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RECOGNISING ACHIEVEMENT

ADVANCED SUBSIDIARY GCE

CHEMISTRY (SALTERS)

2850/01

Chemistry for Life

THURSDAY 11 JANUARY 2007

Morning

Time: 1 hour 15 minutes

Additional materials: Scientific calculator
Data Sheet for Chemistry (Salters) (Inserted)

Candidate Name

Centre Number

Candidate Number

INSTRUCTIONS TO CANDIDATES

- Write your name, Centre number and Candidate number in the boxes above.
- Answer **all** the questions.
- Use blue or black ink. Pencil may be used for graphs and diagrams only.
- Read each question carefully and make sure you know what you have to do before starting your answer.
- Do **not** write in the bar code.
- Do **not** write outside the box bordering each page.
- WRITE YOUR ANSWER TO EACH QUESTION IN THE SPACE PROVIDED. ANSWERS WRITTEN ELSEWHERE WILL NOT BE MARKED.

INFORMATION FOR CANDIDATES

- The number of marks for each question 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.
- A copy of the *Data Sheet for Chemistry (Salters)* 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	**23**	
2	**14**	
3	**20**	
4	**18**	
TOTAL	**75**	

This document consists of **15** printed pages, **1** blank page and a *Data Sheet for Chemistry (Salters)*.

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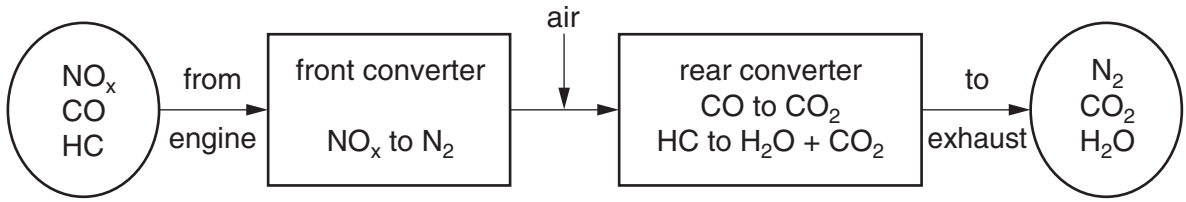
Answer **all** the questions.

1 Heterogeneous catalysts play an extremely important role in many chemical reactions, including the control of polluting emissions and in the manufacture of various chemicals.

(a) Many cars now have 'three-way' catalytic converters fitted. The following diagram illustrates how they work.



(i) Write the formula for one **specific** molecule that could be represented by NO_x.

.....[1]

(ii) Suggest the meaning of the letters HC in the diagram.

.....[1]

(iii) Explain the presence of CO in the gases from the engine.

.....[1]

(iv) The three-way catalytic converter involves both a reduction and an oxidation phase. Why is the conversion of NO_x to N_2 described as reduction?

.....[1]

(b) **(i)** Diesel exhaust contains a higher proportion of particulates than petrol exhaust. Particulates are very small solid soot particles.

Suggest and explain why diesel fuel produces more particulates than petrol.

.....

.....

.....

.....[3]

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(ii) Diesel engines without catalytic converters produce less NO_x than an equivalent petrol engine.

Explain the formation of NO_x in petrol engines.

Suggest why less NO_x is formed in a diesel engine.

.....

.....

.....

.....[3]

(c) The diagram illustrates a model for heterogeneous catalysis.

A diagram has been removed due to third party copyright restrictions

Details:

A diagram showing a model for heterogeneous catalysis

The following phrases describe some of the steps labelled on the above diagram.

Write the numbers of the step or steps corresponding to each phrase.

Bonds in reactants weaken and break Step(s) .....

New bonds in products form Step(s) .....

Diffusion from catalyst surface Step(s) .....[3]

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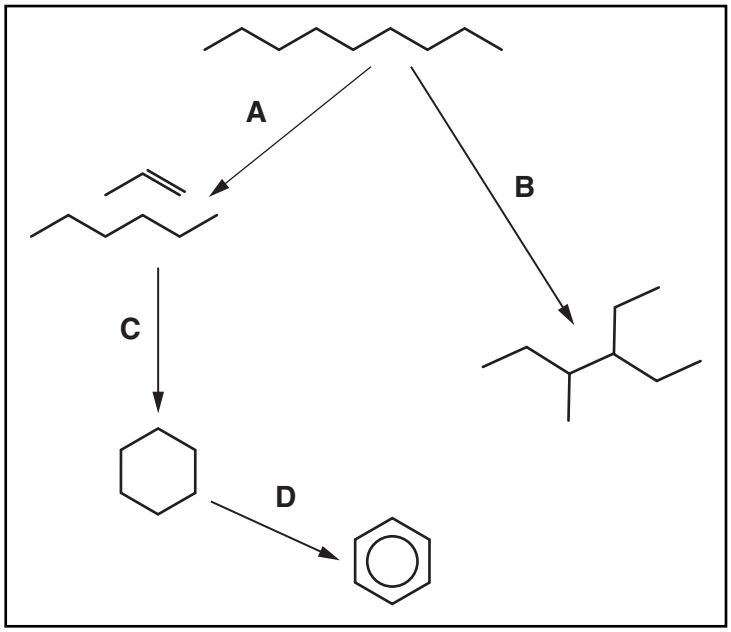
(d) Catalysts also play a role in the oil industry in the production of more useful hydrocarbons from longer chain fractions.
Zeolite catalysts replaced the traditional silica/alumina catalysts in the 1960s.
The following box illustrates some of the reactions catalysed by zeolites.



