education

DEPARTMENT: EDUCATION
MPUMALANGA PROVINCE

GERT SIBANDE DISTRICT

GRADE 12

PHYSICAL SCIENCES TOPIC TEST

TOPIC: REACTION RATES

APRIL 2023

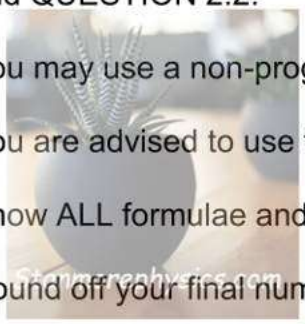
MARKS: 50

TIME: 1 hour

This question paper consists of 12 pages including the data sheet

INSTRUCTIONS AND INFORMATION

1. This question paper consists of FIVE questions. Answer ALL the questions in the ANSWER BOOK.
2. Start EACH question on a NEW page in the ANSWER BOOK.
3. Number the answers correctly according to the numbering system used in this question paper.
4. Leave ONE line between two sub questions, for example between QUESTION 2.1 and QUESTION 2.2.
5. You may use a non-programmable calculator.
6. You are advised to use the attached DATA SHEETS.
7. Show ALL formulae and substitutions in ALL calculations.
8. Round off your final numerical answers to a minimum of TWO decimal places.
9. Write neatly and legibly.



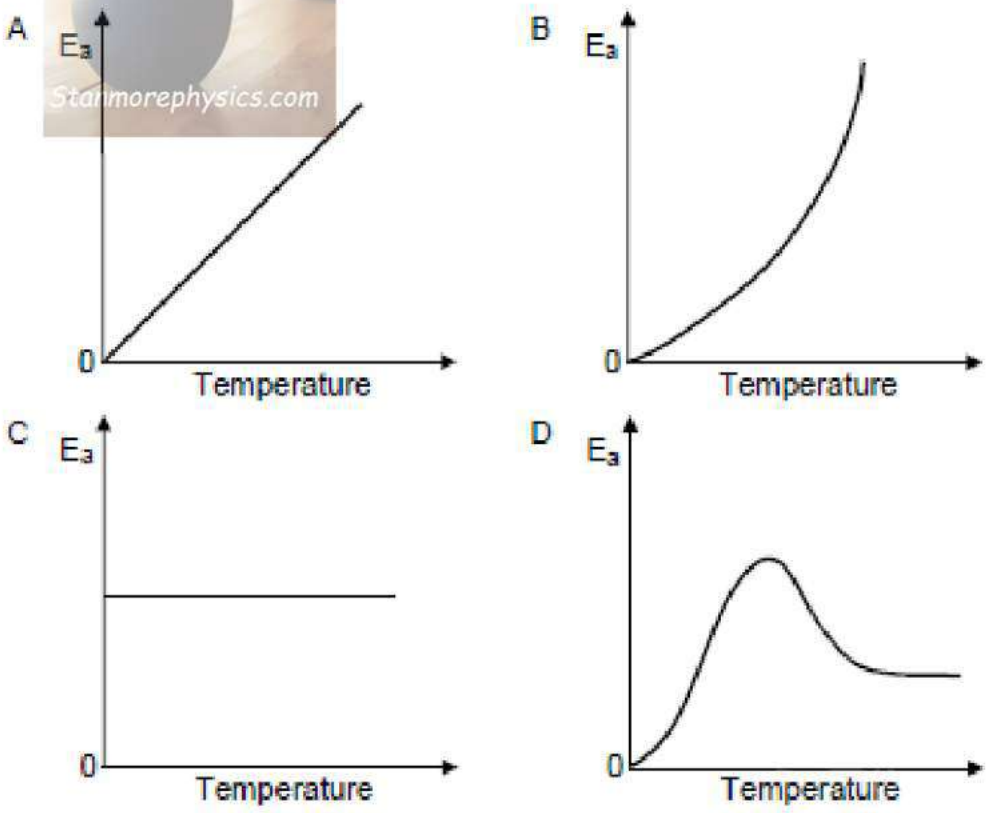
QUESTION 1

Four options (A – D) are given as possible answers to the following questions. Choose the answer and write only the letter (A – D) next to the question number (1.1 – 1.2)

1.1 The rate of a chemical reaction can be defined as …

A. The rate of change in concentration of reactants or products per unit time.
B The change in concentration of reactants or products per unit time.
C. The change in amount of reactants or products per unit time.
D. The rate of change in amount of reactants or products per unit time. (2)

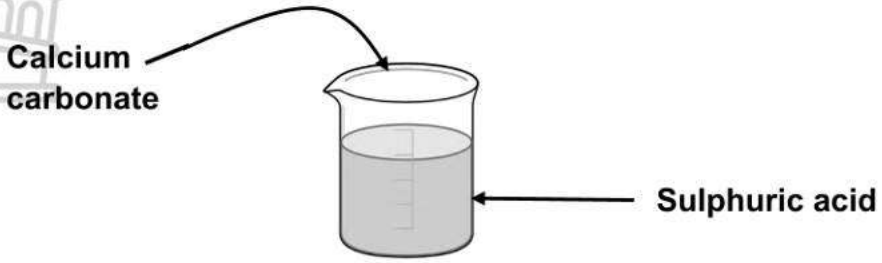
1.2 Which ONE of the following graphs shows the relationship between activation energy (E_a) of a reaction and temperature?



