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2

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Level 2 Chemistry, 2016

91166 Demonstrate understanding of chemical reactivity

9.30 a.m. Monday 21 November 2016
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

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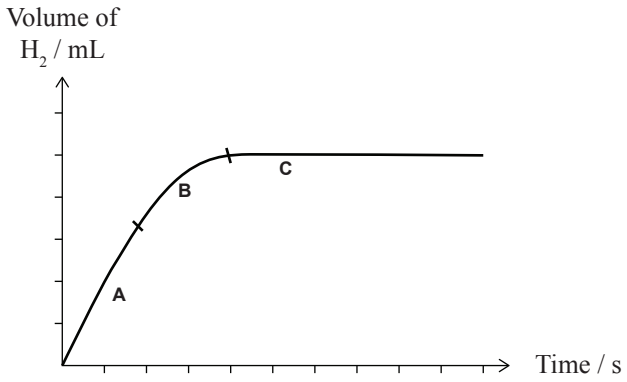
(a) Cleaned magnesium ribbon, Mg(*s*), reacts with a solution of hydrochloric acid, HCl(*aq*). The reaction is represented by the equation:

$$Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$$

The reaction is monitored by measuring the volume of hydrogen gas produced over a given period of time. This is shown in the graph below.



Explain the changes in the rate of reaction between magnesium, Mg(*s*), and hydrochloric acid, HCl(*aq*), in terms of collision theory.

Refer to parts A, B, and C of the graph in your answer.

(b) Compare and contrast the reactions of 0.5 g of magnesium ribbon, Mg(*s*), with 50.0 mL of 0.100 mol L^{-1} hydrochloric acid, HCl(*aq*), and 0.5 g of magnesium powder, Mg(*s*), with 50.0 mL of 0.100 mol L^{-1} hydrochloric acid, HCl(*aq*).

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

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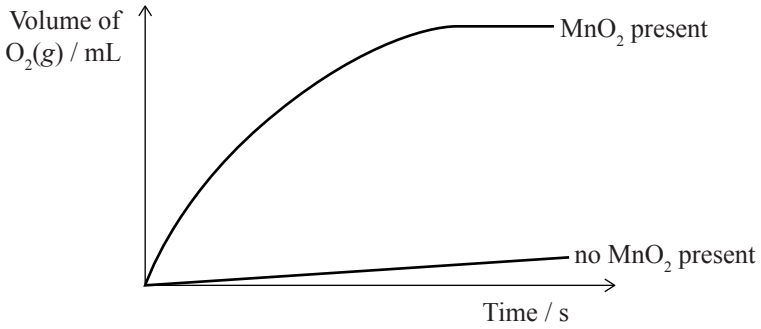
(c) The decomposition reaction of hydrogen peroxide solution, $H_2O_2(aq)$, is a slow reaction. This reaction is represented by the equation:

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

The rate of the decomposition reaction can be changed by adding a small amount of manganese dioxide, $MnO_2(s)$. The graph below shows the volume of oxygen gas formed in the reaction with and without manganese dioxide, $MnO_2(s)$.



(i) State the role of manganese dioxide, $MnO_2(s)$, in this reaction.

(ii) Elaborate on how manganese dioxide, $MnO_2(s)$, changes the rate of the decomposition reaction of the hydrogen peroxide, $H_2O_2(aq)$.

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

You may also include diagrams in your answer.

QUESTION TWO

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(a) Water is an amphiprotic substance because it can accept or donate a proton, therefore acting as an acid or a base.

Complete the equations for the reactions of water, H_2O, with ammonia, NH_3, and the ammonium ion, NH_4^+, in the box below.

H_2O acting as	**Equation**
an acid	$H_2O(\ell) + NH_3(aq) \rightleftharpoons$
a base	$H_2O(\ell) + NH_4^+(aq) \rightleftharpoons$

(b) Sodium carbonate, $Na_2CO_3(s)$, is a salt. When dissolved in water, it dissociates into ions.

Explain whether a solution of sodium carbonate would be acidic or basic.
In your answer you should include TWO relevant equations.

(c) (i) Calculate the pH of a 0.0341 mol L^{-1} hydrochloric acid, $HCl(aq)$, solution.

pH =

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(ii) A solution of sodium hydroxide, NaOH(*aq*), has a pH of 12.4.

Calculate the concentrations of both hydronium ions, H_3O^+, and hydroxide ions, OH^-, in this solution.

$[H_3O^+]$ =

$[OH^-]$ =

(d) The table shows the pH of three acidic solutions, ammonium chloride, NH_4Cl, propanoic acid, C_2H_5COOH, and hydrogen chloride, HCl.

	$NH_4Cl(aq)$	**$C_2H_5COOH(aq)$**	**$HCl(aq)$**
Concentration / mol L^{-1}	0.1	0.1	0.1
pH	5.62	3.44	1.0

(i) Explain why each of the three solutions in the table above has the same concentration, but a different pH.

Use equations to support your answer.

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(ii) Explain why the solution of ammonium chloride, $NH_4Cl(aq)$, is a good conductor of electricity, while the solution of propanoic acid, $C_2H_5COOH(aq)$, is a poor conductor of electricity.

QUESTION THREE

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

$$K_c = \frac{[CH_3OH]}{[CO][H_2]^2}$$

Write the equation for this reaction.

(b) The ionisation of water is represented by the equation:

$$2H_2O(\ell) \rightleftharpoons H_3O^+(aq) + OH^-(aq)$$

Give an account of the extent of ionisation of water, given $K_w = 1 \times 10^{-14}$.

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(c) When acid is added to a yellow solution of chromate ions, $CrO_4^{2-}(aq)$, the following equilibrium is established.

$$\underset{\text{yellow}}{2CrO_4^{2-}(aq)} + 2H^+(aq) \rightleftharpoons \underset{\text{orange}}{Cr_2O_7^{2-}(aq)} + H_2O(\ell)$$

Analyse this equilibrium using equilibrium principles to explain the effect on the colour of the solution when:

(i) more dilute acid is added:

(ii) dilute base is added:

(d) When hydrogen gas, $H_2(g)$, and iodine gas, $I_2(g)$ are mixed, they react to form $HI(g)$, and an equilibrium is established.

$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g) \qquad K_c = 64 \text{ at } 445°C.$$

(i) Calculate the concentration of HI in an equilibrium mixture at 445°C when the concentrations of $H_2(g)$ and $I_2(g)$ are both 0.312 mol L^{-1}.

Question Three continues on the following page.

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(ii) Explain the effect on the position of equilibrium if the overall pressure of the equilibrium system is increased.

(iii) When the temperature of the equilibrium system is increased to 510°C, the K_c value decreases to 46.

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

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

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