OXFORD CAMBRIDGE AND RSA EXAMINATIONS

Advanced Subsidiary GCE

CHEMISTRY (SALTERS)   **2850**

Chemistry for Life

Tuesday   **11 JANUARY 2005**   Morning   1 hour 15 minutes

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

Candidate Name	Centre Number	Candidate Number

TIME   1 hour 15 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 provided 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 may use a scientific calculator.
- You may use a Data Sheet for Chemistry (Salters).
- You are advised to show all the steps in calculations.

FOR EXAMINER'S USE		
Qu.	Max.	Mark
1	14	
2	24	
3	23	
4	14	
TOTAL	75	

This question paper consists of 12 printed pages.

[Turn over

Answer **all** the questions.

1 In April 1986, the nuclear reactor at Chernobyl in the Soviet Union exploded, releasing a mixture of radioactive isotopes into the atmosphere.
One of the main isotopes released was $^{131}_{53}I$.

(a) (i) In the following table, write the number of protons, neutrons and electrons in an atom of $^{131}_{53}I$.

	number
protons	
neutrons	
electrons	

[3]

(ii) What is meant by the term *isotopes*?

....

....[2]

(iii) Radioactive isotopes are unstable and decay by emitting either alpha particles or beta particles.

The table below summarises some of the properties of alpha and beta particles. Complete the table by choosing words or numbers from the following list:

small   large   nil   paper   aluminium foil   lead   0   –1   +2   +1

property	alpha particle	beta particle
relative charge		
relative mass	4	negligible
stopped by	paper	
deflection by electric field		large

[4]

(iv) The relative atomic mass of iodine in the Periodic Table is given as 126.9 on the *Data Sheet*. Explain what this value represents.

....

....

....[3]

(b) Long term exposure to radioactive isotopes such as $^{131}_{53}I$ can cause cancers. However, $^{131}_{53}I$ can be used as a radioactive tracer in small doses when investigating patients suffering from a possible deficiency of iodine.

The half-life of $^{131}_{53}I$ is 8 days. A sample manufactured for use in hospitals has an original count rate of 16 000 counts per minute. It can be used as a tracer as long as its count rate is at or above 500 counts per minute.

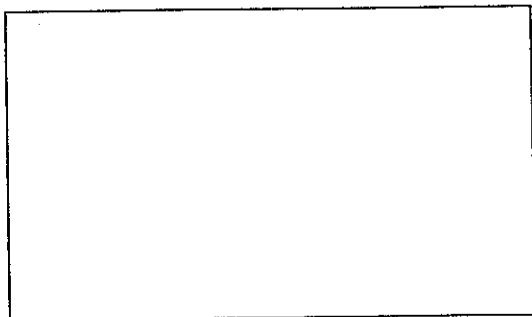For how long after manufacture can it be used as a tracer?
Show your working.

answer .... days [2]

[Total: 14]

[Turn over

2 Butane, C_4H_{10}, is used as a propellant in cans of hairspray. It often contains small amounts of methylpropane.

(a) Methylpropane is a structural isomer of butane.

(i) Draw the **full structural** formulae for methylpropane and butane in the boxes below. [2]
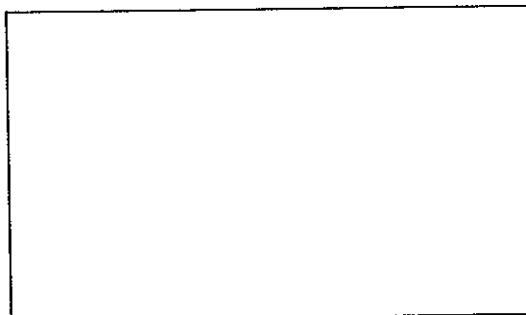
methylpropane   **butane**

(ii) Explain the meaning of the term *structural isomer.* ....

....

....[2]

(b) (i) The typical mass of butane in a small can of hairspray is 36 g.
Calculate the number of moles of butane in the can.
Give your answer to **two** significant figures.
A_r: C, 12; H, 1.0

answer .... mol [3]

(ii) What volume would this amount of gas occupy at room temperature and pressure?