(2)
[4]

QUESTION 2

Grade 12 learners uses the reaction of EXCESS sulphuric acid (H_2SO_4) with calcium carbonate ($CaCO_3$) to investigate some of the factors which influences the reaction rate.



The balanced equation for the reaction is:

$$CaCO_3\,(s) + H_2SO_4\,(q) \longrightarrow CaSO_4\,(aq) + CO_2\,(g) + H_2O\,(l)$$

The SAME volume of sulphuric acid and mass of calcium carbonate were used in each of the four experiments. The reaction conditions and temperature readings before and after completion of the reaction in each experiment are summarised in the table below.

Experiment	REACTION CONDITIONS				Reaction Time (s)
	Concentration of H_2SO_4 $(mol.dm^{-3})$	Temperature (°C)		State of division of $CaCO_3$	
		Before	After		
1	0,2	19	28	lumps	50
2	0,2	19	29	powder	10
3	0,5	19	31	powder	6
4	0,2	19	26	lumps	8

2.1 Write down TWO conditions required for a chemical reaction to take place. (2)

2.2 Is the reaction between sulphuric acid and calcium carbonate EXOTHERMIC or ENDOTHERMIC? (1)

2.3 Which **experiment 1** or **2** has a higher reaction rate?

Use the collision theory to explain the answer. (3)

2.4 The learners compare the results of **Experiments 1** and **3** to draw a conclusion regarding the effect of concentration on the reaction rate. Give a reason why this is not a fair comparison. (1)

2.5 The reactions in both **experiments 3** and **4** run to completion.

How will the yield of carbondioxide gas (CO_2) produced in **experiment 4** compare to that of **experiment 3**? Write down SMALLER THAN, LARGER THAN or EQUAL TO. (1)

2.6 Give a reason for the answer to QUESTION 2.5 (1)

2.7 How does the rate of the reaction in **Experiment 4** compare to that in **Experiment 1**? Write down FASTER THAN, EQUAL TO or SLOWER THAN. Write down the factor responsible for the difference in the reaction rates. (2)

[11]

QUESTION 3

An investigation was performed to study one of the factors which affect the rate of a chemical reaction. The reaction between magnesium (Mg) and EXCESS hydrochloric acid (HCl) solution was used. The chemical reaction which took place is represented by the balanced chemical equation below.

$$Mg\ (s) + 2HCl\ (aq) \longrightarrow MgCl_2\ (aq) + H_2\ (g)$$

5,0 g of magnesium was used in both experiments **A** and **B**.

The conditions used during the investigations are shown in the table below.

	State of Mg (s)	Concentration of HCl ($mol \cdot dm^{-3}$)	Temperature of HCl (°C)	Reaction time(s)
Experiment A	Ribbon	0,2	25	36
Experiment B	Ribbon	0,2	35	16

3.1 Which factor influencing the reaction rate was being investigated? (1)

3.2 Write down the investigative question for this investigation. (1)

3.3 Calculate the rate at which the hydrochloric acid reacts in **experiment B** in $mol.s^{-1}$ (5)

3.4 On the same set of axes, draw sketch graphs of the number of molecules versus kinetic energy (also known as a Maxwell-Boltzmann distribution curve) for each of experiment **A** and experiment **B**.

- Label both axes.
- Clearly label each graph as experiment **A** and experiment **B**. (2)

3.5 Use collision theory to explain the difference between the two graphs in QUESTION 3.4 (4)

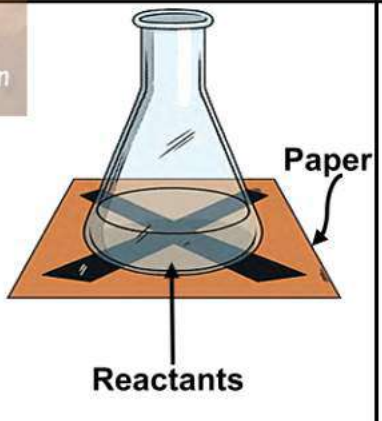
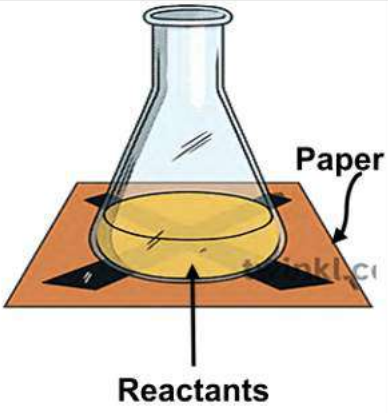
[13]

QUESTION 4

The reaction between sodium thiosulphate and hydrochloric acid is used to investigate one of the factors that affect the reaction rate. The balanced equation for the reaction is:

$$Na_2S_2O_3\,(aq) + 2HCl\,(aq) \longrightarrow 2NaCl\,(aq) + SO_2(aq) + S(s) + H_2O(l)$$

In **experiment 1**, sodium thiosulphate is added to hydrochloric acid in a conical flask that is placed over the cross drawn over a piece of paper. The hydrochloric acid is in EXCESS. The time taken for the cross to become invisible when viewed from the top, is recorded. The same steps are repeated in **experiment 2** but under different conditions, as indicated in the table below.

