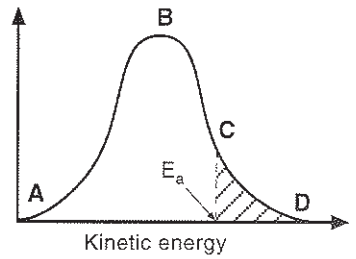
HOME PRACTICE 3.7

1. Distribution graphs can be drawn to aid the understanding of reaction rates.

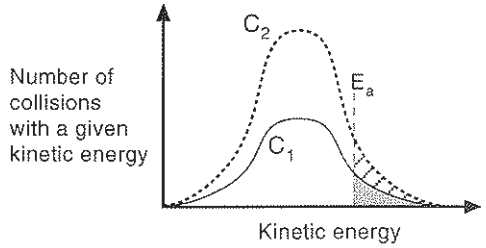


(a) Which of A, B, C or D indicates molecules with the highest kinetic energy? **(1)**

(b) Why does a collision between two molecules with a combined kinetic energy value to the left of E_a **not** result in a reaction? **(1)**

(c) Describe what the shaded area represents. **(1)**

2. Changing experimental conditions can change the energy distribution graph. This graph shows the effect of changing the concentration of a reactant.



(a) Which line represents the faster reaction, C_1 or C_2? **(1)**

(b) Sketch a similar graph to show the energy distribution at temperature, T_1, and use a dotted line to show the energy distribution at a slightly higher temperature, T_2. **(2)**

(c) Explain, **by referring to your graph**, why a moderate increase in temperature can have a dramatic effect on the reaction rate. **(2)**

3. Light can also increase the rate of some reactions, e.g. photosynthesis. Why can this happen? **(2)**

TOTAL **(10)**

Mark your answers by using the Answer Check.

CHALLENGE CHEMISTRY

– Higher –

SECTION 3

REACTION RATES

HOME PRACTICE

The "Home Practice" problems are for doing at home. They follow exactly the lesson topics of the section.

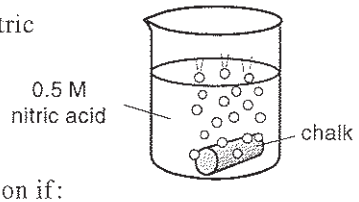
It is good practice to look again at a lesson topic just a short time afterwards, for example – the evening of the same day.

The "Home Practice" problems are designed to help you do that. As each lesson topic is covered in school, then the corresponding "Home Practice" should be done within two days at home.

By doing this consistently, you help to build yourself a memory bridge for the future.

HOME PRACTICE 3.1

1. A piece of chalk is added to 0.5 M nitric acid (i.e. 0.5 mol l^{-1}) at 25 °C.

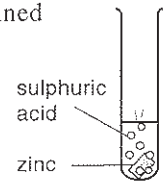


What will happen to the rate of reaction if:

(a) the temperature of the acid is changed to 40 °C? **(1)**

(b) the concentration of the acid is changed to 0.2 M (i.e. 0.2 mol l^{-1})? **(1)**

2. The reaction of zinc with sulphuric acid can be explained in terms of hydrogen ions reacting with zinc atoms.



(a) In terms of collision theory, explain why an equal mass of powdered zinc will react faster than a single piece. **(2)**

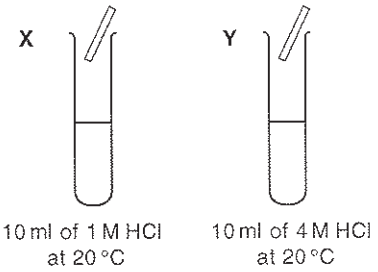
(b) **(i)** What effect will an increase in temperature have on the **number** of collisions per second? **(1)**

(ii) Explain why this changes the rate of reaction. **(1)**

(c) **(i)** What effect will an increase in temperature have on the **energy** of collision of the reactant particles? **(1)**

(ii) Explain why this changes the rate of reaction. **(1)**

3. The diagram shows two equal-sized pieces of magnesium about to be dropped into acids of different concentration.



(a) In which tube will the reaction be faster? **(1)**

(b) Explain your answer in terms of collision theory. **(1)**

TOTAL **(10)**

Mark your answers by using the Answer Check.

