Western Cape Government

Education

SUBJECT and GRADE	Physical Sciences Gr 12
TERM 2	*Week 5*
TOPIC	Rates of Reaction
AIMS OF LESSON	**To understand the <u>rates of reaction</u> and factors affecting it.** The Gr.12 exam guidelines require you to be able to: • Define reaction rate as the change in concentration of reactants or products per unit time. • Calculate reaction rate from given data using the formula $rate = \frac{\Delta c}{\Delta t}$ But questions may also include calculations of rate in terms of change in mass /volume or moles per time. • List the factors that affect the rate of chemical reactions, i.e. nature of reacting substances, surface area, concentration, pressure of gases, temperature and the presence of a catalyst. • Explain in terms of the collision theory how the various factors affect the rate of chemical reactions. The collision theory is a model that explains reaction rate as the result of particles colliding with a certain minimum energy to form products. • Answer questions and interpret data (tables or graphs) on different experimental techniques for measuring the rate of a given reaction. • Define the term (positive) catalyst as a substance that increases the rate of a chemical reaction without itself undergoing a permanent change. • Interpret graphs of distribution of molecular energies (number of particles against their kinetic energy also known as Maxwell-Boltzmann curves) to explain how a catalyst, temperature and concentration affect rate. • Explain that a catalyst increases the rate of a reaction by providing an alternative path of lower activation energy. It therefore decreases the net activation energy. • Use a graph showing the distribution of molecular energies (number of particles against their kinetic energy) to explain why only some molecules have enough energy to react, and hence how adding a catalyst and heating the reactants affects the rate.

RESOURCES	**Paper based resources**	**Digital resources**
	• *Read through the topic on Rates of reaction in your textbook or study guide that you have on hand.* • *Consult the Examination Guidelines (page 19-20)* • *In Mind the Gap books read (pages 54-77)* • *Use Past NSC Examination papers (refer to question 5 paper 2)*	*use the following digital resources:* • *WCED ePortal* • *HeyScience App for Physical Sciences* • *Past NSC Examination papers (refer to question 5)* • *https://youtu.be/NhdtqnEfa9w* • *https://youtu.be/ExHV_cFWYSM?t=311* • *https://youtu.be/m_9bpZep1QM?t=186* • *https://youtu.be/Gl6LVl7oAIU?t=67* • *https://youtu.be/-4HXaUBbv04?t=163* • *https://youtu.be/6mAqX31RRJU?t=220*
INTRODUCTION	• *You do have some pre- knowledge and are reminded of the following:* 1. Be mindful of acid reactions which produce a gas (since reaction rates are reactions which takes place in an open system) eg a) Acid + metal → salt + hydrogen gas and b) Acid + carbonate → salt + water + carbon dioxide 2. You should be able to balance chemical equations 3. Define what a "catalyst" is • Read on the reactivity of metals from Gr 10 especially (comparing reactivity of Mg vs Zn) • *The purpose of the lesson links to further learning and/or functioning in the world.* Application of rates of reaction in Industrial processes: How can you increase the speed of production of products so companies can sell the products quickly to make a profit.	
CONCEPTS AND SKILLS	• Use the Maxwell-Boltzmann curve as set out in your text book. The increase in the curve shows that the number of particles increased. As you move from left to right on the x-axis the number of collisions increase and also the reaction rate. MTG pg 55 – 58	• Study the graph and redraw similar graphs in your note book.

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	• The study of Rates of reaction takes place in an open system unlike chemical equilibrium which takes place in a closed system. When measuring the rate of a reaction we have external factors which will influence the reaction.
	• Factors that affect the rate of a reaction: temperature, concentration, surface area, catalyst, nature of reactants.
	• Collision Theory: For any reaction to occur two things are necessary:
	  1. Particles must have sufficient activation energy to overcome forces of repulsion
	  2. Particles must have correct orientation.
	• Consider the reaction $Zn + 2HC\ell \rightarrow ZnC\ell_2 + H_2$
	  a) If the reactant side is considered, the mass of the content is measured every 10, 20 or 30 seconds. A graph of mass vs time and mass lost vs time are sketched.
	  b) If the product side is considered, the volume of gas produced is measured say every 10, 20 or 30 seconds. A graph of volume vs time is then sketched
	• The graphs above are not straight line. Therefore, in order to determine the rate of the reaction, the gradient of the tangent line is determined.
	Rate of reaction = gradient of tangent line.
		• Write down an Explanation of the Maxwell-Boltzmann curve
		
		Can you:
		• Explain in terms of the collision theory how temperature and catalyst affects the rate of reaction
		• Explain what an open system is
		• Define "rate of reaction"
		• Discuss the difference in the graph of mass vs time AND mass lost vs time
		• Explain what the gradient of the tangent line to the graph represents

Mass lost

a) At t_0: gradient is steepest therefore, rate is fastest because $[HC\ell]$ is maximum.

b) Between t_0 and t_1 slope decreases therefore rate decreases because $[HC\ell]$ decreases.