REACTION CONDITIONS	**EXPERIMENT 1**	**EXPERIMENT 2**
		
Volume of $Na_2S_2O_3$ (aq) (cm^3)	**30**	**35**
Volume of $H_2O(l)$ (cm^3)	**5**	**0**
Volume of HCl (aq) (cm^3)	**5**	**5**
Reaction time (s)	**65**	**50**

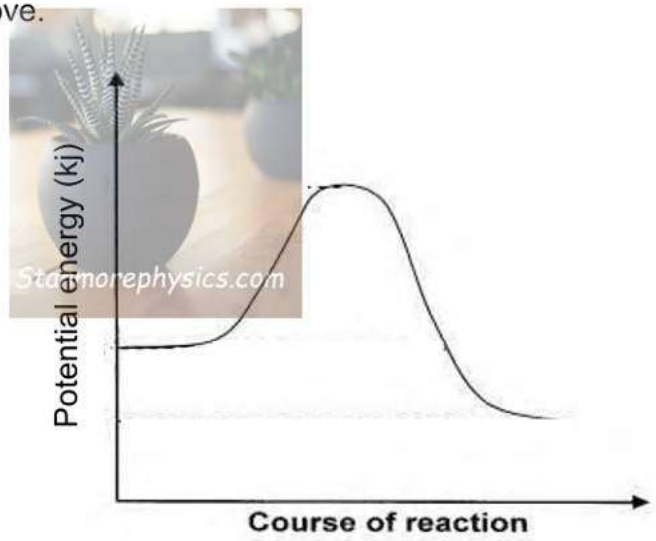
4.1 In which **EXPERIMENT 1** or **2** is the reaction rate faster? (1)

4.2 Use the collision theory to explain the answer in QUESTION 4.1 (3)

4.3 The mass of the sodium thiosulphate used in **EXPERIMENT 1** is 8,0 g. Calculate the maximum volume of SO_2 (g) produced in **EXPERIMENT 1** if the reaction takes place at STANDARD CONDITIONS. (4)

4.4 Each of the conical flasks above and its contents is SEPARATELY placed on the weighing balance. The mass of flask and its contents is then measured at regular intervals of time. Using the same set of axes, sketch a graph of the mass of the flask and its contents versus time for both experiments. Clearly Label the graphs as **EXPERIMENT 1** and **EXPERIMENT 2.** (2)

4.5 The graph below shows the changes in the potential energy of the reaction above.



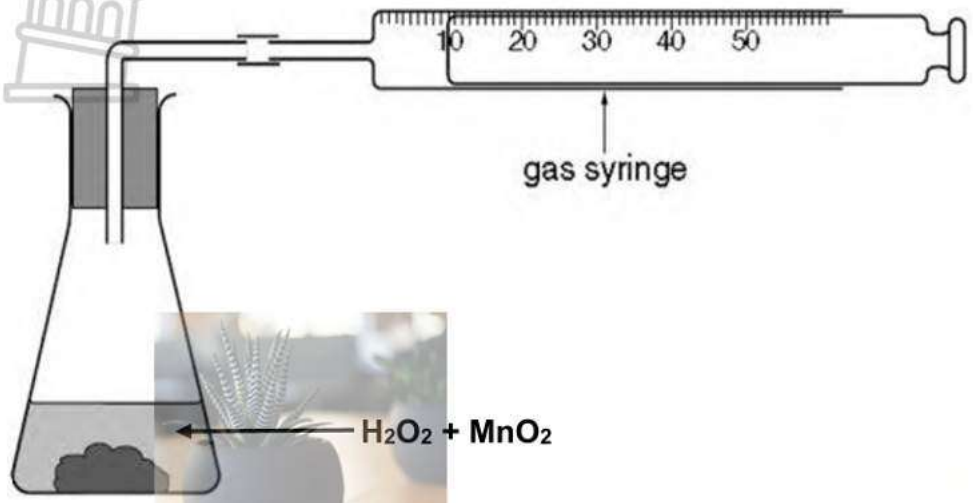
4.5.1 Redraw the above graph in your answer book. On the graph, use a broken line to indicate what would be the reaction path if a catalyst is added to the reaction above. (2)

4.5.2 Use the graph drawn in QUESTION 4.5.1 and the collision theory to explain how the catalyst influences the rate of a chemical reaction. (3)

[15]

QUESTION 5

An experiment is carried out to determine the rate of a chemical reaction, for the decomposition of hydrogen peroxide (H_2O_2) in presence of manganese (iv) oxide (MnO_2). The following set up of apparatus is used.



