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NZQA | Mana Tohu Mātauranga o Aotearoa
New Zealand Qualifications Authority

Level 2 Chemistry 2023

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 and other reference material are 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 (DO NOT WRITE IN THIS AREA / DO NOT WRITE). This area will 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) The acid found in human stomachs is primarily hydrochloric acid, HCl(*aq*), and has a pH value of approximately 1.5.

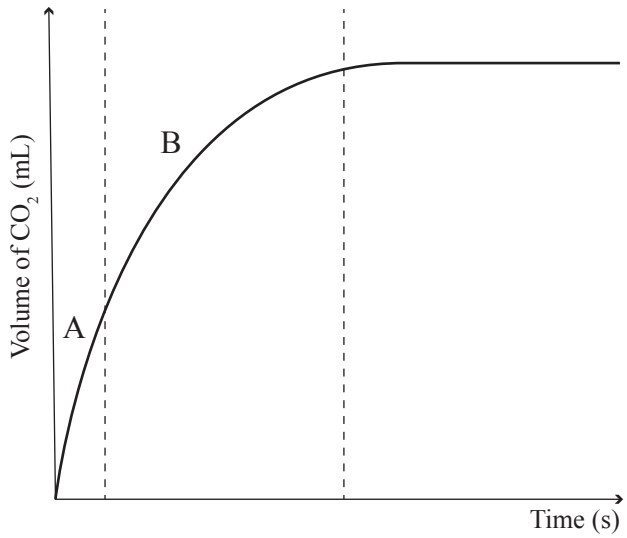
Calculate the concentration of hydronium ions, $H_3O^+(aq)$, present in a hydrochloric acid solution of pH 1.5.

(b) Fast-acting paracetamol tablets contain sodium hydrogen carbonate, $NaHCO_3$, which reacts with stomach acid, HCl(*aq*). The equation is shown below.

$$NaHCO_3(aq) + HCl(aq) \rightarrow NaCl(aq) + CO_2(g) + H_2O(\ell)$$

Some students wanted to investigate how long it takes for all the $NaHCO_3$ in a paracetamol tablet to react in a human stomach. They conducted an experiment where a 0.25 g tablet of $NaHCO_3$ was reacted with an excess of hydrochloric acid at room temperature, approximately 20 °C.

The volume of CO_2 produced during the reaction was recorded and graphed below.



(i) With reference to collision theory, explain why the steepness of the line changes as the reaction proceeds.

Refer to sections A and B in your answer.

(ii) The internal temperature of a human stomach is approximately 37 °C.

Explain why the students' experiment would not give a good indication of how long the $NaHCO_3$ in the tablet takes to react in a human stomach.

Refer to collision theory in your answer.

(c) While the acid found in human stomachs, hydrochloric acid, HCl(*aq*), is considered a strong acid, propanoic acid, $CH_3CH_2COOH(aq)$, is considered weak.

(i) With reference to these two acids, explain the difference between a strong acid and a weak acid.

Include equations in your answer.

(ii) Compare and contrast the pH and electrical conductivity of hydrochloric acid and propanoic acid solutions which are of equal concentration.

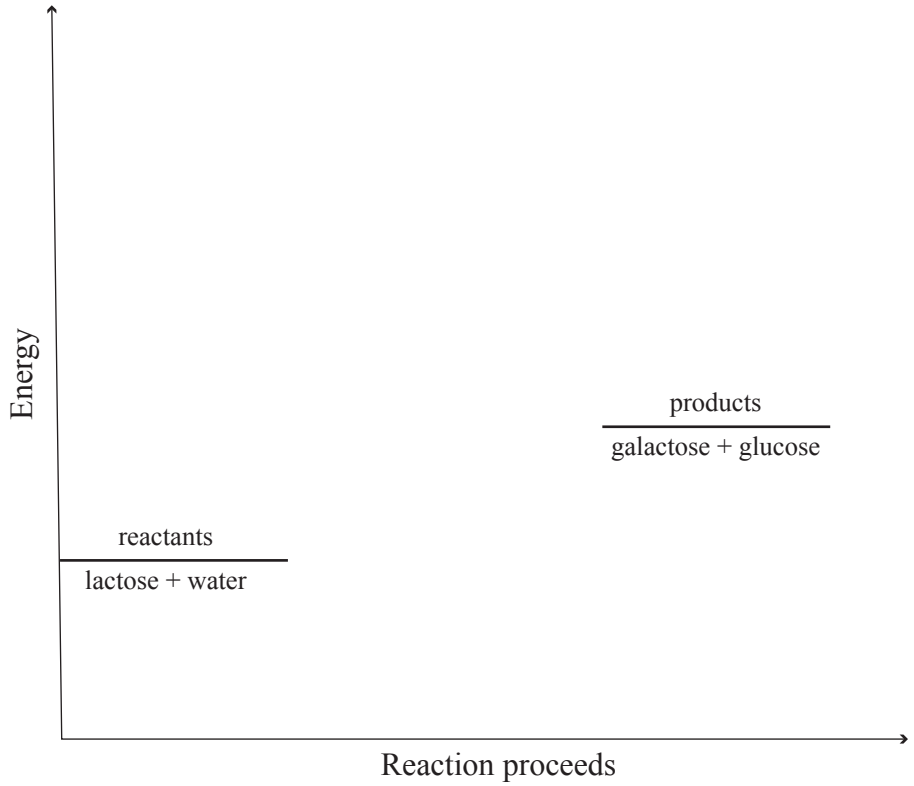
QUESTION TWO

(a) The molecule lactose, which is found in milk, is slowly broken down in the stomach by water into the sugars galactose and glucose. The rate of this reaction is significantly increased by the presence of an enzyme called lactase. The lactase is not used up in the reaction.

