C6: Rate of Reaction 1

ANSWER KEY

14.1	What is the formula for calculating a mean rate of reaction?	Rate = <u>change (in mass or volume)</u> time taken
14.2	How can you measure the quantity of a reactant or product?	In grams (using a balance) or in cm ³ using a gas syringe
14.3	What are the two possible units for rate of reaction?	g/s or cm ³ /s (where s is seconds)
14.4	What is 3 minutes in seconds?	3 x 60 = 180 seconds
14.5	How could you judge the rate of a reaction from a graph?	Look at how steep it is – steeper means faster
14.6	What is "collision theory"?	Chemical reactions only occur when particles collide with sufficient energy
14.7	What five factors can affect the rate of a reaction?	 temperature concentration (of solutions) surface area (of a solid) pressure (of gases) catalyst
14.8	What is the activation energy?	The <u>minimum</u> energy needed to start a reaction (cause a successful collision)
14.9	Explain why reactions are always fastest at the beginning, then gradually slow down	 more particles at start of reaction so <u>more frequent</u> collisions occur particles are used up during reaction so less frequent collisions occur
14.10	(HT) How can you calculate the rate of reaction at a specific point on a curve?	Calculate the gradient – you will need to draw a tangent on the curve with a ruler Gradient at time $t = \frac{a}{b}$ Vol of gas

C6: Rate of Reaction 2

ANSWER KEY

15.1	State the effect of increasing the temperature on the rate of reaction	Increases the rate
15.2	Explain why increasing the temperature increases the rate of reaction	 particles have more energy so move faster so collide <u>more frequently</u> more collisions have the activation energy
15.3	State the effect of increasing the concentration on the rate of reaction	Increases the rate
15.4	Explain why increasing the concentration increases the rate of reaction	 more particles in solution so more frequent collisions occur
15.5	State the effect of increasing the surface area on the rate of a reaction	Increases the rate
15.6	Explain why increasing the surface area increases the rate of a reaction	 more particles are available to collide so more frequent collisions occur
15.7	State the effect on increasing the pressure of a gas on the rate of reaction	Increases the rate
15.8	Explain why increasing the pressure of a gas increases the rate of a reaction	Less space for the particles to move around in, therefore <u>more frequent</u> collisions
15.9	What is a catalyst?	 chemical that speeds up a reaction but is not used up
15.10	How do catalysts speed up reactions?	 provide another route for the reaction which has a lower activation energy

C6: Reversible Reactions

ANSWER KEY

16.1	What is a reversible reaction?	A reaction where both the forwards and backwards reactions can occur
16.2	What chemical symbol represents a reversible reaction?	\
16.3	If a reaction is exothermic in the forward direction what will it be in the reverse direction?	Endothermic
16.4	What is a closed system?	One where no reactants can be added, or products can escape
16.5	What is meant by 'equilibrium'?	 forward and backward reactions are same rate concentrations remain unchanged (constant) in a closed system
16.6	How is the amount of reactant changing at equilibrium?	It is not changing
16.7	How is the amount of product changing at equilibrium?	It is not changing
16.8	(HT) What is Le Chatelier's principle?	When conditions for a reaction at equilibrium are changed, the reaction will move to counteract or <u>oppose the change</u>
16.9	What is yield?	The amount of product made in a reaction
16.10	(HT) A reaction is exothermic in the forward direction. What will occur if the temperature is increased?	 moves in endothermic direction backward reaction will be favoured which will reduce the temperature (equilibrium moves left – yield is lower)
16.11	(HT) A reaction is at equilibrium when some product is removed. What will occur?	 forward reaction will be favoured as that will increase the amount of product again (equilibrium moves right – yield is higher)
16.12	(HT) How does increasing the pressure affect equilibrium?	 favours the side with fewer gaseous molecules to bring the pressure down again
16.13	(HT) How does using a catalyst affect equilibrium?	 no change to equilibrium position both forward and backward rate of reaction is increased equally

FOUNDATION TIER

Q1. A student investigated the effect of temperature on the rate of a reaction.

Figure 1 shows an experiment.



The student:

- put 50 cm³ sodium thiosulfate solution into a conical flask
- heated the sodium thiosulfate solution to the required temperature
- put the flask on a cross drawn on a piece of paper
- added 5 cm³ dilute hydrochloric acid and started a stopclock
- stopped the stopclock when the cross could no longer be seen
- repeated the experiment at different temperatures.