HOME PRACTICE 3.6

1. As a reaction proceeds there are energy changes within the molecules.

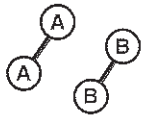
(a) Draw a graph to show how the potential energy of two colliding molecules changes during an **endothermic** reaction.
You should label the axes and the potential energies for the reactant and product molecules. **(3)**

(b) Indicate clearly on your diagram the activation energy for the reaction? **(1)**

(c) Draw a dotted line on your graph to show how the potential energy might change as the reaction proceeds in the presence of a catalyst. **(1)**

2. The activation energy is an important measure for any reaction.
Give the symbol used for activation energy and the units it is measured in. **(1)**

3. During the progress of the reaction between molecules an activated complex can be formed.



(a) Illustrate, using the above two molecules, what an activated complex may look like. **(1)**

(b) Explain what your diagram shows? **(1)**

(c) What energy change is taking place as the activated complex is forming? **(1)**

(d) In terms of energy, what happens when the products are formed from the activated complex? **(1)**

TOTAL **(10)**

Mark your answers by using the Answer Check.

HOME PRACTICE 3.5

1. In an experiment, 1 g of magnesium metal was reacted with an excess of 1 M hydrochloric acid (i.e. 1 mol l^{-1}). The volume of hydrogen gas released was measured in cm^3 every ten seconds until the reaction stopped after two minutes.

(a) Sketch a line graph (no graph paper needed) of how the results might appear, showing

(i) labels for each axis, and **(1)**

(ii) the shape of the graph. **(1)**

(b) Add a dotted line to show how the gas volume would change if the acid concentration were increased to 2 M (i.e. 2 mol l^{-1}). **(1)**

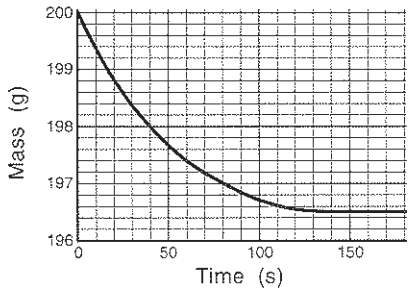
2. Citric acid can be neutralised by reacting it with excess copper carbonate.

citric acid + copper carbonate → copper citrate + carbon dioxide + water

Describe **two** possible ways of measuring the reaction progress. **(2)**

3. In an experiment 8 g of chalk was reacted with an excess of 2 M hydrochloric acid (i.e. 2 mol l^{-1}) in a flask.

The mass of the flask and its contents was measured every ten seconds for 200 seconds. The results were then plotted on a graph, as shown.



(a) At what time: **(i)** did the reaction stop? **(1)**

(ii) was the rate of reaction fastest. **(1)**

(b) Calculate the average rate of reaction between 60 s and 110 s. **(2)**

(c) Sketch a graph (no graph paper needed) showing how the rate of this reaction changes with time. **(1)**

TOTAL **(10)**

Mark your answers by using the Answer Check.

HOME PRACTICE 3.2

1. Catalytic converters are found in car exhausts and are used to convert carbon monoxide and nitrogen dioxide into non-polluting gases.

(a) Write word equations for the **two** main reactions happening in such catalytic converters. **(2)**

(b) Why can catalytic converters **only** be used in cars with **unleaded** petrol? **(1)**

2. Complete the paragraph below using words from this box.

more	strengthens	break	weak	adsorption
less	weakens	make	strong	condensation

Reactant molecules collide with the catalyst and stick to the surface. This is called ...**(a)**... . The reactant molecules form ...**(b)**... bonds with the catalyst and this in turn ...**(c)**... the bonds within the reactant molecules making them ...**(d)**... reactive toward each other. As the bonding changes to that of the product molecules, the weak bonds with the catalyst ...**(e)**... and the product molecules depart. The surface of the catalyst is then available to adsorb ...**(f)**... reactant molecules. **(3)**

