of acid in 1000 cm^3 of water
(**C**)

3 Which statement best explains why coal dust forms an explosive mixture with air?

A Coal dust catalyses the explosion.
B Coal dust has a large surface area.
C Crushing coal breaks chemical bonds.
D Crushing coal releases hydrogen from compounds in coal. (**B**)



4 Dilute sulfuric acid reacts with copper(II) oxide to form copper(II) sulfate and water. What would **not** alter the rate of reaction?

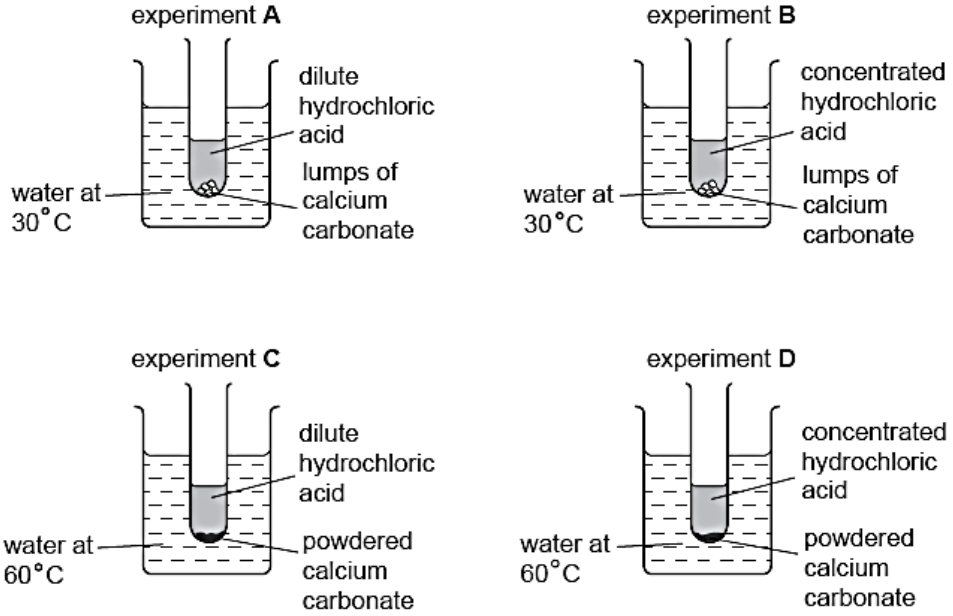
A The concentration of the sulfuric acid.
B The pressure at which the reaction takes place.
C The size of the particles of copper(II) oxide.
D The temperature of the reacting mixture. (**B**)

5 A teacher wanted to demonstrate a reaction between an acid and a solid reactant, but it was too violent to be safe. Which of these changes would make the reaction **safer** to demonstrate?

	acid temperature	acid concentration	size of solid reactant
A	lower	lower	larger
B	lower	lower	smaller
C	higher	higher	larger
D	higher	higher	smaller

(**A**)

6 Which reaction is the fastest?



(**D**)

7 Which factor decreases the activation energy of a reaction?

A addition of a catalyst
B increase in concentration of reactants
C increase in pressure
D increase in temperature

(**A**)

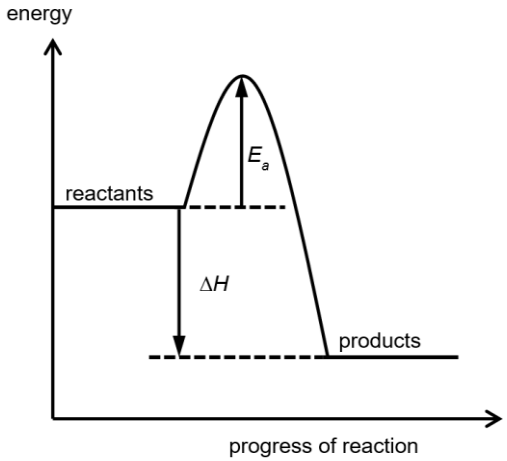
8 The oxide of an element J increases the rate of decomposition of hydrogen peroxide. At the end of the reaction the oxide J is chemically unchanged.

Which details are those of J?

	proton number	mass number
A	18	40
B	20	40
C	25	55
D	53	127

(**C**)

9 The enthalpy diagram shows an uncatalysed, exothermic reaction.



The reaction was repeated in the presence of a catalyst. What effect does the catalyst have on the activation energy, E_a, and the enthalpy change, ΔH?

	E_a	ΔH
A	decreases	decreases
B	decreases	unchanged
C	increases	increases
D	unchanged	decreases

(**B**)

10 In the reaction between zinc and hydrochloric acid, the following changes could be made to the conditions.

1 increase in concentration of acid
2 increase in particle size of the zinc
3 increase in pressure on the system
4 increase in temperature of the system

Which pair of changes will increase the rate of reaction?

A 1 and 2 **B** 1 and 4
C 2 and 3 **D** 3 and 4 (**B**)

Structured Questions

11 Using knowledge of reacting particles, explain each of the observations.

(a) Nitrogen reacts more vigorously with hydrogen at pressures above 200 atm than at 1 atm.