(i) Use words from the following list to describe reactions **A** to **D**.

isomerisation **reforming** **cracking**

reaction **A** .....

reaction **B** .....

reaction **C** .....

reaction **D** ..... [4]

(ii) By what **type** of formula are the molecules represented?

.....[1]

(iii) Give the molecular formula and name of the molecule formed in reaction **B**.

molecular formula.....

name .....[4]

(iv) Suggest **one** reason why the hydrocarbon formed in reaction **B** is more useful than the hydrocarbon it is made from.

.....

.....[1]

[Total: 23]

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2 Major art galleries employ chemists to ensure that the condition of irreplaceable paintings is maintained.
This often involves identifying the pigments the artists used.

(a) One pigment used by Renoir in many of his paintings was the Group 2 compound strontium chromate, known as 'lemon yellow'.

Strontium chromate is an ionic compound with the formula $SrCrO_4$.

(i) What is the charge on the chromate ion? .....[1]

(ii) In the chromate ion there are four bonding sets of electrons, and no lone pairs, around the covalently bonded central chromium atom.

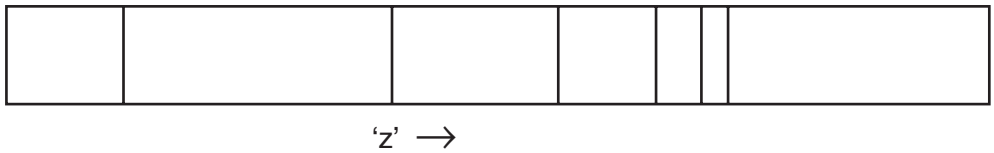
Draw a diagram below to show the **three dimensional** shape of the chromate ion.

chromate ion

[2]

(b) Analysis of pigments such as lemon yellow can be done by vaporising a tiny sample of the pigment and analysing the emission spectrum produced.

A simplified section of the emission spectrum produced by strontium in the visible region is shown below.



(i) What is the quantity labelled as 'z' on the above spectrum?

.....[1]

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(ii) Explain:

- why excited atoms emit light
- why the emission spectrum consists of discrete lines
- why there are sets of lines.

You are advised to draft out your answer in rough first and then present your explanation in a logical order. You may use diagrams in your answer.

explanation .....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....[5]

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(iii) Strontium also produces an **absorption** spectrum.

Describe **two** similarities and **one** difference between the appearance of the emission and absorption spectra of strontium.

similarities .....

.....

.....

difference.....

.....[3]

(c) Another Group 2 compound found in paintings is gypsum, a form of calcium sulphate.

The solubility of Group 2 sulphates decreases down the group.
Give **two** properties of **other** Group 2 compounds that decrease down the group.

.....

.....[2]

[Total: 14]

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3 The work of many chemists was influential in the development of the Periodic Table.
Modern Periodic Tables list the elements in order of increasing atomic number.

(a) The atomic number gives information about the structure of the atom. What **two** pieces of information does it give?

.....

.....[2]

(b) Early Periodic Tables, such as that devised by Mendeleev (shown below), listed the then known elements in order of their relative atomic mass.

Mendeleev reversed the positions of tellurium and iodine (as shown in **bold** in the table).

			Ti = 50	Zr = 90	? = 180
			V = 51	Nb = 94	Ta = 182
			Cr = 52	Mo = 96	W = 186
			Mn = 55	Rh = 104.4	Pt = 197.4
			Fe = 56	Ru = 104.4	Ir = 198
			Ni = Co = 59	Pd = 106.6	Os = 199
H = 1			Cu = 63.4	Ag = 108	Hg = 200
	Be = 9.4	Mg = 24	Zn = 65.2	Cd = 112	
	B = 11	A*l* = 27.4	? = 68	Ur = 116	Au = 197?
	C = 12	Si = 28	? = 70	Sn = 118	
	N = 14	P = 31	As = 75	Sb = 122	Bi = 210?
	O = 16	S = 32	Se = 79.4	**Te = 128?**	
	F = 19	C*l* = 35.5	Br = 80	**I = 127**	
Li = 7	Na = 23	K = 39	Rb = 85.4	Cs = 133	Ti = 204
		Ca = 40	Sr = 87.6	Ba = 137	Pb = 207
		? = 45	Ce = 92		
		?Er = 56	La = 94		
		?Yt = 60	Di = 95		
		?In = 75.6	Th = 118?		

