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91166



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Mana Tohu Mātauranga o Aotearoa
New Zealand Qualifications Authority

Level 2 Chemistry 2025

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 2–16 in the correct order and that none of these pages is blank.

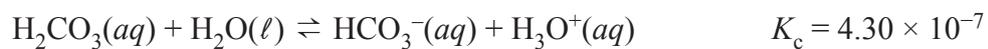
Do not write in any margins (✂/✂/✂). This area will be cut off when the booklet is marked.

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

QUESTION ONE

Ocean acidification occurs due to carbon dioxide in the atmosphere dissolving into seawater and forming various acids.

One step of this process is shown below:



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

- (ii) The value of the equilibrium constant is 4.30×10^{-7} .

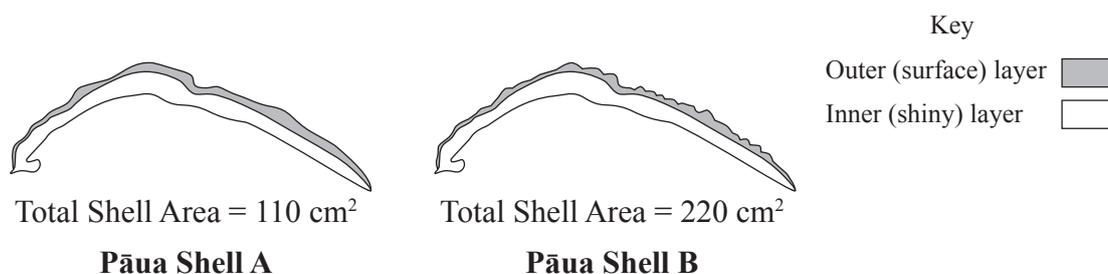
Explain what this indicates about the ratio of products and reactants.

QUESTION TWO

Pāua are a species of marine organism, which form their shells from layers of calcium carbonate, CaCO_3 , and proteins. This layering leads to a very strong shell structure with a dull, pitted outer layer and smooth, shiny inner layer. Unfortunately, the calcium carbonate reacts with acid in the oceans leading to degradation of their shells.

- (a) (i) Describe the chemical observations made when the calcium carbonate shells react with acid in the ocean.

- (ii) Cross-sectional views of two different pāua shells are shown below.



Explain which pāua shell is more vulnerable to the effects of ocean acidification.

In your answer, include concepts of:

- collision theory
- rate of reaction.

(c) Calcium hydroxide, Ca(OH)_2 , calcium chloride, CaCl_2 , and calcium ethanoate, $\text{Ca(CH}_3\text{COO)}_2$, are soluble calcium compounds.

(i) Write an equation to show the complete dissociation of each of these compounds in water.

Calcium hydroxide: _____

Calcium chloride: _____

Calcium ethanoate: _____

(ii) Calcium ethanoate will react further once dissolved.

Write an equation for the reaction of ethanoate, CH_3COO^- .

(iii) The pH of 0.10 mol L^{-1} solutions of these three compounds are below.

Solution	Ca(OH)_2	CaCl_2	$\text{Ca(CH}_3\text{COO)}_2$
pH	13.2	7	8

Discuss the differences in their pH.

In your answer:

- give a definition for acids and bases
- explain how proton transfer is linked to pH
- discuss any ability for these compounds to transfer protons.

There is more space for your answer on the next page.

- (b) (i) The equilibrium expression for the reaction is shown below.

$$K_c = \frac{[\text{PCl}_5]}{[\text{PCl}_3][\text{Cl}_2]}$$

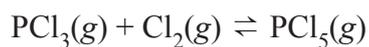
Calculate the equilibrium constant at 300 °C if the concentrations are as follows:

$$[\text{PCl}_3] = 0.016 \text{ mol L}^{-1}$$

$$[\text{Cl}_2] = 0.021 \text{ mol L}^{-1}$$

$$[\text{PCl}_5] = 0.00013 \text{ mol L}^{-1}$$

- (ii) Explain the effect of increasing the concentration of Cl_2 on the equilibrium system AND K_c value.



- (iii) The reaction is set up under new conditions, with different temperatures to favour the production of phosphorus pentachloride, PCl_5 .

	Condition 1	Condition 2
Temperature	200 °C	700 °C
K_c	49	0.023
$[\text{PCl}_3]$	0.12 mol L ⁻¹	0.15 mol L ⁻¹
$[\text{Cl}_2]$	0.09 mol L ⁻¹	0.12 mol L ⁻¹

Use the K_c values to explain which set of conditions (1 or 2) would increase production of PCl_5 .

- (iv) Calculate the concentration of PCl_5 under each of the new conditions listed in (iii).

Question Three continues
on the next page.