One mole of molecules of a gas at room temperature and pressure occupies $24\,dm^3$.

volume of gas = ... dm^3 [1]

(c) Butane is a very flammable gas. On rare occasions, cans of hairspray have caused injury when thrown onto a garden bonfire.

(i) Explain what happens to butane in the can and why this can lead to injury.

....

....

....[2]

(ii) The equation for the complete combustion of butane gas to give carbon dioxide and water vapour is given below.
Balance the equation. Include state symbols in the brackets.

$$.....C_4H_{10}\ (\ )\ +\ .....O_2\ (\ )\ \rightarrow\ .....CO_2\ (\ )\ +\ .....H_2O\ (\ )$$

[2]

(iii) Use your equation and the following bond enthalpies to calculate a value for the enthalpy change of combustion for butane.

bond	average bond enthalpy / $kJ\,mol^{-1}$
C–C	+347
C–H	+413
O–H	+464
O=O	+498
C=O	+805

ΔH_c = ... $kJ\,mol^{-1}$ [4]

(iv) Would you expect the enthalpy change of combustion of methylpropane to be higher, lower or about the same as that of butane?
Explain your answer.

....

....

....

....

....[3]

[Turn over

(d) Butane is a minor component of the fuel used in high performance cars, such as Formula 1 (F1) racing cars. It is known as a C_4 hydrocarbon because each molecule contains four carbon atoms.

The table below shows some other types of hydrocarbons found in F1 fuels, with their maximum permitted composition by mass.

type of hydrocarbon	maximum allowed percentage by mass for each type of hydrocarbon			
	C_4	C_5	C_6	C_7
alkanes	10	30	25	25
cycloalkanes	–	5	10	10
aromatics	–	–	1	35

(i) There are no C_4 or C_5 aromatics listed in the table. Explain why this is the case.

....

....[1]

(ii) Draw the **skeletal** formula for the C_7 cycloalkane, methylcyclohexane.

[2]

(iii) When hydrocarbons are blended, the entropy of the mixture is greater than the sum of the entropies of the hydrocarbons separately.
Explain this increase in entropy of the mixture.

....

....

....[2]

[Total: 24]

3 Most of the chemical elements found on Earth were produced in stars. Chemists have arranged the elements into a Periodic Table which allows them to make predictions about the behaviour of the elements and their compounds.

(a) (i) Calcium in Group 2 reacts with water to produce a solution of calcium hydroxide and bubbles of hydrogen gas.
Predict a balanced equation for the reaction of radium, Ra, with water. Include state symbols. Write your equation in the space below.

[3]

(ii) Use your knowledge of atomic structure to explain why the reaction of calcium with water is less vigorous than the reaction of radium with water.

....

....

....

....

....

....[4]

(b) Many properties such as first ionisation enthalpy vary in a regular way across a **period**.

(i) Write an equation representing the first ionisation enthalpy for **sodium,** including state symbols.

[2]

(ii) Explain the general increase in first ionisation enthalpy as the Period 3 (sodium to argon) is crossed from left to right.

....

....

....

....

....[2]
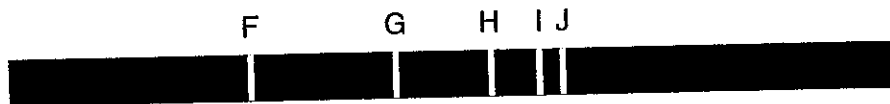
[Turn over

(c) The presence of different elements in the stars is inferred from absorption or emission atomic spectra. The wavelengths involved are in the uv or visible portion of the electromagnetic spectrum.

