Rates of Reaction

Chemistry Past Exam Questions

Higher Level

2013

Section B - Question 7

7. (*a*) Define the *rate of a chemical reaction*. (5)

(*b*) Explain clearly why there is an almost instantaneous reaction between aqueous solutions of sodium chloride and silver nitrate. (6)

(*c*) When hydrogen gas and nitrogen gas are mixed in a ratio of 3 : 1 by volume at room temperature in a sealed container, the formation of ammonia (NH_3) is very slow.

Suggest **two** ways to increase the rate of this reaction.

Explain how each of the ways you suggest speeds up the reaction. (12)

(*d*) Describe how you would measure the reaction time when 10 cm^3 of 1.0 M hydrochloric acid solution and 50 cm^3 of 0.20 M sodium thiosulfate solution react according to the following balanced equation:

$$Na_2S_2O_3 + 2HCl \rightarrow 2NaCl + SO_2 + S + H_2O$$

If you were given additional sodium thiosulfate solutions of the following concentrations: 0.04 M, 0.08 M, 0.12 M and 0.16 M, describe how you would show that the rate of this reaction is directly proportional to the concentration of the sodium thiosulfate solution. (18)

(*e*) Draw a reaction profile diagram for an exothermic reaction indicating clearly on your diagram (*i*) the activation energy (E_A) for the reaction, (*ii*) the heat of reaction (ΔH). (9)

2012

Section B - Question 4 G

(*g*) Why does raising the temperature generally increase the rates of chemical reactions?

Section B - Question 4

9. (*a*) Define *rate of reaction*. (5)

The loss of mass of a mixture of 50 cm^3 of a 2 M solution of hydrochloric acid and excess marble chips was monitored over time and the following data were recorded.

Loss of mass / g	0.00	0.10	0.18	0.29	0.35	0.39	0.41	0.41
Time / s	0	20	40	80	120	160	220	240

Plot a graph to show the mass of carbon dioxide produced (loss of mass) *versus* time. (12)

Use your graph to find the instantaneous rate of the reaction at 60 seconds in terms of g/s carbon dioxide produced. (6)

Mark clearly on your graph the curve you would expect to obtain if the reaction were repeated using 50 cm^3 of a 1 M solution of hydrochloric acid. Justify the shape and position of this curve relative to the graph you have plotted. (9)

(*b*) When hydrogen peroxide is added to a warm solution of potassium sodium tartrate, a slow reaction occurs in which tartrate ions are oxidised to carbon dioxide and water. If cobalt(II) ions (Co^{2+}) are added as a catalyst, a big increase in the reaction rate is observed.

What type of catalysis is involved in this reaction? (3)

What colour changes are observed when Co^{2+} ions catalyse the reaction? (6)

Explain the significance of the colour changes. (9)

2011

Section B - Question 10 A

(*a*) Define the *rate of a chemical reaction*. (5)

There is a slow exothermic reaction between hydrogen and oxygen gases mixed in a 2:1 ratio at room temperature but the reaction becomes violently rapid if powdered platinum catalyst is added. Suggest the type of catalysis responsible for the increased rate of reaction.

Describe the mechanism by which the powdered platinum increases the rate of reaction. (12)

Draw a clearly labelled reaction profile diagram for the reaction with and without the catalyst. (8)

2010

Section A - Question 3

3. A stopwatch was started when 50 cm^3 of a 0.20 M sodium thiosulfate solution was poured into a conical flask containing 10 cm^3 of 1.0 M HCl solution. The conical flask was put standing on top of a black cross marked on white paper. The time for the cross to become obscured by the precipitate produced in the reaction was measured. The reciprocal of this reaction time ($1/t$) was taken as a measure of the initial rate of the chemical reaction.

The stock 0.20 M solution of sodium thiosulfate was then diluted with deionised water to produce 50 cm^3 each of 0.16 M, 0.12 M, 0.08 M, 0.04 M and 0.02 M solutions in turn. The times taken for these solutions to react with 10 cm^3 of the 1.0 M HCl solution were also measured in identical conical flasks as described above. All six reactions were carried out at 20 °C and the results are given in the table.