Hydrogen peroxide decomposes according to the following balanced chemical equation.

$$2H_2O_2\,(aq) \longrightarrow 2H_2O\,(aq) + O_2\,(g)$$

The volume of oxygen gas produced is measured at regular intervals of time, and the results obtained are recorded as shown in the table below.

Experiment	Time (seconds)	Volume of oxygen gas (cm^3)
1	0	0
2	20	6
3	40	30
4	60	42
5	80	50
6	100	57
7	120	60
8	140	60

5.1 The reaction which takes place involves activation energy.

Define the term activation energy. (1)

5.2 Use the results in the table above and the ATTACHED graph paper to plot a graph of volume of oxygen gas versus time. (3)

5.3 Use the graph:

5.3.1 To determine the volume of oxygen gas produced at time (t) = 56 s. (1)

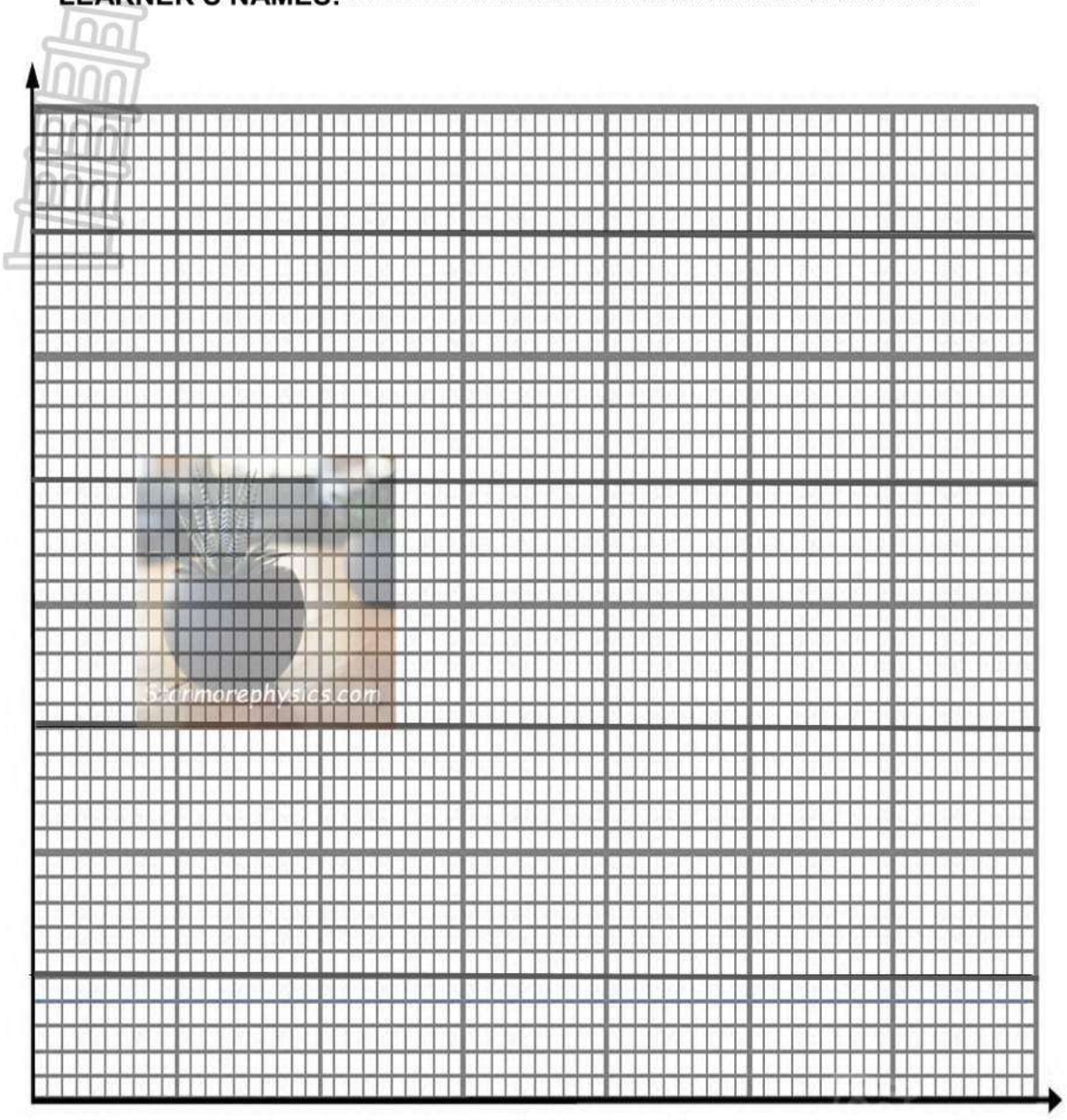
5.3.2 To calculate the average rate for this reaction for the first 60 seconds (2)