(i) Suggest why Mendeleev thought it necessary to reverse the positions of tellurium and iodine.

.....

.....[1]

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(ii) A modern definition of relative atomic mass is 'the weighted mean of the isotopic masses of all the naturally occurring isotopes of an element'.

There are eight isotopes of tellurium. Complete the following table and use it to calculate the relative atomic mass of tellurium.

Give your answer to **three** significant figures.

isotope	percentage abundance	isotopic mass × percentage abundance
tellurium-120	0.09	11
tellurium-122	2.46	300
tellurium-123	0.87	107
tellurium-124	4.61	572
tellurium-125	6.99	874
tellurium-126	18.71	2357
tellurium-128	31.79	
tellurium-130		

relative atomic mass = ... [3]

(iii) Mendeleev would not have been able to do the above calculation because the existence of isotopes was not known.
Which sub-atomic particle is responsible for the existence of isotopes?

.....[1]

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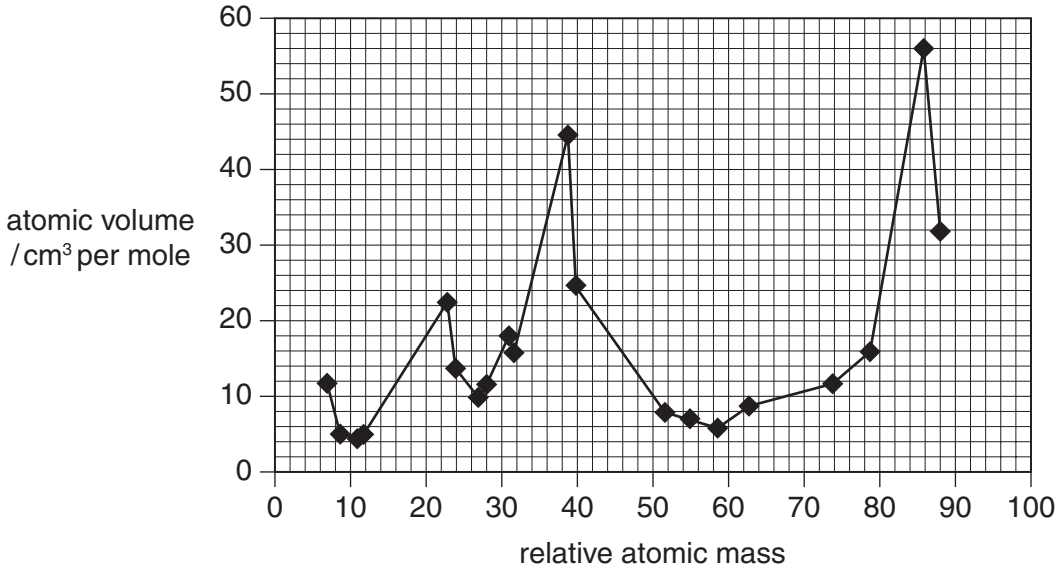
(c) Another chemist looking for patterns in the properties of the elements around the time of Mendeleev was Julius Lothar Meyer.

Lothar Meyer looked at how the atomic volume of an element varies with its relative atomic mass. A simplified version of the graph he plotted is shown below.

Atomic volume against relative atomic mass



(i) Which group of elements form the peaks in Meyer's graph?

.....[1]

(ii) How does the atomic volume change as you go from left to right across a period?

.....[1]

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(d) Since the time of Mendeleev and Lothar Meyer many more elements have been discovered. Sir William Ramsey discovered argon in 1894. He removed oxygen and nitrogen from air and found he was left with about one percent which was the gas argon.

(i) The oxygen can be removed by passing air over hot copper. Copper oxide, CuO, is formed. Write a balanced equation for this reaction. Include state symbols.

[2]

(ii) The nitrogen was removed by passing it over hot magnesium. This produced a white solid called magnesium nitride, Mg_3N_2.
The balanced equation for this reaction is given below.

$$3Mg(s) + N_2(g) \longrightarrow Mg_3N_2(s) \qquad \textbf{equation 3.1}$$

Calculate the number of moles of nitrogen gas in 1 dm^3 of air at room temperature and pressure.

Assume air to be 80% nitrogen gas by volume and that one mole of gas occupies 24 dm^3 at room temperature and pressure.

moles = ... [2]

(iii) Use **equation 3.1** and your answer to **(ii)** to calculate the mass of magnesium that would react with the nitrogen in 1 dm^3 of air, at room temperature and pressure.

