Oxford Cambridge and RSA Examinations

RECOGNISING ACHIEVEMENT

Advanced Subsidiary GCE

CHEMISTRY (SALTERS)
CHEMISTRY FOR LIFE 2850

Specimen Paper

Candidates answer on the question paper.
Additional materials:
Data Booklet for Chemistry (Salters)
To be brought by candidate: electronic calculator

TIME 1 hour 30 minutes

INSTRUCTIONS TO CANDIDATES

Write your name, Centre number and candidate number in the spaces at the top of this page.

Answer **all** questions.

Write your answers in the spaces provided on the question paper.

There should be ample space for your answers. If you need more space for answers or rough work you may use the blank spaces at the end of questions or any blank pages. Rough work that is not to be marked should be crossed out.

You will be awarded marks for the quality of your written communication where an answer requires a piece of extended writing.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets [ ] at the end of each question or part question.

A copy of the Periodic Table and other tables of information are provided in a data booklet for use with this examination; other necessary data are given as required in the questions.

You may use an electronic calculator.

Answer **all** questions.

1. Bone consists of a complex mixture of calcium salts, such as calcium carbonate, and other material. If bone is strongly heated, the calcium salts turn into calcium oxide, CaO. This can be separated from the other material by dissolving it in dilute hydrochloric acid, to form calcium chloride, $CaCl_2$, solution.

   (a) **(i)** Draw a flow diagram to show how calcium carbonate in bone is turned into calcium chloride. Show the formulae of the compounds connected by labelled arrows.

   [3]

   (ii) Complete and balance the chemical equation for the reaction between solid calcium oxide and dilute hydrochloric acid, showing state symbols.

   $$CaO \quad + \quad HCl \quad \rightarrow$$

   [2]

   (b) An experiment showed that 14.4 g of calcium oxide were made from a sample of bone of mass 50.0 g. (A_r: Ca, 40; O, 16)

   Calculate:

   (i) the amount in moles of CaO in 14.4 g;

   [2]

(ii) the amount in moles of Ca in the bone sample;

[1]

(iii) the % of calcium by mass in the bone.

[2]

(c) Strontium compounds are incorporated into bones because their chemistry is similar to that of calcium compounds. For example, both strontium and calcium form ions with the same charge. Explain, in terms of the Periodic Table, the electronic structures of the atoms and ionisation energies, why calcium and strontium (and their compounds) have similar chemical properties.

*(**Note:** In this question, 1 mark is available for the quality of written communication).*

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..... [6]

(d) Strontium-90, $^{90}_{38}Sr$, is a radioactive isotope of strontium that emits β^- particles (electrons). It was produced in nuclear fall-out and became incorporated in peoples' bones.

(i) For the strontium-90 nucleus, write down the number of

protons ..... **[1]**

neutrons ..... **[1]**

(ii) Write a nuclear equation for the process by which a strontium-90 nucleus emits a

β^- particle, representing the β^- particle as ^0_1e.

[3]

(iii) A sample of naturally-occurring strontium was placed in a mass spectrometer and the following peaks were obtained:

Mass	**Intensity (%)**
84	0.56
86	9.86
87	7.02
88	82.56

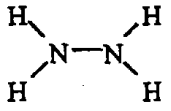
Calculate the relative atomic mass of the sample of strontium, giving your answer to three significant figures. Show your working.

[4]

Total 25 marks

2. The substance hydrazine, N_2H_4, is used as a rocket fuel because it reacts very exothermically with oxygen and it can be stored as a liquid at low temperatures.

(a) The full structural formula of hydrazine is shown below.



hydrazine

(i) Draw a dot-cross diagram for hydrazine, showing the outer electron shells only.

[3]

(ii) State, giving reasons, the value you would expect for the H–N–H bond angle in hydrazine.

Angle: .....**[1]**

Reasons:.....

.....

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

(b) Hydrazine reacts with oxygen according to the equation:

$$N_2H_4(l) + O_2(g) \rightarrow N_2(g) + 2H_2O(l)$$

Calculate a value for the enthalpy change of combustion of hydrazine, following the steps below.

Compound	$\Delta H^{\ominus}_{f,298}$ / kJ mol^{-1}
$N_2H_4(l)$	+51
$H_2O(l)$	–286

(i) Draw a labelled enthalpy cycle to include the information about enthalpy changes of formation above and the enthalpy change of combustion of hydrazine.

[3]

(ii) Use the data on the previous page and your cycle to calculate a value for the enthalpy change of combustion of hydrazine.

[2]

(c) Use the equation in part (b) to calculate the volume of oxygen required to burn 1.0 kg of hydrazine. (A_r: N, 14; H, 1; 1.0 mol of molecules of a gas at room temperature and pressure occupies 24 dm^3)

[3]

(d) At the high temperature of the rocket engine, a reaction might take place between nitrogen gas and oxygen gas to produce nitrogen monoxide, NO.