As the pressure increases, the nitrogen and hydrogen molecules are forced closer together in a smaller volume and the number of particles per unit volume increases. As such, the particles collide more frequently and the frequency of effective collisions increases, increasing the rate of reaction.

(b) Placing a light stick in warm water makes it glow more brightly.

As the temperature increases in warm water, the reacting particles in the light stick gain more kinetic energy and the particles move faster, colliding more frequently. As such, there is an increase in the number of reacting particles colliding with energy equals to or greater than activation energy and the frequency of effective collisions increases, increasing the rate of reaction. This causes the light stick to glow more brightly.

(c) When a piece of raw liver is dropped into hydrogen peroxide, there is rapid reaction and oxygen gas is liberated.

The enzymes present in liver act as biological catalysts to provide an alternative reaction pathway with a lower activation energy than the uncatalysed reaction. As such, there is an increase in the number of reacting particles colliding with energy equals to or greater than activation energy and the frequency of effective collisions increases, increasing the rate of reaction of the decomposition of hydrogen peroxide.

12 A student carried out a series of experiments to measure the time it took for an indigestion tablet to react completely with mixtures of hydrochloric acid and water.

Her results are tabled below.

experiment number	volumes mixed / cm^3		temperature at start / °C	time taken to react completely / s	
	acid	water	acid + water	crushed tablet	whole tablet
1	10	50	19	34	39
2	20	40	20	28	33
3	30	30	28	18	24
4	30	30	20	24	28
5	20	40	19	28	32
6	10	50	29	28	32

(a) Explain how the student would know that the reaction between the tablet and acid has been completed.

The reaction has been completed when the tablet has dissolved completely.

(b) Explain why the total volume of the acid-water mixture was kept constant in all the experiments.

This is to ensure that the volume of the solution used is constant, so that the concentration of the acid in each experiment is proportional to the volume of acid used.

(c) Use the data in the table to explain whether the speed of the reaction between the acid and the tablets was ~~**increased**~~, **remained the same** or **decreased** by

(i) crushing the tablet, speed of reaction: **increased**

explanation

Comparing all experiments between the time taken for the crushed tablet and the time taken for the whole tablet, the time taken for the crushed tablet is about 4 to 5s shorter than the whole tablet. This can be seen from Experiment 1 that the time taken is 34s for crushed tablet, whereas for the whole tablet is 39s.

(ii) increasing the temperature of mixture, speed of reaction: **increased**

explanation

Comparing Experiments 1 and 6 as well as 3 and 4, the time taken for complete reaction is shorter in the experiment with the higher temperature (Experiment 6 of 28s at 29 °C compared to Experiment 1 of 34s at 19 °C, Experiment 4 of 24s at 20 °C compared to Experiment 3 of 18s at 28 °C). A shorter time taken would imply a faster rate of reaction.

(iii) increasing the concentration of the acid, speed of reaction: **increased**

explanation

Comparing Experiments 1 and 5 as well as 2 and 4, the time taken for complete reaction is shorter in the experiment with the higher concentration of acid (Experiment 5 of 28 s using 20 cm^3 of acid compared to Experiment 1 of 34 s using 10 cm^3 of acid, Experiment 4 of 24 s using 30 cm^3 of acid compared to Experiment 2 of 28 s using 20 cm^3 of acid). A shorter time taken would imply a faster rate of reaction.

(d) How would you recommend that these tablets be taken so as to give the quickest relief from an acid stomach?

These tablets should be crushed to ensure a larger surface area to quicken the relief from an acid stomach.

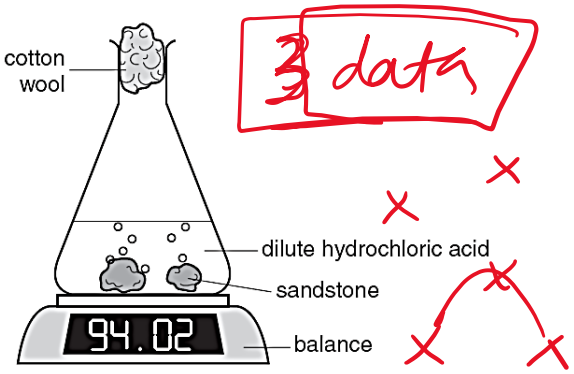
13 Sandstone contains calcium carbonate and sand, which is mainly silicon dioxide. **Excess** sandstone was reacted with dilute hydrochloric acid.

$$2HCl + CaCO_3 \rightarrow CaCl_2 + CO_2 + H_2O$$

The rate of reaction was followed by measuring the mass lost during the reaction.

This is a table of the results.

time / minutes	total mass lost / g
0	0.00
4	0.18
8	0.30
12	0.38
16	0.44
20	0.48
24	0.51



(a) Use information from the table to show that the rate of reaction decreased.

From 0 to 4 minutes, the loss in mass is 0.18 g. From 12 to 16 minutes, the loss in mass is 0.06 g. From 20 to 24 minutes, the loss in mass is 0.03 g. As time progresses, the total mass lost decreases and this shows that the rate of reaction has decreased.