The equation for the reaction is:

Na ₂ S ₂ O ₃ (aq)	+	2HCl(aq)	\longrightarrow	2NaCl(aq)	+	H ₂ O(I)	+	SO ₂ (g)	+	S(s)
sodium thiosulfate		hydrochloric acid		sodium chloride		water		sulfur dioxide		sulfur

(a) Which product is a gas?

(1)

(b) Figure 2 shows the results of this experiment at five different temperatures.

The circled result point is anomalous.



(iv) Give **two** reasons why the rate of the reaction increases as the temperature increases.



(v) Use the correct answer from the box to complete the sentence.

activation	collision	exothermic

The minimum amount of energy particles must have to react is called

the ______ energy.

(1) (Total 8 marks)

Q2. A student investigated the effect of the size of marble chips on the rate of the reaction between marble chips and hydrochloric acid.

This is the method used.

- 1. Add 10.0 g of marble chips into the flask.
- 2. Add 50 cm³ of hydrochloric acid and start a timer.
- 3. Record the mass lost from the flask every 10 seconds.
- 4. Repeat steps 1 to 3 with different sizes of marble chips.

Figure 1 shows the apparatus.



(2)

(a) Draw **one** line from each type of variable to the correct example of the variable.



(e) What is the unit for the mean rate of reaction calculated in part (d)?

Tick one box.



(f) The table below shows the student's results.

Time in seconds	Mass of gas produced in g
0	0.0
10	0.8
20	0.6
30	1.6
40	1.8
50	2.0
60	2.0

Plot the data from the table above on Figure 2

Draw a line of best fit.



Figure 2

(g) **Figure 3** shows a large marble chip and eight small marble chips.



The large marble chip has the same total volume as the eight small marble chips, but a different surface area.

Why do the eight small marble chips react faster than the large marble chip?

Tick **one** box.

The eight small marble chips have a larger surface area, so less frequent collisions.

The eight small marble chips have a larger surface area, so more frequent collisions.

The eight small marble chips have a smaller surface area, so less frequent collisions.

The eight small marble chips have a smaller surface area, so more frequent collisions.

17 53	
2	

(1) (Total 11 marks)

Q3. A student investigated the reaction between magnesium and excess hydrochloric acid.

Figure 1 shows the apparatus.



This is the method used.

- 1. Pour 50 cm³ of hydrochloric acid into a conical flask.
- 2. Add a piece of magnesium.
- 3. Insert stopper and delivery tube and start a timer.
- 4. Collect the gas produced in a gas syringe.
- 5. Record the volume of gas produced every 20 seconds for 2 minutes.
- 6. Repeat steps 1 to 5 with higher concentrations of hydrochloric acid.
- (a) Give the independent variable and **one** control variable in this investigation.

Independent variable

Control variable

(2)

The table below shows the results from the first experiment using hydrochloric acid with a low concentration.

Time in seconds	0	20	40	60	80	100	120
Volume of gas in cm ³	0	48	72	90	97	98	98

(b) Complete Figure 2.

You should:

- plot the data from the table above (the point 0,0 has been plotted for you)
- draw a line of best fit.





(c) How does the **rate** of this reaction change with time?

Use the table above.

Tick (\checkmark) one box.

The rate decreases.	
The rate stays the same.	
The rate increases.	

(d) The student repeated the experiment using hydrochloric acid with a higher concentration.

Which statement is correct?

Tick (\checkmark) one box.

The activation energy for the reaction was higher.

The magnesium reacted more quickly.

The reaction finished at the same time.

The total volume of gas collected was smaller.

(e) Temperature also affects the rate of the reaction.

Explain how increasing the temperature affects the **rate** of the reaction.

You should refer to particles and collisions.



(1)

HIGHER TIER

Q4. Hydrogen peroxide (H_2O_2) decomposes to produce oxygen gas and water.

(a) Balance the equation for the reaction.

 $\underline{\qquad} H_2O_2 \rightarrow \underline{\qquad} H_2O + O_2$

(1)

Two catalysts that can be used in the reaction are raw potato and manganese dioxide.

- (b) A student compared the rate of decomposition of hydrogen peroxide using:
 - a cube of raw potato as the catalyst
 - crushed raw potato as the catalyst.

The student kept all other variables constant.

