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Level 2 Chemistry 2021

91166 Demonstrate understanding of chemical reactivity

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 in the Resource Booklet L2–CHEMR.

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

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

Do not write in any cross-hatched area (▨). This area may be cut off when the booklet is marked.

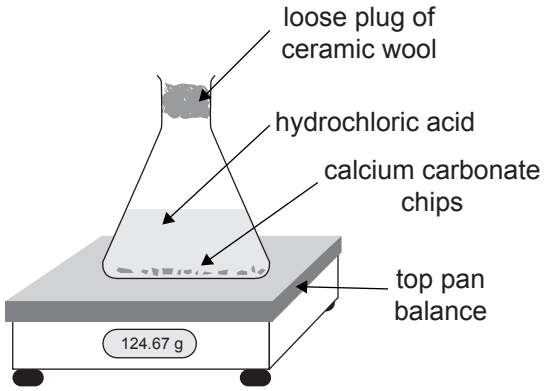
YOU MUST HAND THIS BOOKLET TO THE SUPERVISOR AT THE END OF THE EXAMINATION.

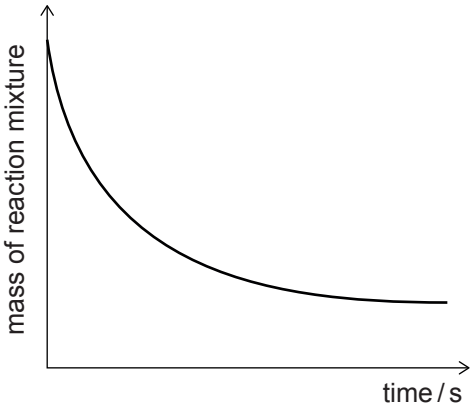
QUESTION ONE

(a) Calcium carbonate chips, $CaCO_3(s)$, react with a solution of hydrochloric acid, $HCl(aq)$.
The reaction is represented by the equation:

$$CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + CO_2(g) + H_2O(\ell)$$

The reaction is monitored by measuring the decrease in mass of the reaction mixture over time. This is shown below.





(i) Why does the reaction mixture decrease in mass as the reaction proceeds?

(ii) Explain the changes in the rate of reaction between calcium carbonate chips, $CaCO_3(s)$, and hydrochloric acid, $HCl(aq)$, as the reaction proceeds.

Refer to the shape of the graph in your answer.

(b) Two further reactions were set up between 5.00 g of calcium carbonate, $CaCO_3(s)$, and 100 mL of hydrochloric acid, HCl(*aq*), as follows.

	Calcium carbonate, $CaCO_3(s)$	**Hydrochloric acid, HCl(*aq*)**
Reaction One	Chips	0.500 mol L^{-1}
Reaction Two	Powder	0.500 mol L^{-1}

Compare and contrast these two reactions.

Refer to collision theory and rates of reaction in your answer.

You should consider the total mass loss of each reaction.

(c) The decomposition reaction of hydrogen peroxide solution, $H_2O_2(aq)$, is a slow reaction. This reaction is represented by the equation:

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

The 'elephant's toothpaste' experiment shows how the rate of the decomposition reaction can be changed by adding a small amount of potassium iodide, KI(s). When potassium iodide is added, large amounts of foam are produced as a result of the rapid production of oxygen gas.

(i) State the role of potassium iodide, KI(s), in this reaction.

(ii) Elaborate on how potassium iodide, KI(s), changes the rate of the reaction.

In your answer you should refer to activation energy and collision theory.

You may also include diagrams in your answer.

QUESTION TWO

(a) The equilibrium constant expression for a reaction is:

$$K_c = \frac{\left[NO_2(g)\right]^2}{\left[NO(g)\right]^2\left[O_2(g)\right]}$$

Write the chemical equation for this reaction. You can assume all species present in the reaction are represented in the K_c expression.

(b) For the above reaction, the value for K_c at 230 °C is 6.44×10^5 (644 000).

At the concentrations below, the reaction is not at equilibrium.

Gas	NO	O_2	NO_2
Concentration (mol L^{-1})	0.0102	0.0128	0.989

(i) By using the K_c expression in part (a) above and the concentrations shown in the table, explain why the reaction is not at equilibrium.

(ii) To reach equilibrium, would the forward or backward reaction need to be favoured?

Justify your answer.

There is more space for your answer to this question on the following page.

(c) The following equation shows a system in equilibrium.

$$CH_3COOH(aq) + H_2O(\ell) \rightleftharpoons CH_3COO^-(aq) + H_3O^+(aq) \quad K_c = 1.74 \times 10^{-5}$$

Explain, using equilibrium principles, the effect on the position of the equilibrium when:

(i) a small amount of concentrated ethanoic acid, $CH_3COOH(\ell)$, is added.

(ii) dilute sodium hydroxide solution, NaOH(aq), is added.

(iii) When the temperature of the equilibrium system is increased, the K_c value also increases.

Justify, using equilibrium principles, whether the forward reaction is exothermic or endothermic.

QUESTION THREE

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

Complete the equations for the reactions of the hydrogen carbonate ion, $HCO_3^-(aq)$, with water in the box below.

HCO_3^- acting as:	**Equation**
an acid	$HCO_3^-(aq) + H_2O(\ell) \rightleftharpoons$
a base	$HCO_3^-(aq) + H_2O(\ell) \rightleftharpoons$

(b) (i) A solution of nitric acid, $HNO_3(aq)$, has a concentration of 0.0625 mol L^{-1}.

Calculate the pH.

(ii) Calculate the hydroxide ion, $OH^-(aq)$, concentration of a solution of potassium hydroxide, $KOH(aq)$, that has a pH of 9.5.

(c) The table shows the concentration and pH of three solutions: potassium hydroxide, KOH(*aq*), methanamine, $CH_3NH_2(aq)$, and methanoic acid, HCOOH(*aq*).

	KOH(*aq*)	**$CH_3NH_2(aq)$**	**HCOOH(*aq*)**
Concentration (mol L^{-1})	0.100	0.100	0.100
pH	13.0	11.8	2.37

Justify why each of the solutions in the table above have the same concentration, but a different pH.

Use equations to support your answer.

Question Three continues on the next page.

(d) Elaborate on the electrical conductivity of solutions of hydrochloric acid, HCl(*aq*), ammonia, $NH_3(aq)$, and ammonium chloride, $NH_4Cl(aq)$.

Use equations to support your answer.

	HCl(*aq*)	**$NH_3(aq)$**	**$NH_4Cl(aq)$**
Concentration (mol L^{-1})	0.100	0.100	0.100
Electrical conductivity	good	poor	good

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

QUESTION NUMBER

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