(b) Explain, using ideas about particles colliding, why the rate of reaction decreased.

As the reaction proceeds, hydrochloric acid is constantly used up and there is lower concentration of acid available. As such, the number of acid particles per unit volume decreases, resulting in less frequent collisions between particles. The frequency of effective collision decreases, decreasing the rate of reaction.

(c) In a second experiment, 10 g of sandstone was added to excess hydrochloric acid. The total mass lost was 0.88 g. Calculate the percentage by mass of calcium carbonate in the sandstone.

No of moles of CO_2 = $\frac{0.88}{44}$ = 0.0200 mol

Comparing mole ratio:

CO_2	: $CaCO_3$
1	: 1
0.0200	: 0.0200

Mass of calcium carbonate = 0.02 × (40 + 12 + 48) = 2.00 g

Percentage of calcium carbonate = $\frac{2}{10}$ x 100 = 20.0%

14 Chemical reactions need activation energy.

(a) State the meaning of *activation energy* and explain in terms of chemical bonds, what activation energy is used for in a chemical reaction.

Activation energy is the minimum amount of energy that reactant particles must possess in order for a chemical reaction to occur. Activation energy is the minimum amount of energy required to break the bonds between reactant particles during collisions.

(b) Aqueous hydrogen peroxide was decomposed into water and oxygen in two separate experiments. One experiment used 0.1 g of manganese(IV) oxide as the catalyst and the other used 0.1 g of copper(I) oxide as the catalyst. All other conditions were the same in the two experiments.

(i) Write the equation for the decomposition of hydrogen peroxide.

$2H_2O_2$ (aq) → O_2(g) + $2H_2O$(*l*)

(ii) Define the term *catalyst*.

A catalyst is a substance that speeds up the rate of reaction without being chemically changed at the end of the reaction.

(iii) The reaction with copper(I) oxide was faster than that with manganese(IV) oxide. State and explain the difference in activation energy for the two reactions.

With copper(I) oxide catalyst, the reaction is able to proceed with a pathway of a lower activation energy than an uncatalysed reaction. Hence, more reacting particles will possess energy equals to or greater than activation energy. This increases the frequency of effective collisions, resulting in faster rate of reaction with copper(I) oxide catalyst.

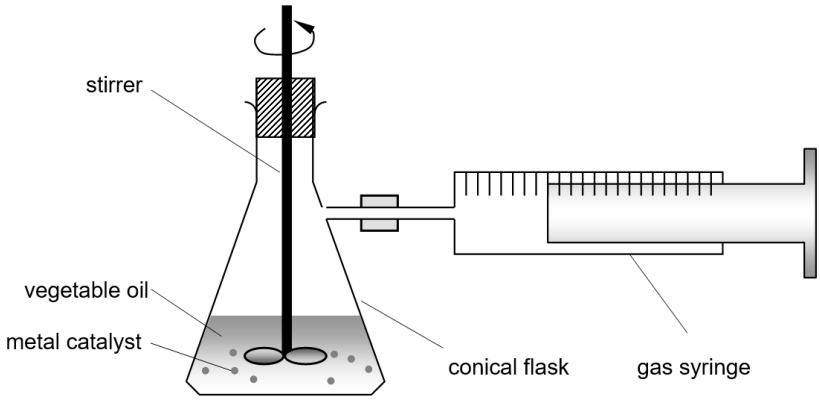
(iv) Determine the mass of copper(I) oxide catalyst obtained at the end of the reaction. Briefly explain your answer.

0.1 g. Catalysts are not consumed in the chemical reaction as they increase the rate of reaction without being chemically changed.

(v) With reference to the Periodic Table, explain what feature is the common for both catalysts.

They are metal oxides / compounds containing transition metals.

15 Vegetable oil reacts with hydrogen gas to produce margarine. The reaction is catalysed by nickel metal. The diagram shows how this reaction was investigated in the laboratory. The whole apparatus, including the gas syringe, is filled with hydrogen at the start of the reaction.



(a) The metal catalyst can be in the form of a fine powder or as small lumps.

(i) Which form of catalyst has the larger surface area?

fine powder

(ii) Explain, using the idea of colliding particles, why the form you have chosen in **(a)(i)** results in a greater rate of reaction.

Fine powder has a larger surface area than small lumps of catalyst. As such, there is a greater exposed surface area of contact, resulting in particles colliding more frequently. Hence, the frequency of effective collision increases, increasing the rate of reaction.

(b) State the measurements you would make which would enable you to follow the rate of reaction.

Gas syringe and stopwatch are needed. The gas syringe is used to measure the volume of gas used up at regular time intervals.

(c) Suggest a reason why nickel is likely to be a better catalyst for this reaction than magnesium.

Nickel is a transition metal and can provide an alternative pathway of lower activation energy than magnesium.

(d) Margarine reacts slowly with oxygen when left exposed to air. This reaction spoils the taste of the margarine and is caused by enzymes in microorganisms. State what is meant by the term *enzyme*.

An enzyme is a biological catalyst that increases the rate of reaction, without itself being chemically changed. In this case, the enzymes speeds up the decomposition of the compounds in margarine.