(i) Write an equation for this reaction.

[1]

(ii) State **one** way in which nitrogen monoxide causes pollution in the atmosphere.

.....

.....

..... [1]

(e) Which has the greater entropy at room temperature, one mole of liquid hydrazine or one mole of gaseous hydrazine? Explain your answer.

.....

.....

..... [2]

Total 18 marks

3. Butane, C_4H_{10}, can be used as a fuel. Here are some data about butane:

Boiling point, 0 °C;

Standard enthalpy change of combustion, $\Delta H^{\ominus}_{c,298} = -2880 \text{ kJ mol}^{-1}$.

(a) To what homologous series does butane belong?

..... [1]

(b) Butane has one structural isomer.

(i) Say what you understand by the term **structural isomer**.

.....

.....

..... [2]

(ii) Draw the full structural formula of the structural isomer of butane and name it.

Name ..... [3]

(c) All the H–C–H bonds in butane have the same angle in the three-dimensional molecule. State the value of this angle and, with the help of a labelled diagram, describe the shape of the butane molecule.

H–C–H bond angle..... [1]

Shape of butane molecule:

[3]

(d) "The standard enthalpy change of combustion of the isomer in part (b) will be very similar to that of butane itself as all the bonds are the same."

Say whether or not this statement is correct and explain why.

.....

.....

.....

..... [3]

(e) Write a balanced equation (with state symbols) for the complete combustion of butane under standard conditions.

[3]

(f) The isomer will have a higher **octane number** than butane itself.

(i) What does the **octane number** of a petrol tell you about its performance in a high-compression engine?

.....

.....

..... [3]

(ii) What feature of the isomer would cause it to have a higher octane number than butane?

.....

..... [1]

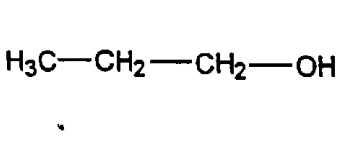
(g) Suggest **one** technical problem (apart from ones associated with octane number) that might arise in using butane as a fuel for cars.

.....

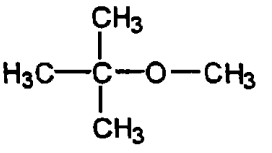
.....

..... [2]

(h) The structures of two 'oxygenates' which can be added to petrol to improve the octane rating are given below.



Compound A



Compound B

(i) Name the **functional group** in Compound A.

..... **[1]**

(ii) Name **Compound A.**

..... **[1]**

(iii) Name the **functional group** in Compound B.

..... **[1]**

(i) A car running on butane would produce carbon monoxide as a polluting gas.

(i) How is carbon monoxide produced in car engines?

.....

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

(ii) Explain why carbon monoxide is a polluting gas.

.....

..... **[1]**

(j) A catalytic converter can convert carbon monoxide in the car's exhaust to carbon dioxide.

(i) Explain why such a catalyst is called **heterogeneous.**

.....

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

(ii) Complete the sequence to explain how such a catalyst works:

1. Reactants get adsorbed on to the catalyst surface.

2. ..... [1]

3. New bonds form.

4. ..... [1]

(iii) Lead-free petrol must be used with catalytic converters because lead 'poisons' the catalyst. Explain what this means.

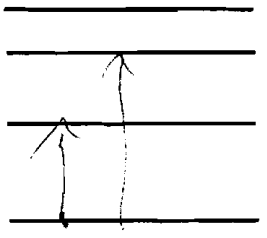
.....

..... [2]

Total 34 marks

4. The presence of sodium in the Sun's photosphere is shown by a pair of dark lines in the Sun's absorption spectrum in the visible region. The element magnesium can be detected in the same way.

(a) The lines below represent some of the electron energy levels of a sodium atom. Draw labelled arrows on the diagram and explain why sodium absorbs only certain definite frequencies of visible light.



[4]

(b) Sodium and magnesium are adjacent in the same period of the Periodic Table. Say whether each of the following statements about ^{23}Na and ^{24}Mg atoms is true or false, briefly justifying your answer.

(i) They have mass numbers which differ by one.

.....

..... [1]

(ii) They have atomic numbers which differ by one.

.....

..... [1]

(iii) They have the same number of full electron shells.

.....

..... [1]

(iv) Their reactions would be expected to be very similar.

.....

.....

..... [2]

(c) The sodium in the Universe was made by nuclear reactions such as

$$2\,{}^{12}C \rightarrow {}^{23}Na + ...$$

(i) Explain why this is called a **fusion** reaction.

.....

.....

..... [2]

(ii) Complete the nuclear equation above by adding atomic numbers and the symbol for the other nucleus formed.

[2]

Total 13 marks