A_r: Mg, 24

mass = ... g [2]

(e) The American chemist Glenn T. Seaborg made the element neptunium, Np, by firing neutrons at uranium atoms. Some of these neutrons 'stuck' to the uranium nucleus and then the nucleus emitted an electron.

(i) Complete the following nuclear equation representing the formation of neptunium atoms from an isotope of uranium.

$$^{238}_{92}U + {}^{\cdots\cdots}_{\cdots\cdots}n \rightarrow {}^{\cdots\cdots}_{\cdots\cdots}Np + {}^{\cdots\cdots}_{\cdots\cdots}e$$

[3]

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(ii) It is not possible to make neptunium atoms by firing **protons** at uranium atoms.

Suggest a reason why this is unlikely to work.

.....

.....

.....[2]

[Total: 20]

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4 The booster engines on the Space Shuttle use solid propellants.
The main ingredients of the most widely used solid propellant are powdered aluminium and the oxidiser 'ammonium perchlorate', NH_4ClO_4.

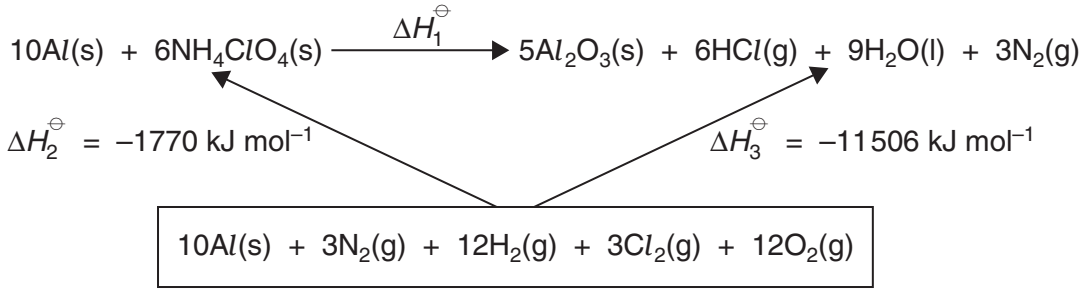
(a) The reaction of the ammonium perchlorate with aluminium can be represented by **equation 4.1** below.

$$10Al(s) + 6NH_4ClO_4(s) \longrightarrow 5Al_2O_3(s) + 6HCl(g) + 9H_2O(l) + 3N_2(g) \qquad \textbf{equation 4.1}$$

The standard enthalpy change for this reaction can be calculated indirectly using an enthalpy cycle.

.

The enthalpy cycle below uses standard enthalpy change of formation values.



(i) Explain the term *standard enthalpy change of formation*.

.....

.....

.....[3]

(ii) Use the cycle and values provided to calculate the standard enthalpy change, $\Delta H_1^{\ominus}$, for this reaction.

$\Delta H_1^{\ominus}$ = ... kJ mol^{-1} [2]

(iii) The values for $\Delta H_2^{\ominus}$ and $\Delta H_3^{\ominus}$ do **not** include standard enthalpy change of formation values for two of the substances in the equation.
Name the **two** substances and explain why they do not contribute to $\Delta H_2^{\ominus}$ and $\Delta H_3^{\ominus}$.

substances ..... and.....

explanation .....

.....[2]

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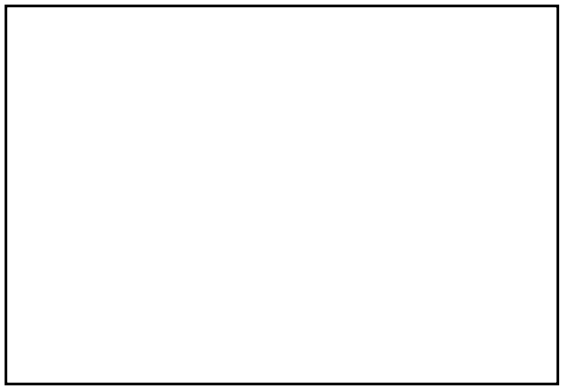
(b) A hydrocarbon polymer is also added to the propellant to bind the aluminium and perchlorate together.
The hydrocarbon binder burns to produce the same products as the hydrocarbons in petrol.

Name **three** possible products from this combustion.

..... ; ..... ; ..... [3]

(c) At the high operating temperature of the solid rocket boosters, a small proportion of nitrogen molecules dissociate into nitrogen atoms.

(i) Draw a dot-cross diagram for the nitrogen molecule.
Show all outer shell electrons.



[2]

(ii) Suggest why it is very difficult to break the nitrogen molecule into its atoms.

.....

.....[2]

(d) The reaction shown in **equation 4.1** is accompanied by a large increase in **entropy**.

Explain why you would predict this increase in entropy from the equation for the reaction.

.....

.....

.....

.....

.....[4]

[Total: 18]

END OF QUESTION PAPER

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