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Level 2 Chemistry, 2015

91166 Demonstrate understanding of chemical reactivity

9.30 a.m. Monday 23 November 2015
Credits: Four

Achievement	Achievement with Merit	Achievement with Excellence
Demonstrate understanding of chemical reactivity.	Demonstrate in-depth understanding of chemical reactivity.	Demonstrate comprehensive understanding of chemical reactivity.

Check that the National Student Number (NSN) on your admission slip is the same as the number at the top of this page.

You should attempt ALL the questions in this booklet.

A periodic table is provided on the Resource Sheet L2–CHEMR.

If you need more room for any answer, use the extra space provided at the back of this booklet and clearly number the question.

Check that this booklet has pages 2–12 in the correct order and that none of these pages is blank.

YOU MUST HAND THIS BOOKLET TO THE SUPERVISOR AT THE END OF THE EXAMINATION.

TOTAL

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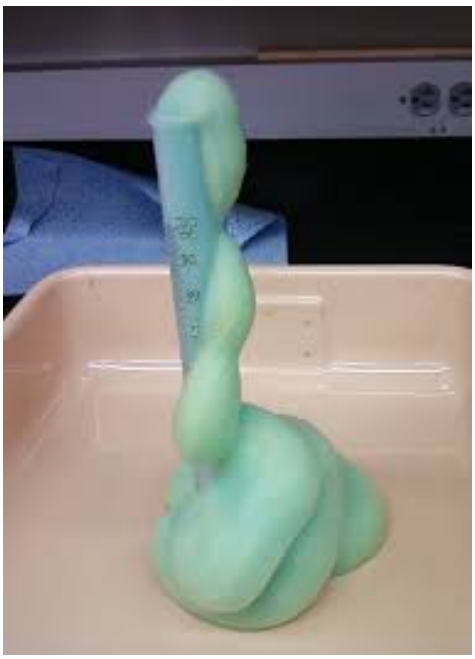
QUESTION ONE

The 'elephant toothpaste' demonstration shows the decomposition of hydrogen peroxide, H_2O_2, into water and oxygen gas.

$$2H_2O_2(aq) \rightarrow 2H_2O(\ell) + O_2(g)$$

This reaction can be observed by adding detergent to the hydrogen peroxide solution. As oxygen gas is produced, the detergent foams up, as seen in the photograph on the right. The time taken for the foam to reach the top of the measuring cylinder can be used to measure the rate of the reaction.



Three experiments were carried out to investigate factors that change the rate of the reaction.

Experiment	Concentration of H_2O_2	Temperature °C	Presence of small amount of MnO_2
1	20%	20	yes
2	20%	30	yes
3	30%	20	yes

(a) The decomposition reaction of hydrogen peroxide, H_2O_2, is very slow. By adding a small amount of powdered manganese dioxide, MnO_2, the rate of the reaction can be increased.

(i) Explain why only a small amount of manganese dioxide is needed to increase the rate of the reaction.

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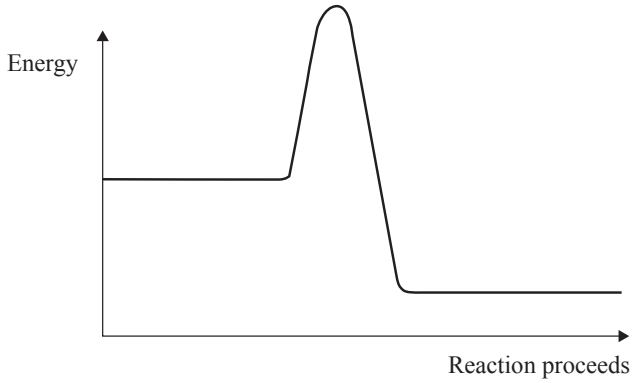
(ii) The diagram below shows the energy diagram for the decomposition reaction **without** manganese dioxide.

Label this diagram and use it to help you explain how the addition of manganese dioxide speeds up the rate of the reaction.



(b) Compare Experiment 2 with Experiment 1.

In your answer, you should:

- identify the factor being changed, and the effect this will have on the rate of reaction
- explain the effect on the rate of reaction by referring to the collision of particles and activation energy, where appropriate.

