# Rates of Reaction Questions

1. 100 mL of 1.00 M HCl is added to a 2 g piece of limestone, $CaCO_3$.
   Which of the following will not increase the initial rate of this reaction?

   A. adding 150 mL of 1 M HCl in place of 100 mL of 1 M HCl

   B. adding 100 mL of 2 M HCl in place of 100 mL of 1 M HCl

   C. heating the 100 mL of 1 M HCl before adding it to the limestone

   D. adding 100 mL of 1 M HCl to powdered $CaCO_3$ in place of the single piece of limestone

2. The $E_a$ for the forward reaction between nitrogen (II) oxide and chlorine shown below is 62 kJ mol–1

   $2NO(g) + Cl_2(g) \rightarrow 2NOCl(g)$ $\Delta H = -38$ kJ mol–1

   The activation energy of the reverse reaction, in kJ mol–1, is

   A. –62

   B. 24

   C. 38

   D. 100

3. The rate of decomposition of hydrogen peroxide is increased by the presence of a catalyst. The catalyst

   A. increases the yield for the reaction.

   B. provides a reaction pathway with a lower activation energy.

   C. provides a reaction pathway with a greater activation energy.

   D. increases the average kinetic energy of the hydrogen peroxide molecules.

4. Some carbon dioxide is to be generated by reacting 50 g of calcium carbonate with a solution of hydrochloric acid. Which of the following actions is least likely to lead to an increase in the rate of formation of carbon dioxide?

   A. grinding the calcium carbonate to a fine powder

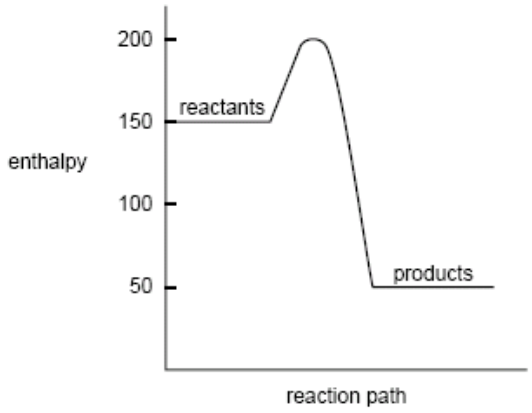
   B. raising the temperature

   C. raising the atmospheric pressure

   D. raising the concentration of hydrochloric acid

*Questions 5 and 6 refer to the following information.*

The relative enthalpies, on an arbitrary scale, of the reactants and products of a chemical reaction, are represented on the following diagram.




5. The numerical value of enthalpy change, $\Delta H$, for the forward reaction, is

   A. +150

   B. +50

   C. –50

   D. –100

6. The numerical value of the activation energy for the reverse reaction is

   A. +150

   B. +50

   C. –50

   D. –100

7. The best description of the effect of a catalyst on a chemical reaction is that it

   A. lowers the activation energy of the forward reaction without changing the activation energy of the reverse reaction.

   B. lowers the activation energy of the forward reaction and raises the activation energy of the reverse reaction.

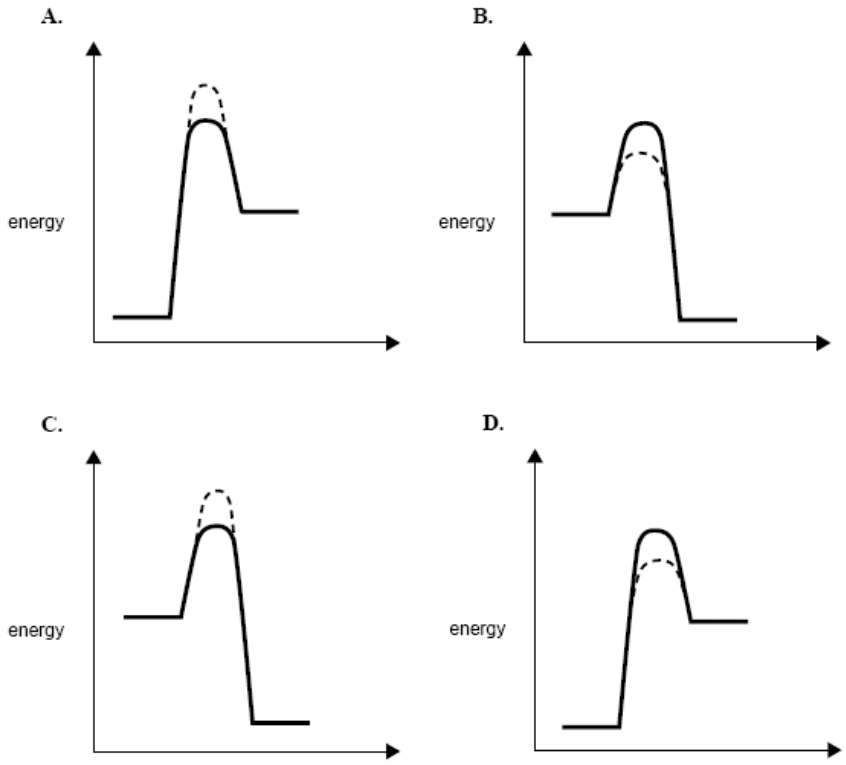
   C. lowers the activation energy of both forward and reverse reactions by the same amount.