Concentration $Na_2S_2O_3$ (M)	0.20	0.16	0.12	0.08	0.04	0.02
Reaction time (min)	1.14	1.43	1.89	2.94	5.88	11.11
$1/t$ (min^{-1})	0.88	0.70	0.53	0.34	0.17	0.09

(*a*) Identify the precipitate produced in each flask. (5)

(*b*) Describe a procedure for diluting the 0.20 M sodium thiosulfate solution to give 50 cm^3 of a 0.12 M solution. (9)

(*c*) Why are the concentration and the volume of the HCl solution kept constant? (6)

(*d*) Plot a graph of reaction rate ($1/t$) *versus* concentration of sodium thiosulfate.

What conclusion can be drawn from the graph about the relationship between the rate of the reaction and the concentration of the sodium thiosulfate? (18)

(*e*) Use your graph to predict the time taken for 50 cm^3 of a 0.10 M solution of sodium thiosulfate to react with 10 cm^3 of the 1.0 M HCl solution at 20 °C. (6)

(*f*) The procedure described above was repeated using 50 cm^3 portions of the 0.20 M sodium thiosulfate solution and 10 cm^3 portions of the 1.0 M HCl solution at a number of different temperatures between 10 °C and 70 °C and the reaction times were measured as before.

Would you expect the reaction times to increase, decrease, or stay the same, as the temperature was increased? Justify your answer. (6)

2009

Section B - Question 9

9. (*a*) Explain (*i*) activation energy, (*ii*) effective collision. (8)

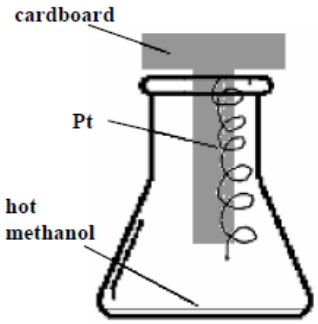
The effect of temperature on the rate of a chemical reaction was investigated using dilute solutions of hydrochloric acid and sodium thiosulfate. Suitable volumes and concentrations of the solutions were used. The reaction is represented by the following balanced equation.

$$2HCl + Na_2S_2O_3 \rightarrow 2NaCl + H_2O + S + SO_2$$

Describe how the time for the reaction between the solutions of hydrochloric acid and sodium thiosulfate was obtained at room temperature. (6)

In a reaction mixture what effect, if any, does an increase in temperature of 10 K have on each of the following:
(*i*) the number of collisions, (*ii*) the effectiveness of the collisions, (*iii*) the activation energy. (9)

(*b*) The catalytic oxidation of methanol using platinum wire is illustrated in the diagram.



State **one** observation made during the experiment.

Name any **two** products of the oxidation reaction.

What type of catalysis is involved in this reaction? (12)

Explain **one** way in which the presence of the platinum catalyst speeds up the oxidation of the hot methanol.

Explain how a catalyst poison interferes with this type of catalysis. (9)

Give another example of a reaction which involves the same type of catalysis, indicating clearly the reactant(s) and the catalyst. (6)

2008

Section A - Question 3

3. (*a*) Hydrogen peroxide solution is an oxidising reagent. Draw *or* describe the warning symbol put on a container of hydrogen peroxide solution to indicate this hazard. (5)

(*b*) Write a balanced equation for the decomposition of hydrogen peroxide. (6)

(*c*) Solid manganese(IV) oxide catalyst was added to a hydrogen peroxide solution at a time known exactly and the rate of production of gas was monitored as the hydrogen peroxide decomposed. Draw a labelled diagram of an apparatus that could be used to carry out this experiment. (12)

(*d*) The table shows the volumes of gas (at room temperature and pressure) produced at intervals over 12 minutes.

Time / minutes	0.0	1.0	2.0	3.0	5.0	7.0	9.0	11.0	12.0
Volume / cm^3	0.0	20.0	36.0	50.5	65.5	73.0	76.5	78.0	78.0

Plot a graph of the volume of gas produced *versus* time.