3. What is the term for biological catalysts? **(1)**

4. Complete the following table with the name of the catalyst used for each process and the type of catalysis involved.

	Reaction	*Catalyst*	*Type of catalysis*
(a)	Haber Process	**(i)**	**(ii)**
(b)	Ostwald Process	**(i)**	**(ii)**
(c)	Fermentation	**(i)**	**(ii)**

(3)

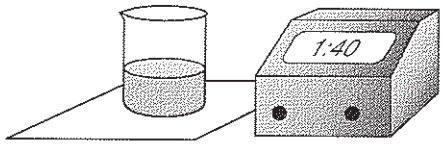
TOTAL **(10)**

Mark your answers by using the Answer Check.

HOME PRACTICE 3.3

A student is investigating how varying the concentration of a reactant affects the rate of a reaction.

The reaction to be used is that between hydrogen peroxide and potassium iodide.



The concentration of iodide ions is to be varied while the addition of a little thiosulphate solution initially prevents the formation of iodine.

1. **(a)** Which indicator could be used in this reaction? **(1)**

(b) How can the stop-point for timing this reaction be determined? **(1)**

(c) **(i)** How is the relative rate calculated? **(1)**

(ii) Why can this method be used as a measure of the rate? **(1)**

2. The student carries out five experiments.

(a) How might the concentration of potassium iodide solution be varied in each experiment? **(1)**

(b) What happens to the rate of the reaction as the concentration of iodide is increased? **(1)**

(c) Sketch a graph (no graph paper needed) of how the results might appear, showing

(i) labels for each axis, and **(1)**

(ii) the shape of the graph. **(1)**

(d) If the relative rate of reaction was $0.15\ min^{-1}$ for a concentration of 0.2 M potassium iodide solution what relative rate would you expect for a concentration of 0.8 M potassium iodide? **(2)**

TOTAL **(10)**

Mark your answers by using the Answer Check.

HOME PRACTICE 3.4

A student is investigating how varying the temperature of a reaction affects the rate of reaction.

The reaction to be used is that between oxalic acid and potassium permanganate.

$$5\,(COOH)_2 + 6\,H^+ + 2\,MnO_4^- \rightarrow 2\,Mn^{2+} + 10\,CO_2 + 8\,H_2O$$

1. **(a)** How can the stop-point for timing this reaction be determined? **(1)**

(b) In the experiment, sulphuric acid is also added. Why? **(1)**

(c) If the reaction times are measured in seconds what will be the units for the relative reaction rates? **(1)**

2. The student carries out four experiments.

(a) What variable must be changed each time? **(1)**

(b) What are **three** variables that must be kept constant in this investigation? **(3)**

(c) Sketch a graph (no graph paper needed) of how the results might appear showing

(i) labels for each axis, and **(1)**

(ii) the shape of the graph. **(1)**

(d) Approximately what effect does a 10 °C rise in temperature have on the rate of reaction? **(1)**

TOTAL **(10)**

Mark your answers by using the Answer Check.

ANSWER CHECK 3.7

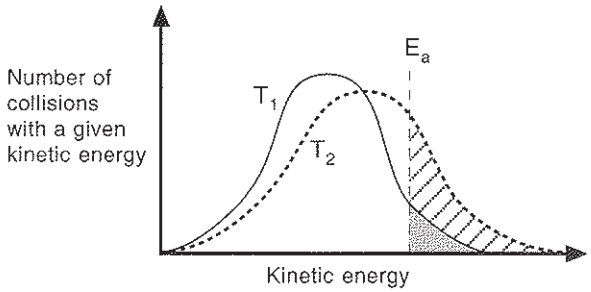
1. (a) **D** (1)

   (b) Not enough energy to form an activated complex **OR**
   The molecules simply bounce off each other without reacting. (1)

   (c) The collisions between molecules with enough energy to form an activated complex. (1)

2. (a) C_2 (1)

   (b)



   Peak of dotted line to the right of T_1 (1)
   [Greater average kinetic energy at higher temperature]

   Peak of dotted line lower than for T_1 (1)
   [Greater spread of energies so fewer have the average energy] (2)

   (c) Many more molecules collide with energy greater than E_a (1)
   so there are many more successful collisions (1) (2)

3. Light energy is being absorbed by molecules and so increasing their energy. (1)

   There are therefore more collisions with energy greater than E_a resulting in a faster reaction. (1) (2)

TOTAL (10)

Learn from any mistakes by checking over all wrong answers.
Ask your teacher about anything you still do not understand.

