OCR
RECOGNISING ACHIEVEMENT

ADVANCED SUBSIDIARY GCE **2850/01**

CHEMISTRY (SALTERS)

Chemistry for Life

THURSDAY 10 JANUARY 2008 Morning

Time: 1 hour 15 minutes

Candidates answer on the question paper.
Additional materials: Scientific calculator
Data Sheet for Chemistry (Salters) (Inserted)

CUP/T52256

Candidate Forename		Candidate Surname	

Centre Number						Candidate Number				

INSTRUCTIONS TO CANDIDATES

- Write your name in capital letters, your Centre Number and Candidate Number in the boxes above.
- Use blue or black ink. Pencil may be used for graphs and diagrams only.
- Read each question carefully and make sure that you know what you have to do before starting your answer.
- Answer **all** the questions.
- Do **not** write in the bar codes.
- Do **not** write outside the box bordering each page.
- Write your answer to each question in the space provided.

INFORMATION FOR CANDIDATES

- The number of marks for each question is given in brackets [ ] at the end of each question or part question.
- The total number of marks for this paper is **75**.
- You may use a scientific calculator.
- A copy of the *Data Sheet for Chemistry* is provided as an insert with this question paper.
- You are advised to show all the steps in any calculation.

FOR EXAMINER'S USE		
Qu.	**Max.**	**Mark**
1	**18**	
2	**19**	
3	**20**	
4	**18**	
TOTAL	**75**	

This document consists of **12** printed pages and a *Data Sheet for Chemistry (Salters)*.

[Turn over

Answer **all** the questions.

1 Three years ago a serious fire at an oil depot in southern England caused a large plume of black smoke to billow across the country. The oil depot stored mainly petrol, diesel and aviation fuel.

(a) The presence of carbon particles caused the smoke to be black.

Why were carbon particles present in the smoke?

.....

.....

.....[2]

(b) Other substances in the smoke included aromatic hydrocarbons, MTBE and oxides of nitrogen.

(i) Give the name of an aromatic hydrocarbon you might expect to find in the smoke.

.....[1]

(ii) Explain how oxides of nitrogen were formed in the fire.

.....

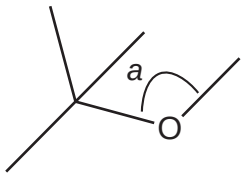
.....

.....

.....[3]

(c) MTBE, $C_5H_{12}O$, is added to petrol to make it burn more efficiently.

A skeletal formula for MTBE is given below ('*a*' represents the bond angle shown).



(i) Name the homologous series to which MTBE belongs.

.....[1]

(ii) Suggest and explain a value for the bond angle '*a*'.

.....

.....

.....

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.....

.....[5]

(iii) Draw the **full** structural formula for MTBE, $C_5H_{12}O$, in the box below.

[1]

(iv) The equation for the complete combustion of MTBE is shown below.

$$C_5H_{12}O(l) + 7.5O_2(g) \longrightarrow 5CO_2(g) + 6H_2O(l)$$

Use the standard enthalpy change of formation data in the following table to calculate a value for the standard enthalpy change of combustion, $\Delta H^{\ominus}_c$, of MTBE.

compound	standard enthalpy change of formation, $\Delta H^{\ominus}_f$/kJ mol^{-1}
MTBE [$C_5H_{12}O(l)$]	–283
$CO_2(g)$	–394
$H_2O(l)$	–286

standard enthalpy change of combustion, $\Delta H^{\ominus}_c$ = ……kJ mol^{-1} [3]

(d) MTBE mixes readily with petrol.

What happens to the entropy of the system on mixing?
Explain your answer.

.....

.....

.....[2]

[Total: 18]

2 In 1970 there was a problem on the Apollo 13 spacecraft. The astronauts had to transfer to the smaller Lunar Excursion Module, or 'LEM'.

(a) In the LEM, filters containing lithium hydroxide, LiOH, removed the carbon dioxide gas breathed out by the astronauts.

The equation for the reaction occurring in the filters is shown below.

$$2LiOH(s) + CO_2(g) \longrightarrow Li_2CO_3(s) + H_2O(l)$$

(i) Name Li_2CO_3.

.....[1]

(ii) Sodium hydroxide reacts with CO_2 in a similar way and is cheaper than lithium hydroxide.

Suggest why lithium hydroxide is used in the LEM's filters rather than sodium hydroxide.

.....

.....

.....

.....[2]

(b) On return to Earth the spacecraft landed in the sea. The astronauts' life raft was inflated using lithium hydride, LiH.

The lithium hydride reacts with water to give off hydrogen gas which inflates the raft. Lithium hydroxide solution is the other product.

(i) Write a balanced equation for the reaction of solid lithium hydride with water.
Include state symbols.

[2]

(ii) Lithium hydride is an ionic compound containing the ion H^-.
Draw an electron dot-cross diagram to illustrate the bonding in lithium hydride.
Show outer electrons only and the charges on each ion.

[3]

(iii) Complete the following table for the hydride, H^-, ion.

subatomic particle	number of subatomic particles in H^-
	1
	0
electron	

[2]

(iv) Lithium has a higher first ionisation enthalpy than the other elements in Group 1.

Write an equation, including state symbols, to represent the first ionisation enthalpy for lithium.

[2]

(v) Explain why lithium has the highest first ionisation enthalpy in Group 1.

.....

.....

.....

.....[4]

(c) Lithium, like other metals, has a giant metallic structure and is a good conductor of electricity.