There is more space for your answer to Question One (b) on the following page.

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(c) Compare Experiment 3 with Experiment 1.

In your answer, you should:

- identify the factor being changed, and the effect this will have on the rate of reaction
- explain the effect on the rate of reaction by referring to the collision of particles and activation energy, where appropriate.

QUESTION TWO

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(a) Ammonia solution, $NH_3(aq)$, is a common chemical in the school laboratory.

(i) Explain, using an equation, whether ammonia solution is acidic or basic.

(ii) Bottles of ammonia solution are often labelled ammonium hydroxide, $NH_4OH(aq)$.

Explain why both names, ammonia and ammonium hydroxide, are appropriate.

(b) The hydrogen carbonate ion, HCO_3^-, is an amphiprotic species because it can donate or accept a proton, therefore acting as an acid or base.

Write equations for the reactions of HCO_3^- with water: one where it acts as an acid, and one where it acts as a base.

HCO_3^- acting as	**Equation**
an acid	$HCO_3^- + H_2O \rightleftharpoons$
a base	$HCO_3^- + H_2O \rightleftharpoons$

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(c) (i) A solution of nitric acid, $HNO_3(aq)$, has a hydronium ion, H_3O^+, concentration of 0.0243 mol L^{-1}.

Determine, by calculation, the pH and the concentration of hydroxide ions, OH^-, in this solution.

$K_w = 1 \times 10^{-14}$

pH = _____

_____

$[OH^-]$ = _____

_____

(ii) Determine the hydroxide ion concentration, $[OH^-]$, of a solution of potassium hydroxide, $KOH(aq)$, with a pH of 11.8.

_____

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(d) Ethanoic acid solution, $CH_3COOH(aq)$, and ammonium chloride solution, $NH_4Cl(aq)$, are both weakly acidic.

Identify and justify, using equations, which acid solution has greater electrical conductivity.

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(e) The table shows the pH of two acidic solutions, methanoic acid, HCOOH, and hydrochloric acid, HCl, which both have a concentration of 0.1 mol L^{-1}.

Solution	HCOOH(*aq*)	HCl(*aq*)
pH	2.4	1

Compare and contrast the pH of each solution, and their expected rate of reaction with a 2 cm strip of cleaned magnesium ribbon, Mg.

QUESTION THREE

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(a) The equilibrium constant for a reaction involving compounds A, B, C, and D is shown as:

$$K_c = \frac{[C]^3[D]}{[A][B]^2}$$

Write the chemical equation for this reaction.

(b) The reaction between ethanoic acid and ethanol is reversible. Ethyl ethanoate and water are the products formed. In a closed system, a dynamic equilibrium is set up.

ethanoic acid + ethanol $\rightleftharpoons$ ethyl ethanoate + water

$CH_3COOH(aq) + C_2H_5OH(aq) \rightleftharpoons CH_3COOC_2H_5(aq) + H_2O(\ell)$

(i) Explain, using equilibrium principles, the effect of adding more ethanol to the reaction mixture.

(ii) The reaction is quite slow, so a small amount of concentrated sulfuric acid is added as a catalyst.

Explain, using equilibrium principles, the effect of adding this catalyst to the equilibrium mixture.

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(c) The following chemical equation represents a reaction that is part of the Contact Process which produces sulfuric acid.

$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$ $\Delta H = -200$ kJ mol^{-1}, $K_c = 4.32$ at 600°C

(i) Write an equilibrium constant expression for this reaction.

$K_c =$

(ii) A reaction mixture has the following concentration of gases at 600°C:

$[SO_2(g)] = 0.300$ mol L^{-1}

$[O_2(g)] = 0.100$ mol L^{-1}

$[SO_3(g)] = 0.250$ mol L^{-1}

Justify why this reaction mixture is not at equilibrium.

In your answer you should use the equilibrium expression from part (c)(i) and the data provided above to show that the reaction mixture is not at equilibrium.

Question Three continues on the following page.

(iii) The reaction on the previous page was repeated at 450°C.

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Explain, using equilibrium principles, how the change in temperature will affect:

- the value of K_c
- the position of equilibrium.

Extra paper if required.
Write the question number(s) if applicable.

QUESTION NUMBER

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