[7]

TOTAL: 50

QUESTION 5.2

LEARNER'S NAMES:----------



DATA FOR PHYSICAL SCIENCES GRADE 12
PAPER 2 (CHEMISTRY)

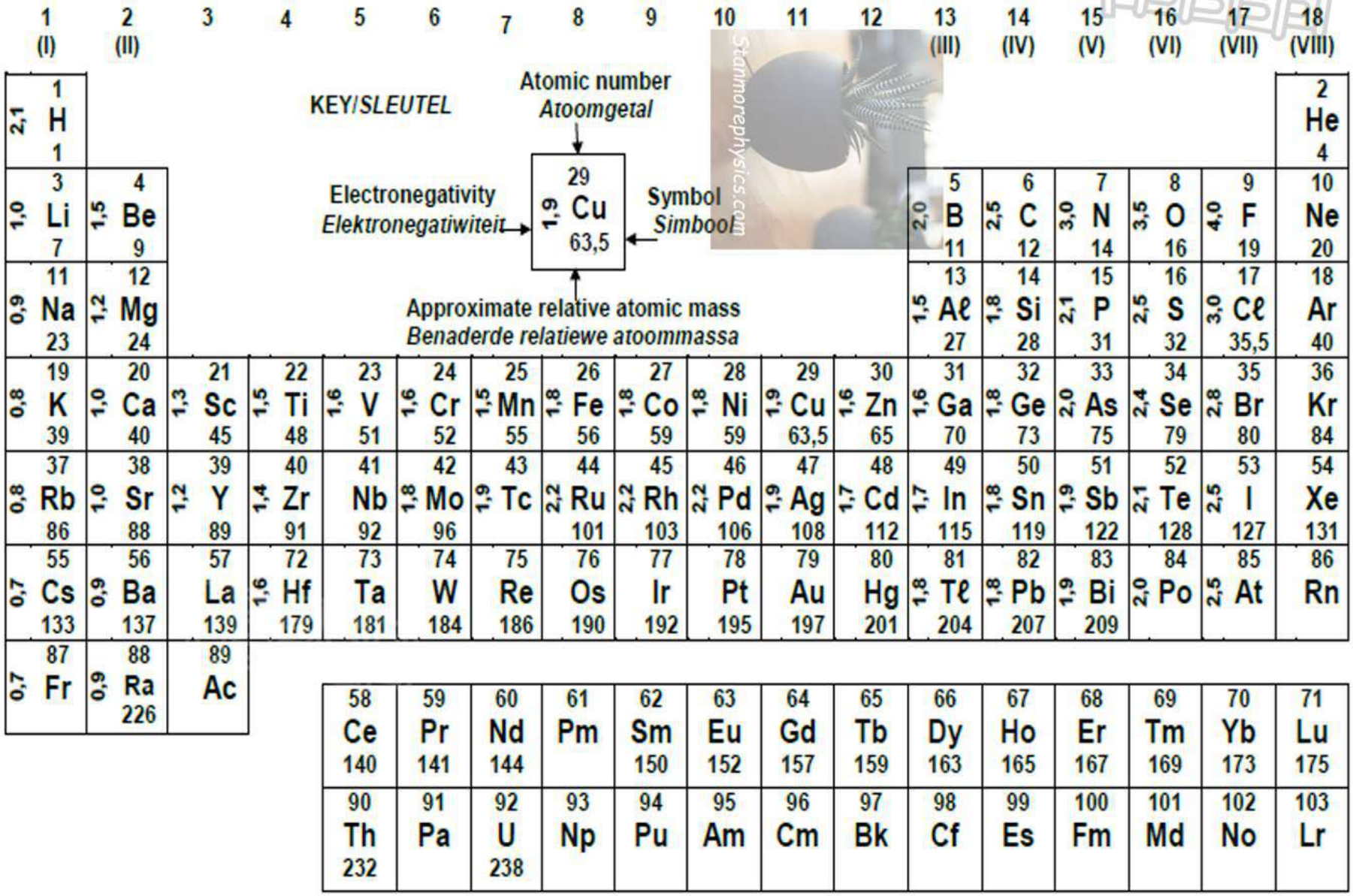
TABLE 1: PHYSICAL CONSTANTS

NAME	SYMBOL	VALUE
Standard pressure	p^{θ}	$1{,}013 \times 10^5$ Pa
Molar gas volume at STP	V_m	22,4 $dm^3 \cdot mol^{-1}$
Standard temperature	T^{θ}	273 K

TABLE 2: FORMULAE

$n = \frac{m}{M}$	$n = \frac{N}{N_A}$
$n = \frac{V}{V_m}$	$c = \frac{n}{V}$ OR $C = \frac{m}{MV}$

