

CHEMISTRY



9701/02

1 hour 15 minutes

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UNIVERSITY of CAMBRIDGE
International Examinations

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Answer **all** the questions in the space provided.

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- 1 The first six ionisation energies of an element **X** are given below.

ionisation energy / kJ mol^{-1}					
first	second	third	fourth	fifth	sixth
950	1800	2700	4800	6000	12300

- (a) Define the term *first ionisation energy*.

.....

 [3]

- (b) Write an equation, with state symbols, for the **second** ionisation energy of element **X**.

..... [2]

- (c) Use the data given above to deduce in which Group of the Periodic Table element **X** is placed. Explain your answer.

Group

explanation

.....

 [3]

The first ionisation energies (I.E.) for the elements of Group IV are given below.

element	C	Si	Ge	Sn	Pb
1st I.E. / kJ mol^{-1}	1090	786	762	707	716

- (d) Explain the trend shown by these values in terms of the atomic structure of the elements.

.....

 [4]

[Total: 12]

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- 2 Carbon disulphide, CS_2 , is a volatile, stinking liquid which is used to manufacture viscose rayon and cellophane.

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- (a) The carbon atom is in the centre of the CS_2 molecule.

Draw a 'dot-and-cross' diagram of the carbon disulphide molecule.

Show outer electrons only.

[2]

- (b) Suggest the shape of the molecule and give its bond angle.

shape

bond angle

[2]

- (c) Explain the term *standard enthalpy change of formation*, ΔH_f^\ominus .

.....

 [3]

- (d) Calculate the standard enthalpy change of formation of CS_2 from the following data.

standard enthalpy change of formation of SO_2 = -298 kJ mol^{-1}

standard enthalpy change of formation of CO_2 = -395 kJ mol^{-1}

standard enthalpy change of combustion of CS_2 = $-1110 \text{ kJ mol}^{-1}$

[3]

- (e) Carbon disulphide reacts with nitrogen monoxide, NO, to form a yellow solid and two colourless gases which are produced in a 1:1 molar ratio.

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Deduce the identity of **each** gas and write a balanced equation for the reaction.

gases and

equation [3]

[Total: 13]

3 Nitrogen, which makes up about 80% of the Earth's atmosphere, is very unreactive.

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(a) (i) Explain the lack of reactivity of nitrogen.

.....

.....

.....

(ii) Nitrogen does, however, undergo some reactions. Write an equation for **one** reaction of nitrogen, stating the conditions under which it occurs.

equation

conditions

.....

.....

(iii) Suggest why nitrogen does react in the example you have chosen.

.....

.....

[6]

Ammonium nitrate, NH_4NO_3 , is a commercially important compound of nitrogen.

(b) (i) State **one** large-scale use of ammonium nitrate.

.....

(ii) What are the environmental consequences of the uncontrolled use of ammonium nitrate?

.....

.....

.....

.....

[4]

When solid ammonium nitrate is heated with solid sodium hydroxide in a test-tube, three products are formed. A colourless alkaline gas, **Y**, is given off, and a colourless liquid can be seen on the cooler parts of the test-tube. A white solid remains in the tube.

(c) (i) Identify gas **Y**.

.....

(ii) Write an equation, with state symbols, for the reaction of ammonium nitrate with sodium hydroxide.

.....

[3]

(d) In order to produce gas **Y** in a pure state in the laboratory, it must be passed through a drying agent.

Why is concentrated sulphuric acid not suitable for drying gas **Y**?

.....

..... [1]

[Total: 14]

- 4 Alcohols are widely used as solvents and in the manufacture of esters.

Butan-1-ol, $C_4H_{10}O$, is an example of a primary alcohol.

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- (a) What is meant by the term *primary alcohol*?

..... [1]

- (b) There are three more alcohols with molecular formula $C_4H_{10}O$ that are **structural** isomers of butan-1-ol.

Complete the table below by drawing displayed formulae of **each** of these three compounds.

For **each** isomer, state whether it is a primary, secondary, or tertiary alcohol.

$ \begin{array}{ccccccc} & H & & H & & H & & H \\ & & & & & & & \\ H & -C & - & C & - & C & - & C-OH \\ & & & & & & & \\ & H & & H & & H & & H \end{array} $			
primary			
butan-1-ol	isomer 2	isomer 3	isomer 4

[6]

- (c) Butan-1-ol can be oxidised to a carboxylic acid by heating with an acidified solution of potassium dichromate(VI).

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- (i) What colour change would be seen during this reaction?

from to

- (ii) State which of the isomers you have drawn in (b) could also be oxidised to form a carboxylic acid.

.....

[3]

[Total: 10]

- 5 Compound **Z**, an organic compound with **three** functional groups, has the molecular formula $C_4H_6O_2$. The functional groups can be confirmed by the following tests.

(a) Test for the first functional group.

Z decolourises aqueous bromine.

What functional group is shown to be present in **Z** by this test?

..... [1]

(b) Tests for the second functional group.

Z reacts with sodium to give hydrogen and a solid compound of formula $C_4H_5O_2Na$.

When **Z** is heated with ethanoic acid and a few drops of concentrated sulphuric acid, a sweet smelling liquid of molecular formula $C_6H_8O_3$ is formed.

What functional group is shown to be present in **Z** by these tests?

..... [1]

(c) Tests for the third functional group.

A few drops of **Z** form a yellow/orange precipitate when added to 2,4-dinitrophenylhydrazine reagent.

When a few drops of **Z** are warmed with Tollens' reagent, a silver mirror is formed.

What functional group is shown to be present in **Z** by these tests?

..... [1]

(d) **Z** does **not** show *cis-trans* isomerism.

Draw the displayed formula of **Z**.

[2]

In parts (e) and (f) you may use R– to represent the part of the molecule that does not react.

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(e) What is the organic compound formed by the reactions of **Z** in **each** of the tests in (b)?

with sodium

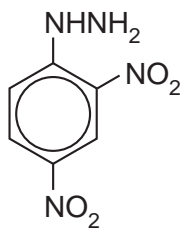
with ethanoic acid

[2]

(f) Draw the structure of the organic compound formed by **Z** in **each** of the tests in (c).

with Tollens' reagent

with 2,4-dinitrophenylhydrazine,



[2]

(g) But-2-enoic acid is an isomer of **Z** which shows *cis-trans* isomerism.

Draw a displayed formula of the *cis* isomer of this acid.

[2]

[Total: 11]

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