   D. lowers the activation energy of the reverse reaction without changing the activation energy of the forward reaction.

8. Which one of the following energy profiles best illustrates the energy change of:

$2H_2O(l) \rightarrow 2H_2(g) + O_2(g) \quad \Delta H = +571.8\ kJ$

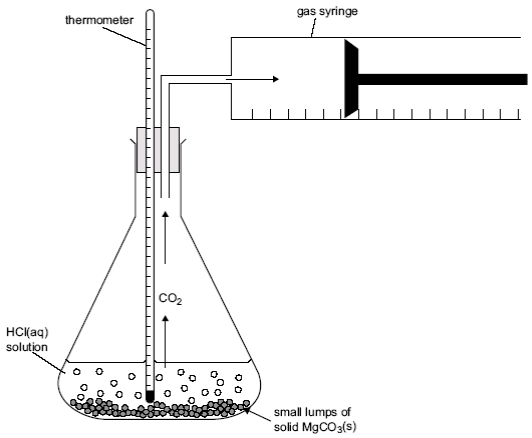
both in the absence (solid lines) and presence (dotted lines) of a catalyst.



9. Magnesium carbonate reacts with aqueous hydrochloric acid according to the reaction:

$$MgCO_3(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2O(l) + CO_2(g)$$

A series of laboratory experiments was set up to study the rate of this reaction under some different conditions. The initial reaction rate was determined by measuring the rate of evolution of $CO_2$ in a gas syringe as shown in the diagram.




Four experiments were carried out as follows. In each case, the amount of HCl present was in excess.

| Experiment | [HCl] (M) | Mass of $MgCO_3$(g) | Initial temp in °C | Final temp in °C | Initial rate of $CO_2$ evolution in mL $min^{-1}$ |
|---|---|---|---|---|---|
| 1 | 0.10 | 1.0 | 20 | 25 | 5 |
| 2 | 0.10 | 1.0 | 30 | 35 | 50 |
| 3 | 0.10 | 2.0 | 20 | 30 | 10 |
| 4 | 0.20 | 1.0 | 20 | 25 | 20 |

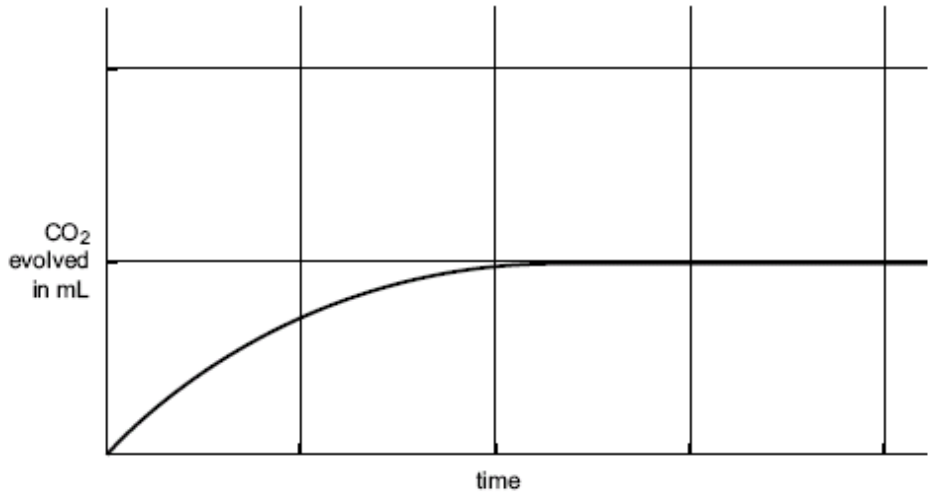
a) Is the reaction exothermic or endothermic? Explain how you can tell from these results.

b) Considering experiments 1 and 2, explain why the increase in the initial temperature has raised the reaction rate.

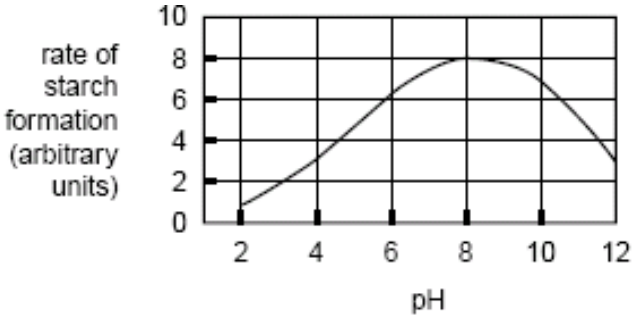
c) Considering experiments 1 and 3, explain why the greater mass of magnesium carbonate would have increased the reaction rate.

