Name:	Teacher:

Level 2 Chemistry

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.

You should attempt ALL the questions in this booklet.

A periodic table is provided in the Resource Sheet.

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 2–9 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.

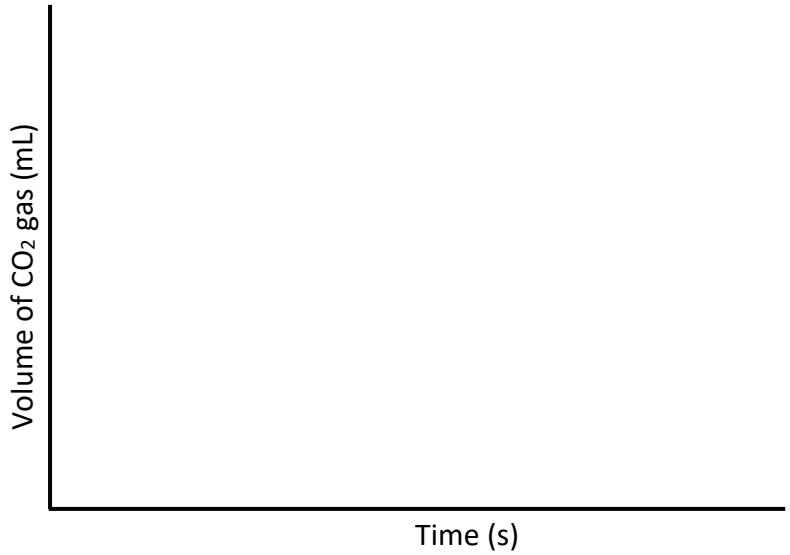
QUESTION ONE

Marble is mostly made of the chemical calcium carbonate ($CaCO_3$). It reacts with dilute hydrochloric acid (HCl) as shown in the equation below:

$$CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + H_2O(l) + CO_2(g)$$

(a) (i) Sketch a labelled diagram for the rate of reaction curves for the following two experiments, on the axes below. The temperature is held constant at 25°C in both experiments.

- Experiment 1: 1.00 g of marble chips is added to 200 mL of 1.00 mol L^{-1} HCl.
- Experiment 2: 1.00 g of crushed (powdered) marble is added to 200 mL of 1.00 mol L^{-1} HCl.



(ii) Experiment 1 was repeated at 35°C. Explain how the increase in the temperature of the system would affect the rate of reaction.

You should refer to collision theory and activation energy in your answer.

Sulfuric acid is manufactured by the Contact process. One stage in this process is the conversion of sulfur dioxide into sulfur trioxide in the presence of vanadium(V) oxide, V_2O_5.

The addition of vanadium(V) oxide to a mixture of sulfur dioxide and oxygen gases helps to speed up the production of sulfur trioxide.

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

(b) Identify and explain the role of vanadium(V) oxide in this reaction. In your answer, you should refer to activation energy and collision theory.
You may include a diagram or diagrams in your answer.

QUESTION TWO

(a) (i) Identify two species that represent a conjugate acid–base pair in the equation below.

$$HSO_4^-(aq) + H_2O(l) \rightleftharpoons OH^-(aq) + H_2SO_4(aq)$$

(ii) Explain by means of equations how the hydrogen carbonate ion (HCO_3^-) can act both as an acid and as a base.

(b) (i) Describe the meaning of the term 'weak acid' using ethanoic acid, CH_3COOH to illustrate your answer. In your answer you should include an appropriate chemical equation.

