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SUPERVISOR'S USE ONLY

Level 2 Chemistry, 2018

91166 Demonstrate understanding of chemical reactivity

9.30 a.m. Monday 26 November 2018
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 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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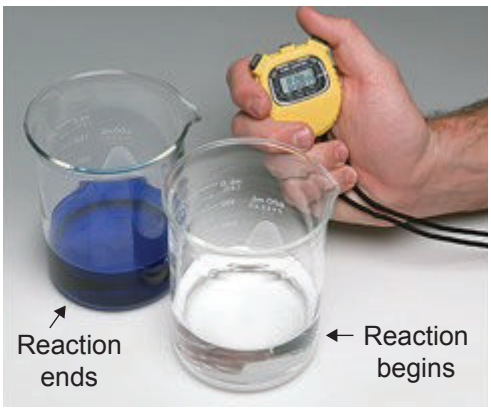
(a) In the iodine clock reaction, a solution of hydrogen peroxide is mixed with a solution containing potassium iodide, starch, and sodium thiosulfate.

After some time, the colourless mixture suddenly turns dark blue.



The table shows the time taken for the reaction performed at different temperatures. The concentration of all reactants was kept constant.

Temperature / °C	Time for dark blue colour to appear / s
20	15
30	9
40	4

Explain the effect of changing the temperature on the rate of reaction.

Refer to collision theory and activation energy in your answer.

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(b) Consider the following observations in another experiment using hydrogen peroxide:

- When hydrogen peroxide is mixed with solution **X**, which contains universal indicator, the colour changes from blue to green to yellow to orange-red **over a time of one hour**.
- If a crystal of **ammonium molybdate** is added to solution **X** before the hydrogen peroxide is added, the same colour changes will be seen in **three to four minutes**.

(i) Identify and explain the role of ammonium molybdate.

Use a diagram and refer to activation energy in your answer.

(ii) The pH of the original solution **X** is 10.8.

Calculate the hydronium ion concentration, $[H_3O^+]$, and the hydroxide ion concentration, $[OH^-]$, in the solution.

$[H_3O^+]$ =

$[OH^-]$ =

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(iii) The sodium hydroxide solution, NaOH(*aq*), used to prepare solution **X** has a concentration of 0.0125 mol L^{-1}.

Calculate the pH of the sodium hydroxide solution.

(iv) Another chemical in solution **X** is a salt, sodium ethanoate, CH_3COONa. When solid sodium ethanoate is dissolved in water, it separates into ions.

Use TWO relevant equations to explain whether **the solution** is acidic or basic.

QUESTION TWO

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The Contact Process is used industrially in the manufacture of sulfuric acid. One step in this process is the oxidation of sulfur dioxide, $SO_2(g)$, to sulfur trioxide, $SO_3(g)$.

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$$

(a) Write the equilibrium constant expression for this reaction.

$K_c =$

(b) (i) Calculate the equilibrium constant (K_c) for this reaction at 600ºC using the following concentrations:

$[SO_2] = 0.100 \text{ mol L}^{-1}$
$[O_2] = 0.200 \text{ mol L}^{-1}$
$[SO_3] = 0.0930 \text{ mol L}^{-1}$

(ii) Explain what the size of the K_c value indicates about the extent of the reaction at equilibrium.

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(c) Explain, using equilibrium principles, why it is important for an industrial plant to continue to remove the sulfur trioxide gas, $SO_3(g)$, as it is produced.

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$$

(d) Predict, using equilibrium principles, the effect on the concentration of sulfur trioxide gas, $SO_3(g)$, of carrying out the reaction in a **larger** reaction vessel.

(e) When the reaction is carried out at 450ºC, the K_c value is higher than the value at 600°C.

Justify whether the oxidation of sulfur dioxide gas, $SO_2(g)$, to sulfur trioxide gas, $SO_3(g)$, is exothermic or endothermic.

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QUESTION THREE

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(a) The hydrogensulfate ion, HSO_4^-, is an amphiprotic species because it can both accept or donate a proton, thus acting as an acid or base.

Complete the equations for the reactions of the hydrogensulfate ion, HSO_4^-, with water in the box below.

HSO_4^- acting as	**Equation**
an acid	$HSO_4^-(aq) + H_2O(\ell) \rightleftharpoons$
a base	$HSO_4^-(aq) + H_2O(\ell) \rightleftharpoons$

(b) The pH and relative electrical conductivity of aqueous solutions of potassium hydroxide, KOH(*aq*), and ammonia, $NH_3(aq)$, are shown in the table below. Both have concentrations of 0.100 mol L^{-1}.

Chemical	**pH**	**Conductivity**
KOH(*aq*)	13	good
$NH_3(aq)$	11.1	poor

Explain the difference in pH and conductivity of these two solutions.

Use relevant equations in your answer.

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(c) The table below gives the pH of solutions of ethanoic acid, $CH_3COOH(aq)$, and nitric acid, $HNO_3(aq)$, of concentrations of 0.200 mol L^{-1}.

Solution	**$CH_3COOH(aq)$**	**$HNO_3(aq)$**
pH	2.73	0.70

(i) Use the pH values to analyse the strength of the acids by calculating the concentration of their H_3O^+ ions.

(ii) Using your calculations in (i) above, predict the rate of reaction of each acid with a 2 cm strip of cleaned magnesium ribbon, Mg.

Refer to the collision theory in your answer.

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

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