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Level 2 Chemistry 2020

91166 Demonstrate understanding of chemical reactivity

9.30 a.m. Thursday 26 November 2020
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) (i) Sodium hydrogen carbonate, $NaHCO_3$, is a salt and will dissociate into ions when dissolved in water.

Write an equation for this process.

(ii) One of the ions formed from the dissociation is amphiprotic because it can either accept or donate a proton.

Write equations for each of these reactions.

Acting as:	Equation
an acid	
a base	

(b) (i) A solution of sodium hydroxide, NaOH(aq), has a pH of 11.8.

Calculate the concentration of hydroxide ions, OH^-, in this solution.

(ii) The ionisation constant of water, K_w, like all equilibrium constants, varies with temperature.

Calculate the pH of pure water at 0 °C when $K_w = 0.114 \times 10^{-14}$

$K_w = [H_3O^+][OH^-]$

(c) The table below shows the concentration and pH of three basic solutions, sodium ethanoate, $CH_3COONa(aq)$, ammonia, $NH_3(aq)$, and sodium hydroxide, NaOH(aq).

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	$CH_3COONa(aq)$	$NH_3(aq)$	NaOH(aq)
Concentration (mol L^{-1})	0.1	0.1	0.1
pH	8.88	10.6	13.0

Explain why each of these solutions has a different pH value, yet they are the same concentration.

Use equations to support your answer.

QUESTION TWO

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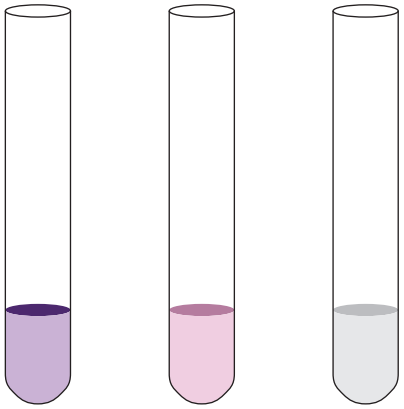
When oxalic acid solution, $H_2C_2O_4(aq)$, reacts with purple acidified potassium permanganate solution, $H^+ / MnO_4^-(aq)$, the purple colour fades and the reaction is complete when the mixture turns colourless.

The picture shows the colour changes after 45 seconds for three different temperatures.

Colour change after 45 seconds



20 °C 40 °C 60 °C

(a) Explain how the rate of reaction for this experiment is affected by the temperature at which the reaction occurs.

In your answer refer to the information in the picture, collision theory, and activation energy.

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(b) (i) Complete the table below by calculating either the pH or the hydronium ion concentration, $[H_3O^+]$, for the three hydrochloric acid solutions, HCl(aq).

Solution	Acid	pH	$[H_3O^+]$ mol L^{-1}
A	HCl(aq)	0.89	
B	HCl(aq)		0.0158
C	HCl(aq)	2.94	

(ii) 2.0 g of powdered calcium carbonate, $CaCO_3(s)$, is added to each of the three solutions, A, B, and C, above. The volume of acid in each solution is the same.

Identify which solution would have the highest rate of reaction with $CaCO_3(s)$.

Explain your answer, with reference to collision theory.

(c) Compare the electrical conductivity of a hydrochloric acid solution, HCl(aq), with a solution of ethanoic acid, $CH_3COOH(aq)$, of the same concentration.

Use equations to support your answer.

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QUESTION THREE

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(a) (i) Write the equilibrium constant expression, K_c, for the conversion of gaseous carbonyl fluoride, $COF_2(g)$, to the gas carbon tetrafluoride, $CF_4(g)$ and carbon dioxide, $CO_2(g)$.

$$2COF_2(g) \rightleftharpoons CF_4(g) + CO_2(g)$$

(ii) At equilibrium, carbonyl fluoride, COF_2, has a concentration of 0.040 mol L^{-1}. The concentration of both carbon tetrafluoride, CF_4, and carbon dioxide, CO_2, is 0.80 mol L^{-1}.

Calculate the K_c for this equilibrium.

(iii) At a **different** temperature, the K_c value is 50.

Explain what the value of the K_c indicates about the extent of this reaction.

(iv) The enthalpy change, $\Delta_r H$, for the decomposition of carbonyl fluoride is –24 kJ mol^{-1}.

Explain what happens to the value of K_c when the temperature is decreased.

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

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(b) The following equilibrium was established in the laboratory by mixing iron(III) nitrate solution, $Fe(NO_3)_3(aq)$, with potassium thiocyanate solution, KSCN(aq).

$$Fe^{3+}(aq) + SCN^{-}(aq) \rightleftharpoons [FeSCN]^{2+}(aq)$$

orange *colourless* *dark red*

The forward reaction produces heat.

Explain, using equilibrium principles, the effect on the colour of the solution if:

(i) More potassium thiocyanate solution, KSCN(aq), is added to the reaction mixture.

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(ii) Solid sodium fluoride is added to the mixture. The added F^- ions react with the Fe^{3+} ions.

(iii) A test tube containing the reaction mixture is placed in a beaker of recently boiled water.

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

QUESTION NUMBER

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