CHALLENGE CHEMISTRY

– Higher –

SECTION 3

REACTION RATES

ANSWER CHECK

FOR

HOME PRACTICE

QUESTIONS

Checking your answers is an important part of the learning process.

You should check out every mistake, even if it is just one mark.

If you still do not understand a question, even after studying this answer check, then ask your teacher.

ANSWER CHECK 3.1

1. **(a)** Increase **OR** speed up (1)

(b) Decrease **OR** slow down (1)

2. **(a)** Reactions (collisions) only happen at the surface of solids. (½)
Powdered solids have a larger surface area (½) therefore more zinc atoms are exposed to collisions with hydrogen ions (½)
Chemical change depends on particles colliding, so more collisions gives a faster rate of reaction. (½) (2)

(b) **(i)** There will be **more** collisions per second. (1)

(ii) Particles can only react if they **collide**. (1)

(c) **(i)** They will collide with **higher** energy. (1)

(ii) The particles colliding must have **enough** energy otherwise the collision will **not** result in a reaction. (1)

3. **(a)** Y is faster. (1)

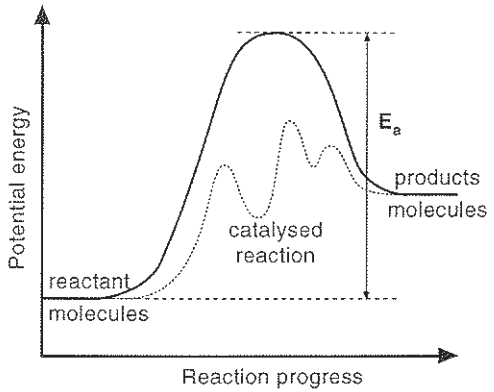
(b) There are more acid particles (or hydrogen ions) (½) so there will be more collisions. (½) (1)

TOTAL (10)

Learn from any mistakes by checking over all wrong answers.
Ask your teacher about anything you still do not understand.

ANSWER CHECK 3.6

1. **(a)**



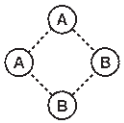
Axes labelled (½) + (½)
Graph rises then falls (½)
PEs representing reactant molecules and product molecules labelled on graph (½)
PE of products higher than PE of reactants (1) (3)

(b) E_a correctly labelled on the diagram (1)

(c) On graph, start and finish of dotted line same as for black line but pathway in between must be lower. (1)

2. E_a (½) in kJ mol^{-1} (½) (1)

3. **(a)**



(1)

(b) The reactant bonds are half broken and the product bonds half formed. (1)

(c) Kinetic energy changes to potential energy. (1)

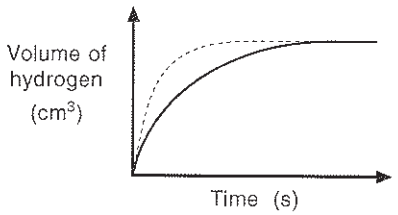
(d) Potential energy changes to kinetic energy. (1)

TOTAL (10)

Learn from any mistakes by checking over all wrong answers.
Ask your teacher about anything you still do not understand.