TABLE 3: THE PERIODIC TABLE OF ELEMENTS/*TABEL 3: DIE PERIODIEKE TABEL VAN ELEMENTE*



1 (I)	2 (II)	3	4	5	6	7	8	9	10	11	12	13 (III)	14 (IV)	15 (V)	16 (VI)	17 (VII)	18 (VIII)
1 2,1 H 1																	2 He 4
3 1,0 Li 7	4 1,5 Be 9											5 2,0 B 11	6 2,5 C 12	7 3,0 N 14	8 3,5 O 16	9 4,0 F 19	10 Ne 20
11 0,9 Na 23	12 1,2 Mg 24											13 1,5 Aℓ 27	14 1,8 Si 28	15 2,1 P 31	16 2,5 S 32	17 3,0 Cℓ 35,5	18 Ar 40
19 0,8 K 39	20 1,0 Ca 40	21 1,3 Sc 45	22 1,5 Ti 48	23 1,6 V 51	24 1,6 Cr 52	25 1,5 Mn 55	26 1,8 Fe 56	27 1,8 Co 59	28 1,8 Ni 59	29 1,9 Cu 63,5	30 1,6 Zn 65	31 1,6 Ga 70	32 1,8 Ge 73	33 2,0 As 75	34 2,4 Se 79	35 2,8 Br 80	36 Kr 84
37 0,8 Rb 86	38 1,0 Sr 88	39 1,2 Y 89	40 1,4 Zr 91	41 Nb 92	42 1,8 Mo 96	43 1,9 Tc	44 2,2 Ru 101	45 2,2 Rh 103	46 2,2 Pd 106	47 1,9 Ag 108	48 1,7 Cd 112	49 1,7 In 115	50 1,8 Sn 119	51 1,9 Sb 122	52 2,1 Te 128	53 2,5 I 127	54 Xe 131
55 0,7 Cs 133	56 0,9 Ba 137	57 La 139	72 1,6 Hf 179	73 Ta 181	74 W 184	75 Re 186	76 Os 190	77 Ir 192	78 Pt 195	79 Au 197	80 Hg 201	81 1,8 Tℓ 204	82 1,8 Pb 207	83 1,9 Bi 209	84 2,0 Po	85 2,5 At	86 Rn
87 0,7 Fr	88 0,9 Ra 226	89 Ac															

58 Ce 140	59 Pr 141	60 Nd 144	61 Pm	62 Sm 150	63 Eu 152	64 Gd 157	65 Tb 159	66 Dy 163	67 Ho 165	68 Er 167	69 Tm 169	70 Yb 173	71 Lu 175
90 Th 232	91 Pa	92 U 238	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr

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PHYSICAL SCIENCES TOPIC TEST

TOPIC: REACTION RATES

APRIL 2023

MARKING GUIDELINES

MARKS: 50

These marking guidelines consist of 6 pages

QUESTION 1

1.1 B ✓✓ (2)

1.2 D ✓✓ (2)

[4]

QUESTION 2

2.1 Reacting molecules must have correct orientation. ✓

Reacting molecules must have kinetic energy equal to or greater than the activation energy of that reaction. ✓ (2)

2.2 EXOTHERMIC.

Temperature increases during reaction. ✓ (2)

2.3 (Experiment) 2. ✓

OPTION 1

Increase in surface area (powder) increases the number of particles with correct orientation. ✓

More number of effective collisions per unit time ✓

(**OR:** This increases the frequency of effective collisions)

OPTION 2

Decrease in surface area (granules) decreases the number of particles With correct orientation. ✓

Less number of effective collisions per unit time ✓

(**OR:** Less frequency of effective collisions) (3)

2.4 More than one independent variable. ✓

OR: Different concentrations and state of division. (1)

2.5 **OPTION 1**

Increase in concentration increases the number of particles per unit volume ✓

More molecules have sufficient/enough kinetic energy ✓

More number of effective collisions per unit time. ✓

(**OR**: More frequency of effective collisions).

OPTION 2

Decrease in concentration decreases the number of particles per unit volume ✓

Less molecules have sufficient/enough kinetic energy ✓

Less number of effective collisions per unit time. ✓

(**OR**: Less frequency of effective collisions). (3)

2.6 EQUAL TO✓ (1)

2.7 Zn is the limiting agent/Acid is in excess.✓
OR: The same number of moles/mass/ number of particles of Zn produce same number of moles of H_2. (1)