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	• The factors listed above will have the following effects on the reaction rate. 1) When the temperature increases, the reaction rate will also increase because the kinetic energy of the particles will increase and result in more collisions. 2) If the concentration of the reactants increases, the reaction rate will increase as a higher concentration speeds up the reaction. 3) If the surface area increases the rate of the reaction will increase because the area of contact is greater. 4) A catalyst is a chemical substance that speeds up a reaction. 5) The nature of the reactants refers to the reactivity of the reactant. E.g. Mg reacts faster than Cu. • Do calculations from your text books on Rate of Reaction using any of the following equations: Rate of reaction $= \frac{\Delta conc}{\Delta time}$ (unit: mol.dm^{-3}.s^{-1}) OR Rate of reaction $= \frac{\Delta mass}{\Delta time}$ (unit: g.s^{-1}) OR Rate of reaction $= \frac{\Delta mol}{\Delta time}$ (unit: mol.s^{-1}) OR Rate of reaction $= \frac{\Delta vol}{\Delta time}$ (unit: dm^3.s^{-1}) NB. In the question, the examiner will give you the unit of the rate at which the reaction must be calculated. The unit will guide you as to which of the above equation should be used.	• Interpret information from a table / graph. • Calculate rate of reactions
ACTIVITIES/ASSESSMENT	*Do the activities/assessment in your text books or study guides.* • Work through the examples and Activities from Mind The Gap (pages 58 – 77) • Use previous NSC question papers and do question 5 in paper 2.	

CONSOLIDATION	Now try the following questions as Consolidation
	QUESTION 1

The apparatus shown below is used to investigate the rate at which hydrogen gas is produced when a certain amount of magnesium reacts with an excess of a dilute hydrochloric acid solution.
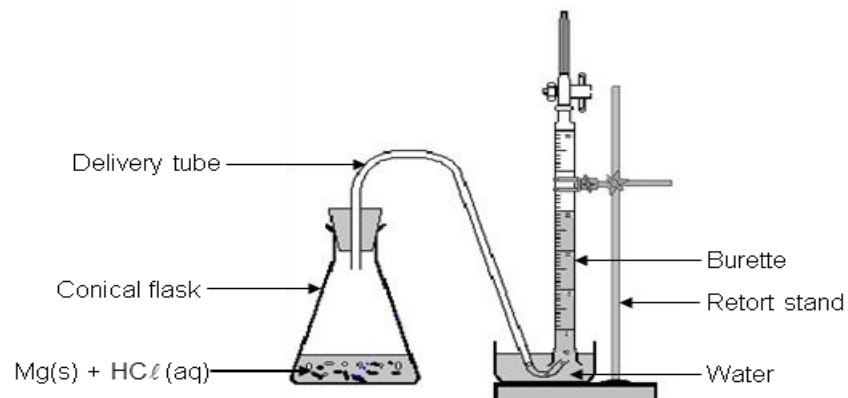
The reaction that takes place is represented by the following balanced equation:

$$2HC\ell(aq) + Mg(s) \rightarrow MgC\ell_2(aq) + H_2(g)$$
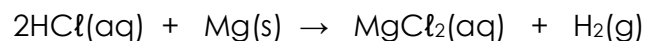
Two experiments are conducted using the apparatus above. The conditions for each experiment are given in the table below.

	Experiment 1	**Experiment 2**
Magnesium	granules	granules
Hydrochloric acid	$0,1$ mol.dm^{-3}	$0,05$ mol.dm^{-3}
Temperature($^{\circ}$C)	25 $^{\circ}$C	25 $^{\circ}$C

1.1   Write down a hypothesis for this investigation.   (1)

1.2   Why should the learners ensure that equal amounts of magnesium powder are used in each of the two experiments?   (1)

After completing the investigation, the learners represent the results obtained during each experiment on the graph below.