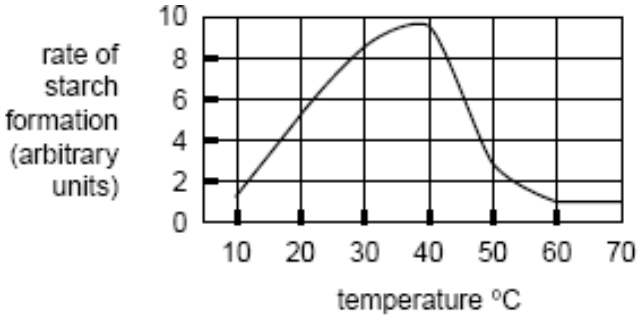
d) Considering experiments 1 and 4, explain why the higher concentration of HCl would have increased the reaction rate.

e) Results from experiment 1 are plotted on the sketch graph below. On the same axes, sketch the results from experiment 3.



10. Enzymes are proteins that catalyse chemical reactions in biological systems. The enzyme, starch phosphorylase, catalyses the formation of starch from glucose in plants. Students studying the effects of pH and temperature on starch phosphorylase in the laboratory obtained the following results.



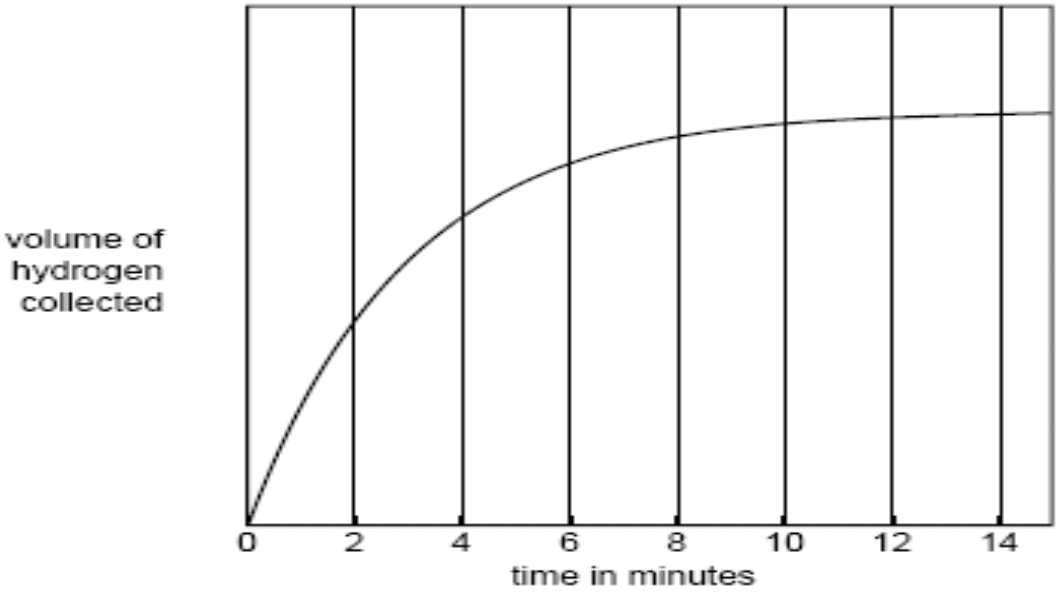

a) At what pH does this enzyme operate at its maximum rate?

b) Explain why the rate of starch formation:

i. gradually increases as the temperature increases from 10°C to 40°C.

ii. decreases quickly as the temperature increases from 40°C to 50°C

11. 0.12 g of powdered magnesium was added to 250 mL of 0.10 M hydrochloric acid (excess) at 25°C. The hydrogen gas produced was collected in a gas syringe and its volume recorded every minute, as shown in the graph below.




The reaction was repeated a number of times, varying only the conditions outlined below. Sketch the expected graph for each test on the axes above.

a) Temp = 10°C
b) Using 250 mL 1M HCl
c) A catalyst was added
d) Using 0.05g Mg

**Answers:**

1. A 2. D 3. B 4. C 5. D 6. A 7. C 8. D

9. (a) Exo, heat that is released increases the temp of the system.

(b) Higher temp = higher KE of particles > significantly more collisions with required energy (+ more frequent collisions) > more effective collisions > faster rate

(c) Higher mass Mg = more Mg particles > higher concentration > more frequent collisions > more effective collisions > faster rate

(d) Higher HCl concentration > more frequent collisions > more effective collisions > faster rate

(e) Line should be above expt 1 and follow similar pattern - faster initial rate and higher product

10. (a) 8

(b) (i) higher temp = higher KE of particles = more collisions between substrate and enzyme = faster rate

(ii) enzyme denatures at 40°C – shape of active site no longer matches substrate (increase temp = increased vibrations in enzyme, vibrations > IMFs holding enzyme in shape = loses shape), thus enzyme cannot bond with substrate = ineffective enzyme = significant decrease in rate

11.