2.8 FASTER THAN ✓
A catalyst was used in experiment 5.✓ (2)
[15]

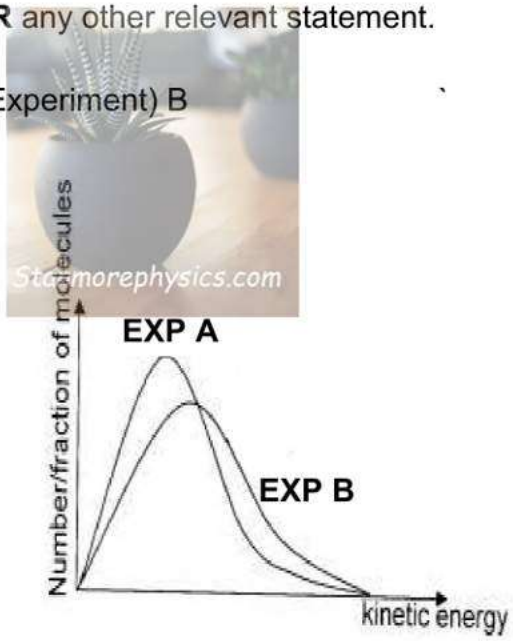
QUESTION 3

3.1 Temperature. (1)

3.2 What is the effect of temperature on the rate of a chemical reaction?✓✓
OR: What is the relationship between temperature and the rate of a chemical reaction?
OR any other relevant statement. (2)

3.3 (Experiment) B (1)

3.4



Marking criteria for Q 3.3	
Correct shape for both graphs	✓
Graph of experi**ment A** reaches a higher maximum/ peak value than **experiment B**	✓
Graph of **experiment B** shows more molecules of higher kinetic energy	✓
If no labels on axes: max **2/3**	

(3)

3.5 **OPTION 1**

Experiment **B** shows a higher reaction rate.✓

Increase in temperature increases the average kinetic energy (of the reacting Molecules).✓

More molecules have sufficient/enough kinetic energy.✓
(**OR:** More molecules have average kinetic energy equal to or greater than the activation energy).

More number of effective collisions per unit time.✓

(**OR:** More frequency of effective collisions).

OPTION 2

Experiment **A** shows a lower reaction rate.✓

Decrease in temperature decreases the average kinetic energy (of the reacting Molecules).✓

Less molecules have sufficient/enough kinetic energy.✓
(**OR:** Less molecules have average kinetic energy equal to or greater than the activation energy).

Less number of effective collisions per unit time.✓

(**OR:** Less frequency of effective collisions). (4)

[11]

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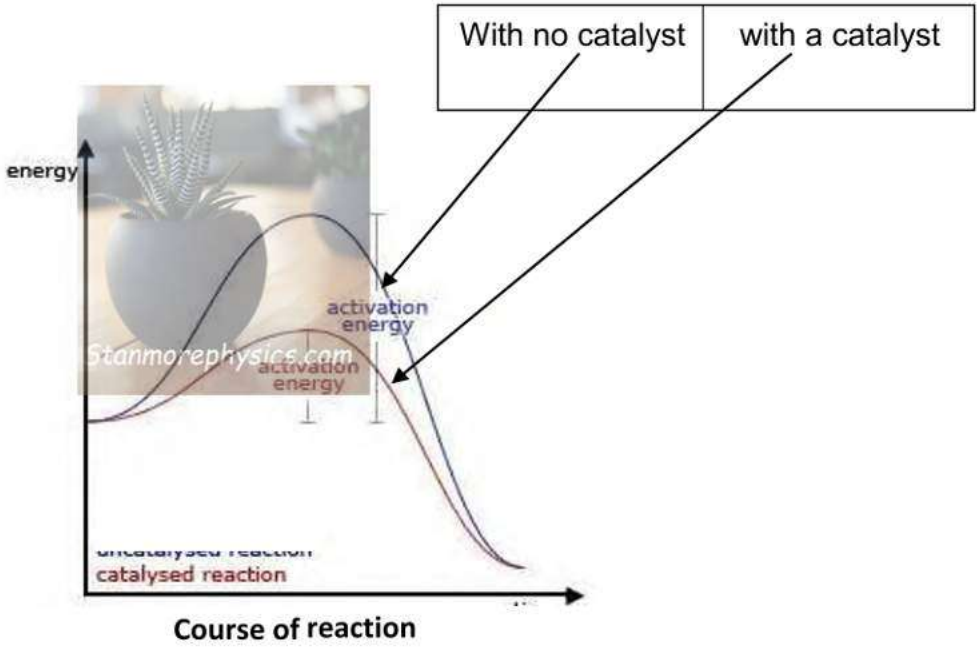
QUESTION 4

4.1 EXOTHERMIC.✓

The energy/potential energy of the products is lower than that of the reactants ✓
OR: More energy released than absorbed **OR**: Energy is released. (2)

4.2 (Point) A✓ (1)

4.3



Marking criteria for Q 4.3	
Start of the graph and end of the graph	✓
Gradient lower than that of initial graph	✓