The hydrogen peroxide decomposed at a different rate when using a cube of raw potato compared with using crushed raw potato.

Explain why.

(c) The student repeated the investigation using boiled potato instead of raw potato.

When boiled potato is added to hydrogen peroxide no bubbles of oxygen are observed.

Explain why.

(3)

(d) The student then investigated the rate of decomposition of hydrogen peroxide using manganese dioxide as the catalyst.

The student measured the volume of oxygen produced every 5 seconds for 50 seconds.



The graph below shows the results.

Determine the rate of reaction at 15 s



Q5. This question is about magnesium.

A student investigated the rate of the reaction between magnesium and hydrochloric acid.

Figure 1 shows the apparatus.



Figure 1

(a) Which is the correct ionic equation for the reaction? Tick (\checkmark) **one** box.



(b) What happens in the reaction between magnesium and hydrochloric acid? Tick (√) one box.



(1)

(c) The table shows the student's results.

Time in seconds	0	10	35	50	95	120	140
Volume of gas in cm ²	0.0	12.5	36.0	43.5	59.0	60.0	60.0

Plot the data from the table on Figure 2.

Draw a line of best fit.



	(d)	Describe the changes in the rate of this reaction.	
			(3)
	(e)	Explain why the rate of this reaction changes.	
		Give your answer in terms of collision theory.	
			(3)
			(Total 11 marks)
Q6.	Ble	ach is a solution of sodium hypochlorite (NaClO).	
	Chlo	rine gas is produced when bleach reacts with hydrochloric acid.	
		NaClO(aq) + 2HCl (aq) \rightleftharpoons NaCl(aq) + H ₂ O(l) + Cl ₂ (g)	
	(a)	Give the test and result for chlorine gas.	

The diagram below shows a sealed flask of sodium hypochlorite and hydrochloric acid at equilibrium.

(2)

Sodium hypochlorite solution and hydrochloric acid

The	stopper in the diagram above is removed and hydrochloric acid is added.
The	stopper is replaced.
Expl	ain what happens to the equilibrium.
 prine g	as is also produced when hydrogen chloride decomposes.
	as is also produced when hydrogen chloride decomposes. $2\text{HCl}(g) \rightleftharpoons \text{H}_2(g) + \text{Cl}_2(g)$
orine g	as is also produced when hydrogen chloride decomposes. $2HCI(g) \rightleftharpoons H_2(g) + CI_2(g)$ rd reaction is endothermic.
orine g forwat Pred prod	as is also produced when hydrogen chloride decomposes. $2HCI(g) \rightleftharpoons H_2(g) + CI_2(g)$ rd reaction is endothermic. ict the effect of increasing the temperature on the amount of chlorine gas uced at equilibrium.
forwa Pred prod Expl	as is also produced when hydrogen chloride decomposes. $2HCI(g) \rightleftharpoons H_2(g) + CI_2(g)$ rd reaction is endothermic. ict the effect of increasing the temperature on the amount of chlorine gas uced at equilibrium. ain your answer using Le Chatelier's Principle.
forwar Pred prod Expl	as is also produced when hydrogen chloride decomposes. $2HCl(g) \rightleftharpoons H_2(g) + Cl_2(g)$ rd reaction is endothermic. ict the effect of increasing the temperature on the amount of chlorine gas uced at equilibrium. ain your answer using Le Chatelier's Principle.
forwar Pred prod Expl	as is also produced when hydrogen chloride decomposes. $2HCl(g) \rightleftharpoons H_2(g) + Cl_2(g)$ rd reaction is endothermic. ict the effect of increasing the temperature on the amount of chlorine gas uced at equilibrium. ain your answer using Le Chatelier's Principle.

(2) (Total 12 marks)

Mark schemes

Q1.				
(a)	sulfur dioxide			
		1		
(b)	(i)	curved line of best fit between the 4 non-anomalous points	1	
	(ii)	temperature was lower (than 40 °C) accept student missed the moment when the cross disappeared accept smaller volume of acid or acid more dilute	1	
	(iii)	0.005 or 1/200 correct answer with or without working gains 2 marks if answer incorrect, allow 1 mark for 0.32 / 64	2	
	(iv)	The particles move faster.	1	
		The particles collide with more energy.	1	
	(v)	activation	1 [8]	
Q2. (a)	lines • •	from: independent to size of marble chips control to volume of acid	1	
		Ignore arrowneads do not accept if more than one line from one box		
(b)	calci	um chloride		
	carbon dioxide do not accept carbon oxide			
	wate	r do not accept hydrogen oxide all three needed for 2 marks allow 1 mark if two correct	2	