ANSWER CHECK 3.5

1. **(a)**



Axes labelled (½) + (½)

Rising curved line (½)
finishing horizontal (½) **(2)**

(b) Dotted line steeper at start (½) but finishing at same volume (½) **(1)**

2. Any **two** from:

- Collect and record the total volume of carbon dioxide at suitable time intervals. **(1)**
- Measure and record pH at suitable time intervals. **(1)**
- Measure and record the mass of the container and its contents at suitable time intervals. **(1)** **(2)**

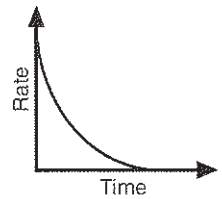
3. **(a)** **(i)** 140 s (± 10 s) **(1)**

(ii) At time zero **OR** at start **OR** in the first second **(1)**

(b) $\frac{197.4 - 196.6}{110 - 60}$ (½) (½)

$= 0.016\ g\ s^{-1}$ **(1)** [**OR** $-0.016\ g\ s^{-1}$] **(2)**

(c)



Shape of curve (½)

ending on base line (½) **(1)**

TOTAL **(10)**

Learn from any mistakes by checking over all wrong answers.
Ask your teacher about anything you still do not understand.

ANSWER CHECK 3.2

1. **(a)** nitrogen dioxide → nitrogen + oxygen **(1)**

carbon monoxide + oxygen → carbon dioxide **(1)** **(2)**

(b) Lead (and its compounds) will poison the catalyst. **(1)**

2. **(a)** ... adsorption (½)

(b) ... weak (½)

(c) ... weakens (½)

(d) ... more (½)

(e) ... break (½)

(f) ... more (½) **(3)**

3. Enzymes **(1)**

4.

	Reaction	*Catalyst*	*Type of catalysis*
(a)	*Haber Process*	**(i)** iron (½)	**(ii)** heterogeneous (½)
(b)	*Ostwald Process*	**(i)** platinum (½)	**(ii)** heterogeneous (½)
(c)	*Fermentation*	**(i)** enzymes **OR** yeast (½)	**(ii)** homogeneous (½)

(3)

TOTAL **(10)**

Learn from any mistakes by checking over all wrong answers.
Ask your teacher about anything you still do not understand.

ANSWER CHECK 3.3

1. **(a)** Starch solution **(1)**

(b) (Timing until) the appearance of a blue/black colour **(1)**

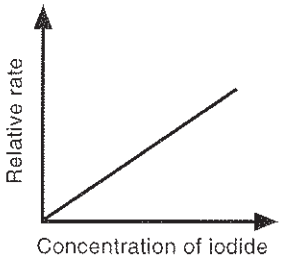
(c) **(i)** $\frac{1}{\text{time}}$ **OR** $\frac{1}{\mathbf{t}}$ **(1)**

(ii) Because the amount of thiosulphate solution in each experiment is the same. **(1)**

2. **(a)** By using different volumes of the given potassium iodide solution made up to the same total volume with water. **(1)**

(b) Increases **(1)**

(c)



Axes correctly labelled (½) + (½)

Straight line drawn through origin **(1)** **(2)**

(d) 0.8 M is 4 times as concentrated as 0.2 M **(1)**

So relative rate = 4 x 0.15 = 0.6 min^{-1} **(1)** **(2)**

TOTAL **(10)**

Learn from any mistakes by checking over all wrong answers.
Ask your teacher about anything you still do not understand.

ANSWER CHECK 3.4

1. **(a)** (Timing until) the disappearance of the permanganate colour

OR The solution changing from purple to colourless **(1)**

(b) To provide hydrogen ions for the reaction **(1)**

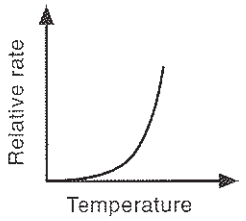
(c) s^{-1} **(1)**

2. **(a)** Temperature (of the reaction mixture) **(1)**

(b) Any **three** from:

- Total volume **(1)**
- Volume of permanganate **(1)**
- Volume of oxalic acid **(1)**
- Volume of sulphuric acid **(1)**
- Concentration of permanganate **(1)**
- Concentration of oxalic acid **(1)**
- Concentration of sulphuric acid **(1)** [Maximum 3] **(3)**

(c)



Axes labelled (½) + (½)

Curved line sloping upward **(1)** **(2)**

(d) Doubles the rate (approximately) **(1)**

TOTAL **(10)**

Learn from any mistakes by checking over all wrong answers.
Ask your teacher about anything you still do not understand.