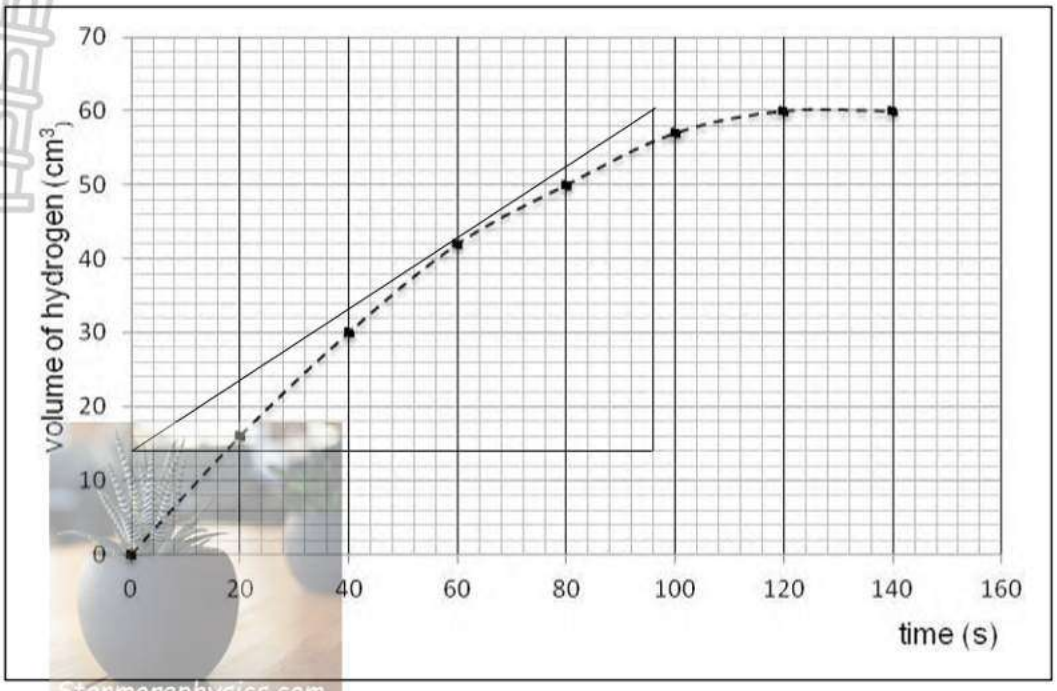
(2)

4.4 A catalyst provides an alternative pathway of lower activation energy.✓
(**NOT:** "A catalyst lowers the activation energy")
More molecules have sufficient/enough kinetic energy. ✓
(**OR**: More molecules have kinetic energy equal to or greater than the Activation energy)
More number of effective collisions per unit time. ✓
(**OR**: More frequency of effective collisions) (3)
[8]

QUESTION 5

5.1 Minimum energy required for the reaction to take place. ✓✓ (2)

5.2



Marking criteria for Q 4.2	
4 points Correctly plotted	✓✓
Correct shape of the graph	✓

(3)

5.3.1 volume of H_2 gas / reaction rate. ✓ (1)

5.3.2 40 cm^3 ✓ (1)

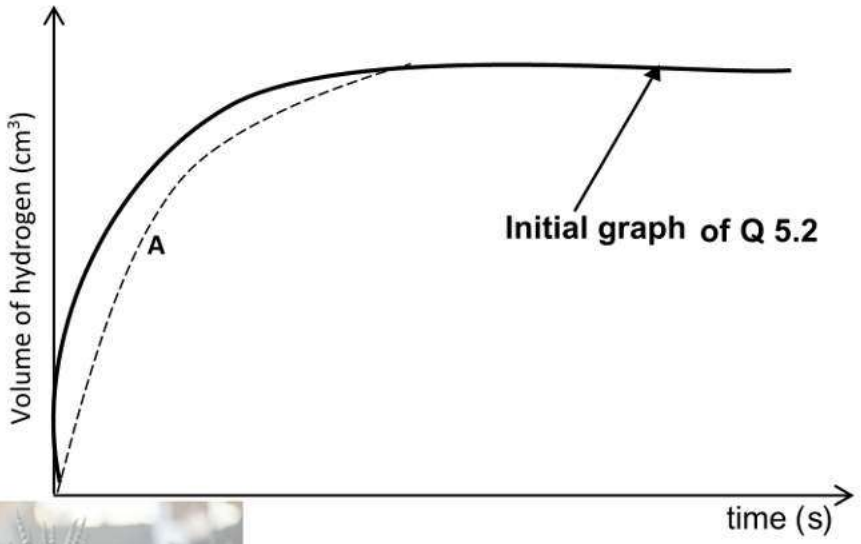
5.3.3 **[Refer to the tangent on the graph drawn in Q 5.2]**
Different points can be used.

$$\text{Average rate} = \frac{\Delta V}{\Delta t}$$

$$\text{Average rate} = \frac{60 - 14}{96 - 0} \checkmark$$

Average rate = 0,479 $cm^3.s^{-1}$ ✓ **[Accepted range: 0,45 – 0,54]** (2)

5.4



Marking criteria for Q 5.4	
Correct gradient: (lower than that of initial graph of Q5.2)	✓
Initial and final volume of the gas	✓

(2)

5.5 The reaction is complete/ Magnesium is used up.✓ (1)

5.6 When magnesium is used up the reaction will stop✓

OR: Mg is the limiting reactant.

OR: [HCℓ] stays constant. (1)

[13]

TOTAL: 50