(c) stops loss of acid

		allow stops loss of water / liquid	
		allow to ensure that only the gas escapes	
		do not accept stops acid evaporating	
		do not accept stops gas / CO ₂ / water vapour	
		escaping	1
(d)	0.053		
		allow 0.05	
		allow 0.053333 do not accort 0.052	
		ianore units	
			1
(a)	als		
(6)	y/s		1
(5)	all is a light a		
(1)	all points c	correctly plotted	
		allow $\pm \frac{1}{2}$ a small square	
			2
	line of bos	st fit	
		should be a curve nearer to $(10.0.8)$ than the	
		anomaly (20, 0.6) and through all other points	
		if plotting incorrect allow 1 mark for appropriate	
		line of best fit through student's points	
			1
(g)	the eight s	mall marble chips have a larger surface area, so more frequent	
	collisions		1
			، [11]
02			
U J.	indonond	ont	
(a)	concentrat	tion (of hydrochloric acid)	
			1
	control		
	any one fr	rom:	
	• temp	perature (of hydrochloric acid)	
	 volu long 	me of (hydrochloric) acid	
	• surfa	ace area of magnesium	
		allow same mass of magnesium allow same form	
		of magnesium	
		ignore amount	
			1
(b)	all points o	correctly plotted	
. ,		allow a tolerance of $\pm \frac{1}{2}$ a small square	
		allow 1 mark for 4 or 5 points correctly plotted	
			2

	line of best fit	
	must include 0,0	1
(c)	the rate decreases	
		1
(d)	the magnesium reacted more quickly	1
(e)	rate increases	
	allow reaction happens faster	1
	(because) particles have more energy allow (because) particles move faster	
	allow (because) more particles have energy greater than the activation energy	_
		1
	(so) more frequent collisions	1
		[10]
Q4.		
(a)	$2 H_2O_2 \rightarrow 2 H_2O + O_2$ allow correct multiples	
		1
(b)	crushed potato has a larger surface area allow converse	1
	(so) has more frequent collisions ignore more collisions unqualified	
		1
	(so) has a greater rate of reaction	1
(c)	enzyme is denatured (by high temperature)	1
	(so) active site changes shape	
	or (so) hydrogen peroxide / substrate no longer fits	1
(d)	correctly drawn tangent at 15 s	1
()		1
	correct value for x step and y step from tangent	1
	value for Δy	
	(rate =) value for Δx	

allow correct use of an incorrectly determined

1

1

[10]

Q5.

(a)	$Mg + 2H^{*} \longrightarrow Mg^{2*} + H_{2}$	1
(b)	electron transfer	1
(c)	all points correctly plotted allow a tolerance of ± 1/2 a small square allow 1 mark for at least 4 points correctly plotted	2
	line of best fit	- 1
(d)	(rate) decreases	
	allow (rate is) fastest at the beginning	1
	(rate decrease) more slowly as time increases (in rate)	1
	(rate) becomes zero at time read from graph allow reaction stops at time read from graph	1
(e)	(rate decreases because) fewer particles (of acid / magnesium) as reaction	
	allow (rate decreases because) concentration of acid decreases as reaction progresses	1
	(so) less frequent collisions allow collisions less likely	
	ignore less / fewer collisions	1
	reaction stops due to limiting factor / reagent	
	allow reaction stops because a reactant is used up	1
	Incorrect reference to energy scores max. 1	[11]

Q6.

(a)	<u>damp / moist</u> litmus paper
	ignore colour of litmus paper

	bleaches / goes white	1	
(b)	forward and reverse rates equal	1	
	because no escape of reactants or products	1	
	allow particles for reactants or products	1	
(c)	equilibrium shifts allow no longer in equilibrium	1	
	to right-hand side allow in favour of forward reaction	1	
	to produce more of any products or		
	allow correct references to Le Chatelier's Principle	1	
	(new) equilibrium will be established	1	
(d)	amount of chlorine gas increases	1	
	(because) system shifts to counteract the change		
	allow (because) system shifts to take in energy allow (because) system shifts in endothermic direction	1	
(e)	no change	1	
	because equal numbers of molecules		
	moles (of gas) on each side	1	[12]