Year 11 Chemistry

Name:

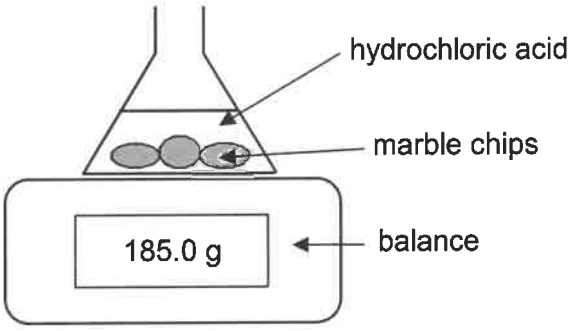
Rates of Reaction

Extended Response

Total marks available: 40

Question 1 **(15 marks)**

An experiment was designed in order to determine the rate of reaction between marble chips (mostly composed of calcium carbonate, ($CaCO_3$) and hydrochloric acid). The equipment was set up as shown in the diagram below. 5.00 g of marble chips were placed into a conical flask containing excess hydrochloric acid and the mass of the flask was weighed at intervals until the reaction had completely stopped. The results were recorded in the table.



Time (s)	Mass (g)
0	185.0
2	184.2
5	183.6
10	183.4
15	183.3
20	183.2
30	183.2

(a) Write a balanced equation for the reaction used in this experiment. (2 marks)

(b) Draw a graph that illustrates the results of this experiment. (4 marks)

(c) Explain, in terms of the collision theory, why the reaction rate changes as the reaction progresses. How is this change in reaction rate related to the shape of the graph? (3 marks)

(d) What test could you perform to confirm the identity of the gas produced and what result would indicate a positive test result? (1 mark)

(e) Calculate the mass of carbon dioxide produced from the marble chips. (1 mark)

(f) Calculate the percent by mass of calcium carbonate in the marble chips. (4 marks)

Question 2 **(9 marks)**

Most modern cars are powered by an engine with a 4-stroke combustion cycle. The purpose of each stroke is described below.

1. Intake stroke - the fuel is injected in as a fine mist, where it mixes with air
2. Compression stroke - the fuel/air mixture is compressed into a small volume
3. Combustion stroke - a spark plug ignites the fuel/air mixture, which explodes
4. Exhaust stroke - exhaust fumes leave through the valve

Explain, in terms of the collision theory, how each of the conditions described in **stroke 1, 2 and 3** affect the rate of reaction between the fuel and the air.

Stroke	Explanation
1	
2	
3	

Question 3 **(16 marks)**

Read the following information regarding catalytic converters and use it where necessary to help you to answer the questions that follow.

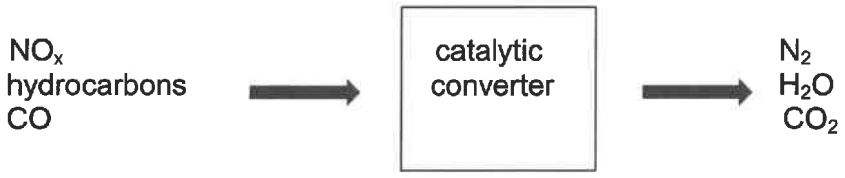
There are millions of cars on the road, and each one is a source of air pollution. Especially in large cities, the amount of pollution that all the cars produce together can create big problems. To solve these problems, cities, states and the government have created clean-air laws that restrict the amount of pollution that cars can produce. Over the years, car manufacturers have made many refinements to car engines and fuel systems to keep up with these laws. One of these changes came about in 1975 with a device called a ***catalytic converter****. The job of the catalytic converter is to convert harmful pollutants into less harmful emissions before they leave the car's exhaust system.*

The main emissions of a car engine are:

- ***Nitrogen gas*** *(N_2) - Air is 78% nitrogen gas, and most of this passes right through the car engine.*
- ***Carbon dioxide*** *(CO_2) - This is one product of combustion. The carbon in the fuel bonds with the oxygen in the air.*
- ***Water vapour*** *(H_2O) - This is another product of combustion. The hydrogen in the fuel bonds with the oxygen in the air.*

These emissions are mostly benign, although carbon dioxide emissions are believed to contribute to global warming. Because the combustion process is never perfect, some smaller amounts of more harmful emissions are also produced in car engines. Catalytic converters are designed to reduce all three:

- ***Carbon monoxide*** *(CO) is a poisonous gas that is colourless and odourless. It is produced when hydrocarbons are burnt in a limited supply of oxygen*
- ***Hydrocarbons*** *or* ***volatile organic compounds*** *(VOCs) are a major component of smog produced mostly from evaporated, unburned fuel*
- ***Nitrogen oxides*** *(NO and NO_2, together called NOx) are a contributor to smog and acid rain, which also causes irritation to human mucus membranes. These are produced when nitrogen gas is mixed with oxygen gas at high temperatures like those experienced in a car engine*



The catalytic converter commonly contains minute particles of Pt, Pd and Rh coated onto the surface of a ceramic support that has a honeycomb structure. The Pd is responsible for catalysing the exothermic reaction between CO and O_2 to produce CO_2 whereas the Rh catalyst speeds up the reaction between the pollutants CO and NO to produce CO_2 and N_2

(a) Describe and explain the effect of a catalyst on the rate of a reaction. (3 marks)

(b) In the space below draw a reaction profile diagram for an **endothermic reaction** to demonstrate how a catalyst works. For maximum marks, make sure your diagram is clearly labelled and has all necessary sections included. (4 marks)

(c) Write a balanced equation for the production of the following two gases by the engine of a motor car. In the first reaction you can assume the hydrocarbon fuel being burnt is pure octane.(2 marks)

Reaction producing CO (carbon monoxide)	
Reaction producing NO (nitrogen monoxide)	

(d) Using information from the final paragraph of the text, write balanced equations for the reactions catalysed by Pd and Rh. (2 marks)

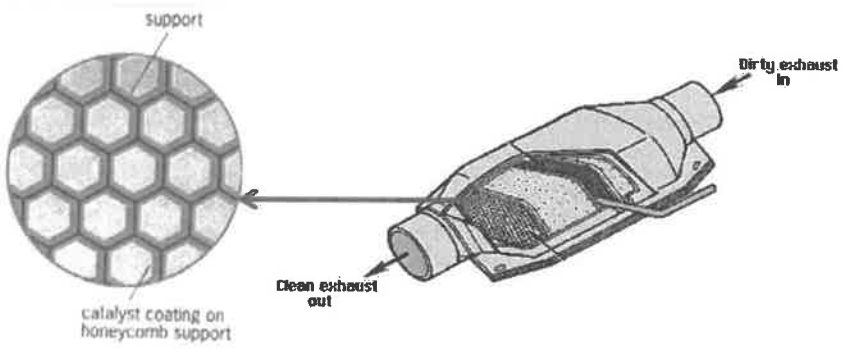
Reaction catalysed by Pd	
Reaction catalysed by Rh	

(e) The symbols Pd and Rh are for which two elements? (1 mark)

_____ and _____

(f) What is the general name given to the group of elements (many of which make excellent catalysts) to which these belong? (1 mark)

(g) Explain why the Pd and Rh are coated onto the surface of the ceramic support material and why the structure has a honeycombed shape as shown in this diagram. (2 marks)



(h) From a chemical point of view, explain why the catalytic converter in a motor vehicle should last the lifetime of the vehicle. (1 mark)