(i) Identify the role of lactase in the reaction.

(ii) Complete the energy diagram below by **drawing two lines** to show the reaction with and without the addition of lactase.

Be sure to label your lines.



If you need to redraw your response, use the diagram on page 11.

(iii) Explain how the rate of reaction is altered by the presence of the lactase enzyme.

Refer to collision theory and activation energy in your answer.

(b) The steam-methane reforming process, which is one of the primary means of producing hydrogen gas, $H_2(g)$, is shown below.

$$CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3H_2(g)$$

(i) Write the K_c expression for the reaction.

$K_c =$

(ii) Explain, using equilibrium principles, why removing hydrogen gas, $H_2(g)$, as it forms, is advantageous in the production of hydrogen gas.

(iii) At higher temperatures, the value of K_c increases.

Explain, using equilibrium principles, whether the forwards reaction is endothermic or exothermic.

QUESTION THREE

(a) Both water, $H_2O(\ell)$, and hydrogen carbonate, $HCO_3^-(aq)$, are amphiprotic, meaning they can act as either an acid or a base. The reaction of hydrogen carbonate with water is shown below.

$$HCO_3^-(aq) + H_2O(\ell) \rightleftharpoons CO_3^{2-}(aq) + H_3O^+(aq)$$

Identify the two acid / base conjugate pairs in the reaction of hydrogen carbonate with water.

Pair 1: _____

Pair 2: _____

(b) A 0.1 mol L^{-1} solution of the weakly basic salt sodium ethanoate, $CH_3COONa(aq)$, has a pH of 8.88.

Write equations below to show:

(i) The dissolving of sodium ethanoate in water:

(ii) The reaction that follows, which results in a basic solution:

A solution of potassium hydroxide, $KOH(aq)$, of equal concentration has a significantly higher pH than the sodium ethanoate solution, $CH_3COONa(aq)$.

(iii) Calculate the pH of a 0.1 mol L^{-1} solution of potassium hydroxide, $KOH(aq)$.

(iv) Justify the difference in the pH of the two solutions.

Include relevant equations in your answer.

Question Three continues on the next page.

(c) The K_c expression for a reaction at equilibrium is shown below.

$$K_c = \frac{[COF_2]^2}{[CF_4][CO_2]} = 2.00 \text{ at } 1000 \text{ °C}$$

(i) Using the K_c expression above, write the equation for this reaction.

You can assume all species in the reaction are present in the K_c expression above, and are all gases.

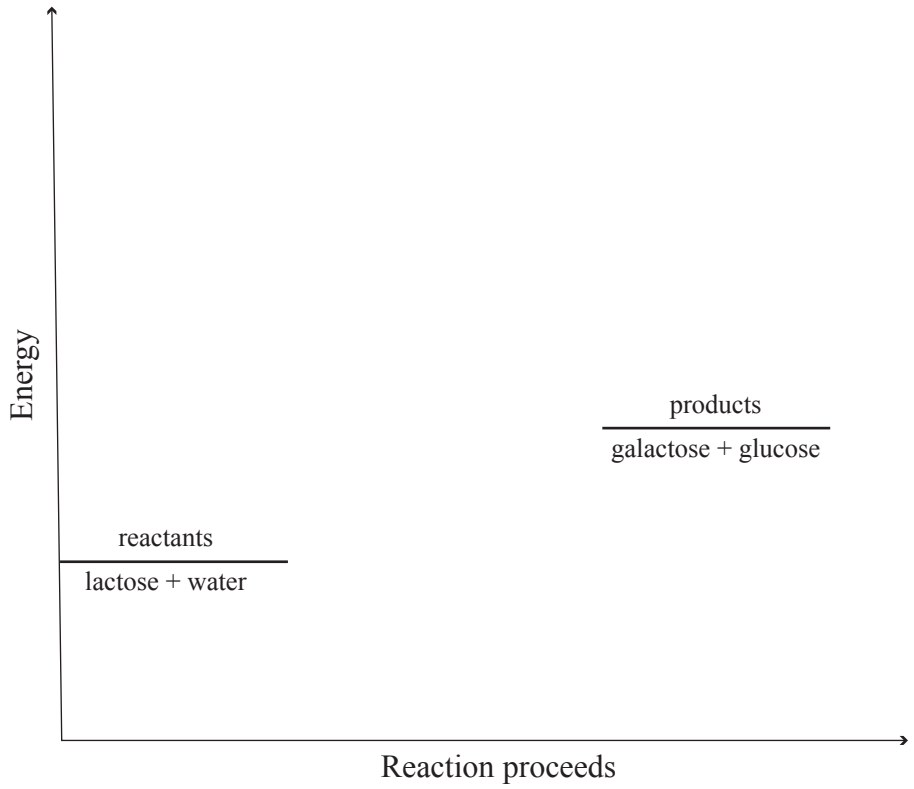
(ii) The reaction was carried out at 1000 °C, and allowed to reach equilibrium. The concentrations of all species were then recorded.

If the concentrations of $CF_4(g)$ and $CO_2(g)$ were found to be equal to one another, and $[COF_2] = 0.105$ mol L^{-1}, calculate the concentration of $CF_4(g)$ at equilibrium.

(iii) Explain what effect, if any, increasing the pressure of the system would have on the position of equilibrium.

SPARE DIAGRAMS

If you need to redraw your response to Question Two (a)(ii), use the diagram below. Make sure it is clear which answer you want marked.



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

QUESTION NUMBER