(i) Draw a **labelled** diagram to illustrate the metallic bonding in lithium.

[2]

(ii) Suggest how the structure explains the electrical conductivity.

.....

.....[1]

[Total: 19]

3 The possibility of running a car with nothing more than water in its tank seems unlikely. However, researchers believe they have devised a scheme to liberate hydrogen safely from water as it is needed.

(a) In the process, water is heated to form steam. The steam reacts with solid boron, B, also stored on board the car, to produce hydrogen gas and solid boron oxide, B_2O_3.

(i) The equation for the reaction of solid boron with steam is given below.
Put in the state symbols and balance the equation.

$$B(.....) + H_2O(.....) \rightarrow B_2O_3(.....) + H_2(.....)$$ **equation 3.1** [2]

(ii) The boron oxide is removed and taken to a reprocessing plant. There it is heated with magnesium powder to regenerate the boron.
Write a balanced equation for this reaction.

[2]

(b) 5 kg of hydrogen would be needed to provide the same amount of energy as 40 dm^3 of a conventional liquid hydrocarbon fuel.

(i) Calculate the number of moles of hydrogen, H_2, in 5 kg of hydrogen gas.

A_r: H, 1

number of moles = ... [1]

(ii) Use your answer to **(i)** and **equation 3.1** to calculate the mass, in kg, of solid boron needed to produce 5 kg of hydrogen.

A_r: B, 11

mass = ... kg [3]

(iii) One mole of hydrogen gas releases 286 kJ of energy on combustion. Calculate the amount of energy released from the combustion of 5 kg of hydrogen.

energy released = ... kJ [1]

(c) NO is formed in both petrol and hydrogen powered cars. In a petrol powered car, NO is removed from the exhaust gases by reaction with carbon monoxide on a catalytic converter forming less harmful products.

(i) Write an equation for this reaction.

[2]

(ii) The converter contains a heterogeneous catalyst. Explain how a heterogeneous catalyst works.

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.....

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.....[4]

(iii) Suggest why NO levels are not reduced by a catalytic converter in a car running on hydrogen.

.....

.....

.....[1]

(d) Give **one** advantage and **one** disadvantage of using hydrogen as a fuel in cars.

advantage .....

.....

disadvantage .....

.....[2]

(e) Another research team has investigated the reaction between aluminium and water to generate the hydrogen.

Use your knowledge of the Periodic Table to suggest why researchers might have decided to look at aluminium as well as boron.

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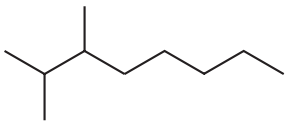
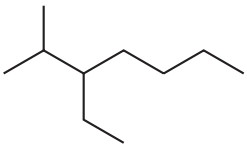
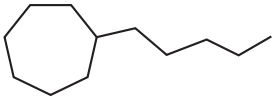
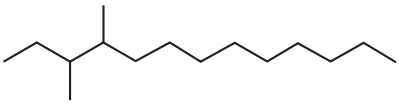
.....[2]

[Total: 20]

TURN OVER FOR QUESTION 4

4 A rocket propellant consists of a fuel and an oxidiser.
The Atlas and Delta II launch rockets use liquid oxygen as the oxidiser and kerosene as fuel.

(a) The formulae of some of the hydrocarbons present in kerosene are shown in the table below.

hydrocarbon	letter
	**A**
$CH_3(CH_2)_{10}CH_3$	**B**
	**C**
	**D**
	**E**

(i) Give the name of the homologous series to which compounds **A**, **B**, **C** and **E** belong.

.....[1]

(ii) Name the compound represented by letter **C**.

.....[2]

(iii) Using examples from the molecules in the table above, explain the term *structural isomerism*.

.....

.....

.....

.....[3]

(iv) Give the molecular formula of molecule **E**.

.....[2]

(v) For convenience the kerosene used in rocket propellants is often represented by the straight chain compound, dodecane, $C_{12}H_{26}$. Give the letter from the table which represents the molecule dodecane.

…… [1]

(b) In the petrochemical industry, kerosene can be processed by reforming, isomerisation or cracking to make more useful molecules for use in car fuels.

Using the appropriate letters, **A**–**E**, identify a molecule that could be formed from dodecane by

(i) reforming…… [1]

(ii) cracking…… [1]

(c) One of the useful properties of molecules formed by reforming and cracking is that they have a higher octane number than the original molecule.

What is the effect on engine performance of using a fuel with a high octane number?

.....

.....[2]

(d) An important property of fuels is their energy density. This is the energy produced per **kilogram** of fuel.

(i) Calculate the energy density of the dodecane fuel used in the Atlas and Delta II rockets. Give your answer to **two** significant figures.
The enthalpy of combustion, ΔH_c, of dodecane, $C_{12}H_{26}$, is –8062 kJ mol^{-1}.
M_r: $C_{12}H_{26}$, 170

energy density = ... kJ kg^{-1} [3]

(ii) In the rockets, 108 000 kJ of energy are produced for every kg of liquid oxygen used to oxidise the dodecane.
Use your answer in **(i)** to calculate the mass of dodecane that would produce 108 000 kJ of energy.

mass of kerosene = ... kg [1]

(iii) The theoretical mass of dodecane that could be burnt for every kg of liquid oxygen used is 3.48 kg.

Suggest **one** reason why the rockets are designed to use less than the theoretical mass of dodecane per kg of oxygen.

.....

.....[1]

[Total: 18]

END OF QUESTION PAPER