Explain why the graph is steepest at the beginning. (15)

(*e*) Use your graph to

(*i*) determine the instantaneous rate of gas production at 5 minutes,

(*ii*) calculate the total mass of gas produced in this experiment. (12)

2007

Section B - Question 9

9. (*a*) Define the *rate of a chemical reaction*.
Why does the rate of chemical reactions generally decrease with time? (8)

(*b*) The rate of reaction between an excess of marble chips ($\mathbf{CaCO_3}$) (diameter 11 – 15 mm) and 50 cm^3 of 2.0 M hydrochloric acid was monitored by measuring the mass of carbon dioxide produced.

The table shows the total mass of carbon dioxide gas produced at stated intervals over 9 minutes.

Time/minutes	0.0	1.0	2.0	3.0	4.0	5.5	7.0	8.0	9.0
Mass of $\mathbf{CO_2}$/g	0.00	0.66	1.20	1.60	1.90	2.10	2.18	2.20	2.20

Plot a graph of the mass of carbon dioxide produced *versus* time. (12)

Use the graph to determine
(*i*) the instantaneous rate of reaction in grams per minute at 4.0 minutes,
(*ii*) the instantaneous rate of reaction at this time in moles per minute. (9)

(*c*) Describe and explain the effect on the rate of reaction of repeating the experiment using 50 cm^3 of 1.0 M hydrochloric acid and the same mass of the same size marble chips. (6)

(*d*) Particle size has a critical effect on the rate of a chemical reaction.

(*i*) Mark clearly on your graph the approximate curve you would expect to plot if the experiment were repeated using 50 cm^3 of 2.0 M HCl and using the same mass of marble chips but this time with a diameter range of 1 – 5 mm. (6)

(*ii*) Dust explosions present a risk in industry. Give **three** conditions necessary for a dust explosion to occur. (9)

2006

Section B - Question 9

7. (*a*) Define the *activation energy* of a chemical reaction. (5)

(*b*) Give **two** reasons why the rate of a chemical reaction increases as the temperature rises. Which of these is the more significant? Why? (12)

(*c*) Describe how you could investigate the effect of temperature on the rate of the reaction between a 0.1 M sodium thiosulfate solution and a 2 M hydrochloric acid solution. (12)

The reaction is described by the following balanced equation.

$$Na_2S_2O_3 + 2HCl \longrightarrow 2NaCl + SO_2 + S + H_2O$$

(*d*) When silver nitrate and sodium chloride solutions are mixed a precipitate appears immediately. Explain the speed of this reaction compared to the slower reaction when solutions of sodium thiosulfate and hydrochloric acid are mixed. (6)

(*e*) What type of catalysis occurs in the catalytic converter of a modern car? Give the names *or* formulas of **two** substances entering a car's catalytic converter and the names *or* formulas of the substances to which they are converted in the interior of the catalytic converter. (15)

2005

Section A - Question 3

3. Hydrogen peroxide decomposes rapidly in the presence of a manganese(IV) oxide ($\mathbf{MnO_2}$) catalyst.

(*a*) Write a balanced equation for the decomposition of hydrogen peroxide. (5)

(*b*) Draw a labelled diagram of an apparatus a student could assemble to measure the rate of decomposition of hydrogen peroxide in the presence of a manganese(IV) oxide ($\mathbf{MnO_2}$) catalyst. Indicate clearly how the reaction could be started at a time known exactly, and how the gas produced is collected and its volume measured. (12)

(*c*) A student has a choice of using the same mass of finely powdered manganese(IV) oxide or coarsely powdered (granulated) manganese(IV) oxide. Which of these would you expect to have a greater average rate of reaction over the first minute of the reaction? Give a reason for your answer. (6)

A set of results obtained in an experiment to measure the rate of decomposition of hydrogen peroxide, in a solution of known volume and concentration, is given in the table.

Time/minutes	0	1	2	3	4	5	6	7	8
Volume of $\mathbf{O_2}$/cm^3	0.0	13.5	23.4	30.5	35.4	38.3	39.6	40.0	40.0

(*d*) Plot a graph to illustrate the volume of oxygen produced *versus* time. (12)

(*e*) Use the graph to determine
(*i*) the volume of oxygen produced during the first 2.5 minutes and
(*ii*) the instantaneous rate of the reaction at 2.5 minutes. (9)

(*f*) What changes would you expect in the graph if the experiment were repeated using a solution of the same volume but exactly half the concentration of the original hydrogen peroxide solution? (6)