

OXFORD CAMBRIDGE AND RSA EXAMINATIONS

Advanced Subsidiary GCE

CHEMISTRY

How Far, How Fast?

2813/01

Wednesday

29 MAY 2002

Morning

45 minutes

Candidates answer on the question paper.

Additional materials:

Data Sheet for Chemistry

Scientific Calculator

Candidate Name	Centre Number	Candidate Number												
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TIME 45 minutes

INSTRUCTIONS TO CANDIDATES

- Write your name in the space above.
- Write your Centre number and Candidate number in the boxes above.
- Answer **all** the questions.
- Write your answers in the spaces on the question paper.
- Read each question carefully and make sure you know what you have to do before starting your answer.

INFORMATION FOR CANDIDATES

- The number of marks is given in brackets [] at the end of each question or part question.
- You will be awarded marks for the quality of written communication where this is indicated in the question.
- You may use a scientific calculator.
- You may use the *Data Sheet for Chemistry*.
- You are advised to show all the steps in any calculations.

FOR EXAMINER'S USE		
Qu.	Max.	Mark
1	5	
2	7	
3	5	
4	14	
5	7	
6	7	
TOTAL	45	

This question paper consists of 10 printed pages and 2 blank pages.

Answer **all** questions.

- 1 The enthalpy change for the reaction between hydrochloric acid, HCl(aq) , and sodium hydroxide, NaOH(aq) , can be determined in the following way.
- 50.0 cm^3 of 2.00 mol dm^{-3} HCl(aq) is placed in a plastic cup, and its temperature recorded.
 - 50.0 cm^3 of 2.00 mol dm^{-3} NaOH(aq) is placed in another plastic cup, and its temperature recorded.
 - The two solutions are mixed with stirring, and the final temperature recorded.

The following results were obtained from one such experiment:

initial temperature of both HCl(aq) and NaOH(aq) = 18.0°C

final temperature after mixing = 31.9°C

(Take the specific heat capacity of all solutions to be $4.18 \text{ J g}^{-1} \text{ K}^{-1}$, and the densities of all solutions to be 1.00 g cm^{-3} .)

- (a) Calculate the heat evolved in the above experiment. Include units in your answer.

heat evolved = [3]

- (b) Calculate how many moles of HCl were used.

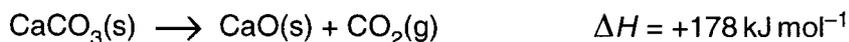
moles of HCl = [1]

- (c) Hence calculate the enthalpy change, in kJ, for the reaction of 1 mol of HCl with 1 mol of NaOH .

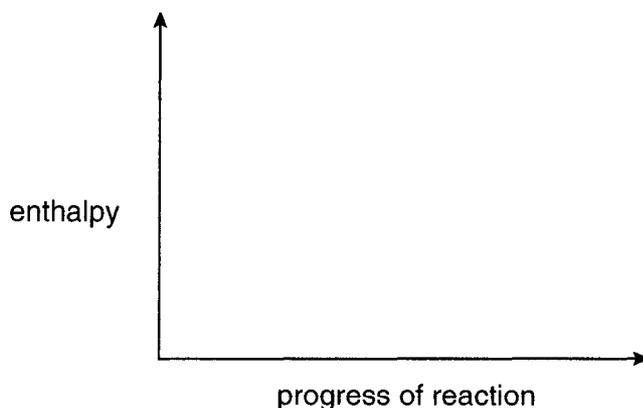
enthalpy change = kJ [1]

[Total : 5]

- 2 On heating in a lime kiln at 1000 °C, limestone decomposes according to the following equation.



- (a) Using the axes below, sketch the enthalpy profile of this reaction. Label the activation energy E_A and the enthalpy change ΔH .



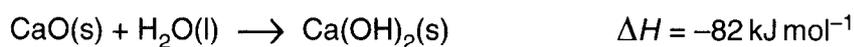
[3]

- (b) Suggest **two** reasons why this reaction needs heating to a high temperature.

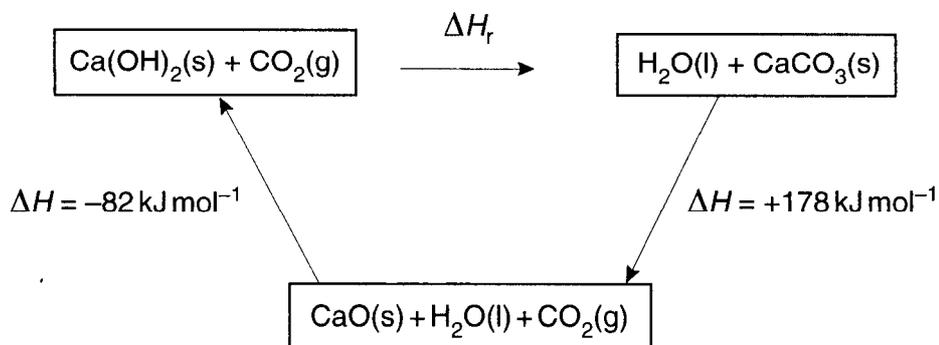
1.