(ii) Compare and contrast solutions of 0.500 mol L^{-1} hydrochloric acid (pH 0.30) and 0.500 mol L^{-1} ethanoic acid (pH 2.5). In your answer you should elaborate on

- their relative pH values
- the electrical conductivity of the two acids
- the rate of their reaction with magnesium ribbon

(c) (i) A solution of hydrochloric acid, HCl(aq), has a hydronium ion concentration, $[H_3O^+]$, of 0.0524 mol L^{-1}. Calculate the pH and hydroxide ion concentration, $[OH^-]$, of the solution.

pH:

$[OH^-]$:

(ii) Calculate the H_3O^+ and OH^- concentration of a sodium hydroxide solution, NaOH, with a pH of 11.2

QUESTION THREE

Consider the following reaction: $A_2(g) + 3B(g) \rightleftharpoons A_2B_3(g)$

Quantities of all three chemicals are placed into a 1.0 L sealed container, the temperature was raised to 200°C and the system was allowed time to come to equilibrium.

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

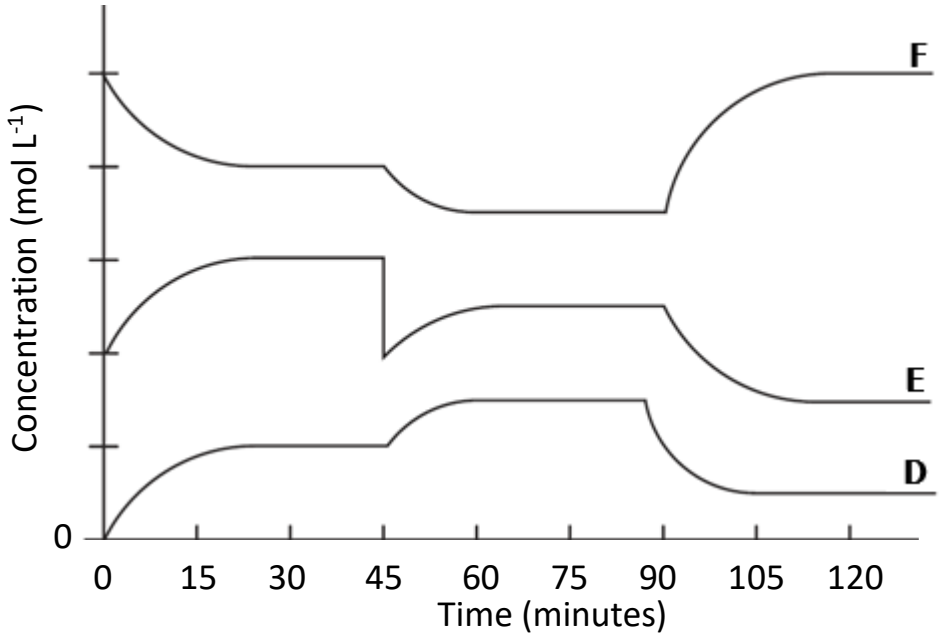
(ii) The K_c for the reaction at 200°C is 83.
Calculate the concentration of A_2, if the concentration of B is 0.100 mol L^{-1} and the concentration of A_2B_3 is 0.520 mol L^{-1}. Give your answer to appropriate significant figures.

(iii) Explain the effect on K_c if the concentration of B, is increased to 0.200 mol L^{-1} at 200°C (no calculations are necessary).

(b) In another reaction D(g) can react with E(g) to make F(g)

$$D(g) + E(g) \rightleftharpoons F(g)$$

A chemist studied this reaction at 300°C. He measured the concentration of each of these gases in a sealed container over two hours (120 minutes). During this time the chemist imposed **two** changes on the system, at around 45 and 90 minutes.



(i) What gas or gases were present in the sealed container at the start of the experiment?

(ii) The graph above shows that the reaction came to equilibrium three times:

- Estimate the time when the reaction *first* reached equilibrium
- Explain how you know the reaction had reached equilibrium

(iii) The first change was imposed on the system at 45 minutes. In your answer you should

- identify what the change was
- refer to equilibrium principles to explain the observed data

(iv) At around 90 minutes the temperature of the sealed container was changed to 100°C.
With reference to the graph, explain how the data provides evidence to determine if the forward reaction is exothermic or endothermic.

Extra paper if required.

Write the question number(s) if applicable