Graph of volume of hydrogen gas versus time
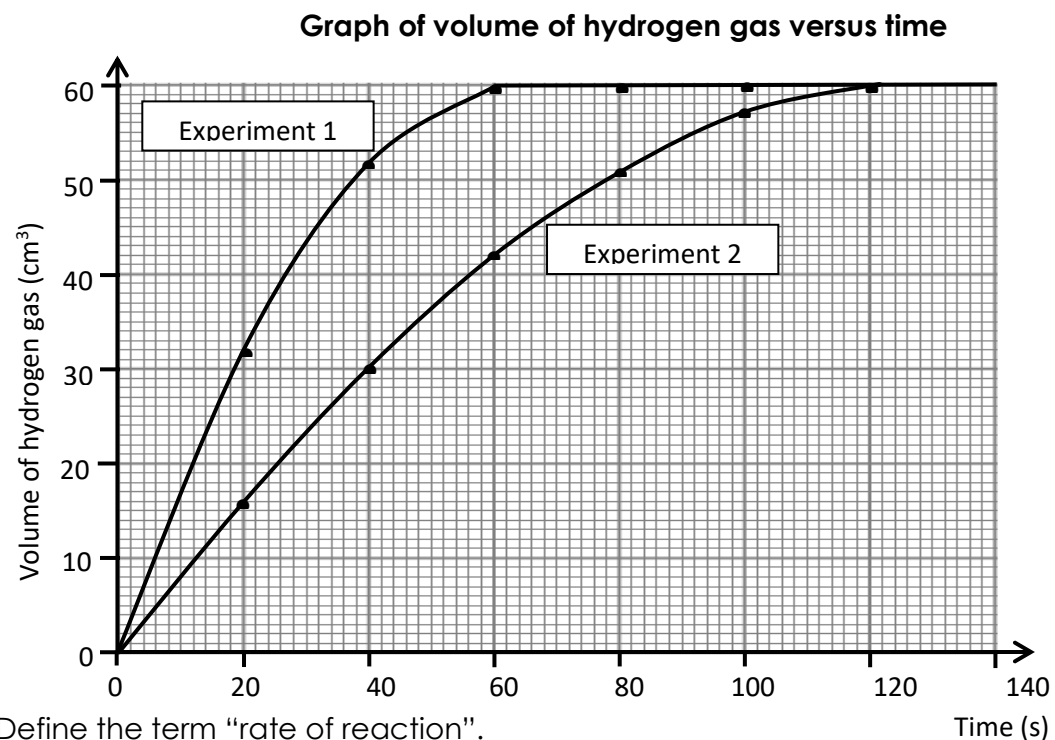
1.3 Define the term "rate of reaction". (2)

1.4 Calculate the average rate of reaction (in $cm^3.s^{-1}$), for **Experiment 2** in the first minute. (3)

1.5 How does the rate of reaction for **Experiment 1,** compare to that of **Experiment 2**? Write down only HIGHER THAN, LOWER THAN OR EQUAL TO. (1)

1.6 Motivate your answer to QUESTION 1.5 above, by referring to the shapes of the graphs and using the Collision Theory. (3)

1.7 Calculate the mass of magnesium that was used in each of the experiments. Assume that 1 mole of the hydrogen gas occupies a volume of 24,04 dm^3 at 25°C. (5)

[16]

QUESTION 2

A group of learners use the reaction between magnesium and hydrochloric acid to investigate one of the factors that affects reaction rate. The equation below represents the reaction that takes place.

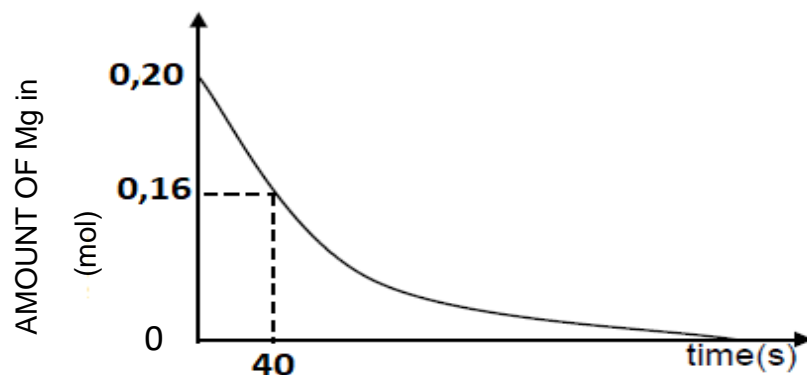$$Mg(s) + 2HC\ell(aq) \rightarrow MgC\ell_2(aq) + H_2(g)$$
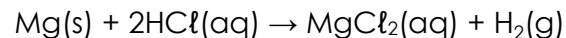
They add a certain mass of magnesium granules to excess DILUTE hydrochloric acid and measure the mass of magnesium used per unit time.
The learners then repeat the experiment using the same mass of magnesium granules to excess CONCENTRATED hydrochloric acid.

2.1   Define the term *reaction rate*.   (2)

2.2   Give a reason why the acid must be in excess.   (1)

2.3   Write down a suitable hypothesis for this investigation.   (2)

The results obtained for the reaction using DILUTE Hydrochloric acid are represented in the graph below.

	2.4 Calculate the average rate of the reaction (in g·s⁻¹) during the first 40 s. (4)

2.5 Copy the above graph into your ANSWER BOOK. On the same set of axes, use a dotted line to show the curve that will be obtained when concentrated hydrochloric acid is used. Label that curve **P** (no numerical values are required)   (2)

2.6 Using the COLLISION THEORY explain how an increase in concentration affects the rate of the reaction.   (2)
[13] |
| VALUES | *The values relevant to the topic*
- In the world of industry, products need to be produced as fast as possible, so the company can sell these to make a profit. But products should not be produced too fast, as the bond formed will not be strong. Therefore, it is important to obtain the best condition(s)
- Every reaction requires activation energy. This requires some heat to be introduced into the system. But this could entail burning more coal which will increase the greenhouse gasses. To reduce the activation energy and the amount of coal to be burnt, a suitable catalyst is added. A suitable catalyst is like a fingerprint, as one catalyst is linked to one industrial process. More of this will be discussed when we do the section on FERTILIZERS. |