 2.
 [2]

- (c) When water is added to calcium oxide, CaO, it becomes 'slaked' to give calcium hydroxide, Ca(OH)₂.



Calculate the enthalpy change ΔH_r in the following cycle.



$$\Delta H_r = \dots \text{ kJ mol}^{-1} \quad [2]$$

[Total : 7]

- 3 The chlorination of methane in the gas phase involves the following two steps.

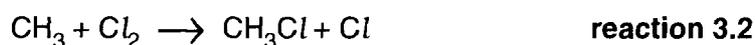


Table 3.1 lists some relevant average bond enthalpies.

Table 3.1

bond	bond enthalpy / kJ mol^{-1}
C—H	+413
C—Cl	+327
H—Cl	+432
Cl—Cl	+243

- (a) (i) Use these bond enthalpies to calculate the enthalpy changes of reactions 3.1 and 3.2.

reaction 3.1

Answer kJ mol^{-1}

reaction 3.2

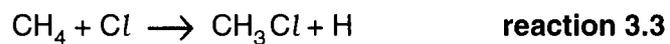
Answer kJ mol^{-1}
[2]

- (ii) Suggest which might be the faster of these two reactions. Give a reason for your answer.

.....

..... [1]

- (b) An alternative reaction route has been suggested for this reaction, which involves the following two steps.



Use Table 3.1 to suggest why this reaction route is unlikely to take place.

.....
.....
..... [2]

[Total : 5]

- 4 It has been suggested that using methane, CH_4 , as a fuel for cars rather than petrol would decrease the amount of carbon dioxide produced per mile. This question looks at how much this reduction in CO_2 emission might be. You may assume that petrol is pure octane, C_8H_{18} .

The combustion of methane can be represented by the following equation.



- (a) Balance the following equation for the combustion of octane.



- (b) The enthalpy change of combustion, ΔH_c^\ominus , of octane is -5472 kJ per mole of octane.

Use your balanced equation and the given ΔH_c^\ominus data to calculate for each fuel:

- (i) the enthalpy change **per mole of CO_2 produced**, and hence
 (ii) the number of moles of CO_2 produced per kJ of heat energy given out.

Write your answers in the Table below.

fuel	ΔH_c^\ominus per mole of alkane burned / kJ	ΔH_c^\ominus per mole of CO_2 produced / kJ	moles of CO_2 produced per kJ of heat given out
methane	-890		
octane	-5472		

[4]

- (iii) Hence calculate a value for the ratio:

$$\frac{\text{moles of CO}_2 \text{ produced per kJ from methane}}{\text{moles of CO}_2 \text{ produced per kJ from octane}}$$

Ratio [1]

(c) Both methane and octane undergo incomplete combustion in a car engine. As a result of this, unburned hydrocarbons and carbon monoxide, CO, occur in the exhaust gases. Nitrogen monoxide, NO, is also formed inside the engine. All three pollutants can be removed by fitting a catalytic converter to the exhaust system.

(i) State **one** environmental consequence of **each** of the following emissions.

unburned hydrocarbons

.....

CO

.....

NO

..... [3]

(ii) How is the NO formed in a car engine?

.....

..... [1]

(iii) NO and CO react together on the surface of the catalyst. Write an equation for this reaction.

..... [1]

(iv) What is the catalyst made of?

..... [1]

(v) The catalyst is a heterogeneous catalyst. What is the meaning of *heterogeneous*?

.....

..... [1]

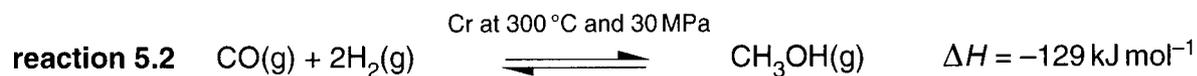
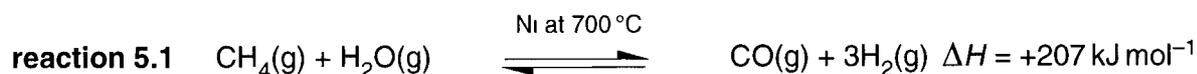
(vi) The catalytic converter is positioned as close to the engine as possible, so that it heats up quickly. Why does the converter work best when it is hot?

.....

..... [1]

[Total : 14]

- 5 Methanol is an important industrial organic chemical. It is used as a solvent and a feedstock for the manufacture of several other compounds such as ethanoic acid. A two-stage process to make methanol from natural gas, methane, is summarised in the following equations.



- (a) Describe and explain the effect of increasing the pressure on the **rate** of reaction 5.1.

.....

 [2]

- (b) Describe and explain how the **equilibrium position** of reaction 5.1 is affected by

- (i) increasing the temperature,

.....

 [2]

- (ii) increasing the pressure.

.....

 [2]

- (c) Reaction 5.2 uses the products from reaction 5.1. Suggest a reason why these two reactions cannot proceed one after the other in the same reaction vessel.

.....
 [1]

[Total : 7]