(i) The labelled diagrams below represent part of an absorption spectrum and an emission spectrum, drawn to the same scale.
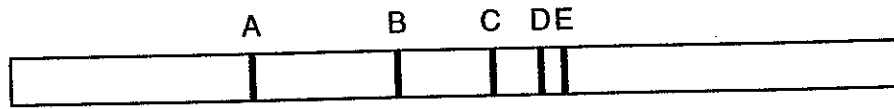
frequency ⟶

absorption spectrum

frequency ⟶

emission spectrum

Using the **letters**, choose a line from the spectra that corresponds to:

1. the line of longest wavelength in the **emission** spectrum

.... [1]

2. the line corresponding to the **absorption** of the largest quantum of energy.

.... [1]

(ii) The emission and absorption spectra shown are for the **same element.**
What evidence is there from the two spectra that this is the case?
Explain your answer in terms of transitions between atomic energy levels. Use the
following diagram to illustrate your explanation.

```
                           ──────────────    energy level 5
                           ──────────────    energy level 4
  electronic              ──────────────    energy level 3
   energy
                           ──────────────    energy level 2


                           ──────────────    ground state energy level 1
```

....

....

....

....

....[2]
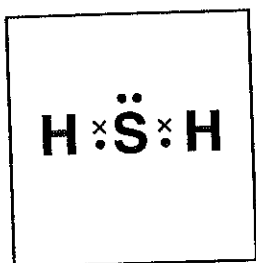
[Turn over

**(d)** Atoms react together to form molecules in the dense gas clouds in interstellar space. Molecules of H_2S, NH_3 and OCS (similar in structure to CO_2) have been detected.

(i) **Complete** the dot-and-cross diagram for each molecule in the boxes below. [3]

H ×S× H   H ×N× H   :O:C S:
                     ×•
                     H
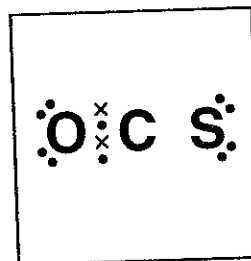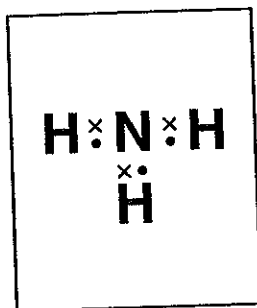
(ii) Use the theory of 'electron pair repulsion' to decide which of the possible shapes below represents the shape of each molecule.
Write the formula of each of the molecules H_2S, NH_3 and OCS underneath its shape.
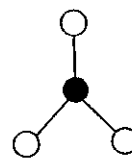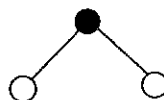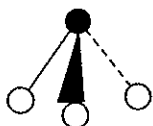
[3]

(iii) What is the significance of the wedge (◣➤) and the dotted line (------) in the shape on the left?

....

....[2]

[Total: 23]

4 Environmental issues are an increasing concern and the idea of 'green chemistry' is becoming more and more important.

Research is being carried out to find ways of lowering the amounts of pollutants in the air caused by motor vehicles.

(a) In the left hand column below are some of the pollutants emitted from car exhausts.
For each pollutant, briefly explain in the right hand column how it gets into the exhaust gases.
The first has been done for you. [3]

pollutant	how it gets into the exhaust gases
oxides of sulphur	from the combustion of sulphur impurities in the fuel
carbon monoxide	
oxides of nitrogen	
hydrocarbons	

(b) Hydrogen and methanol are fuels that could be used as an alternative to petrol.
Suggest **one** advantage and **one** disadvantage, different in each case, for each fuel **compared to petrol.**

(i) hydrogen advantage ....

disadvantage ....[2]

(ii) methanol advantage ....

disadvantage ....[2]

[Turn over

(c) Another approach is to deal with the emissions directly. A catalytic converter does this using a solid catalyst made of a precious metal such as platinum.

(i) What **type** of catalysis is this?

.... [1]

(ii) Describe how this type of catalysis works. In your answer, you should use the following ideas.

adsorption   diffusion   bonds weakening and breaking   bonds forming

....

....

....

....

....

....[4]

(iii) Use some of the ideas in **(ii)** to explain how a catalyst poison can cause a catalyst to become inactive.

....

....

....

....

....[2]

[Total: 14]

END OF QUESTION PAPER