



UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
International General Certificate of Secondary Education

CANDIDATE
NAME

CENTRE
NUMBER

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CHEMISTRY

0620/33

Paper 3 (Extended)

October/November 2013

1 hour 15 minutes

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.

Write in dark blue or black pen.

You may use a pencil for any diagrams, graphs or rough working.

Do not use staples, paper clips, highlighters, glue or correction fluid.

DO NOT WRITE IN ANY BARCODES.

Answer **all** questions.

Electronic calculators may be used.

A copy of the Periodic Table is printed on page 12.

You may lose marks if you do not show your working or if you do not use appropriate units.

At the end of the examination, fasten all your work securely together.

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

This document consists of **12** printed pages.



1 Zirconium (Zr) is a metal in Period 5. Its main oxidation state is +4.

(a) The following are all zirconium atoms: ${}_{40}^{90}\text{Zr}$, ${}_{40}^{91}\text{Zr}$ and ${}_{40}^{92}\text{Zr}$.

In terms of numbers of electrons, neutrons and protons, how are these three atoms the same and how are they different?

They are the same because

.....

They are different because

..... [3]

(b) Containers for fuel rods in nuclear reactors are made of zirconium.
Nuclear reactors are used to produce energy and to make radioactive isotopes.

(i) Which isotope of a different element is used as a fuel in nuclear reactors?

..... [1]

(ii) State one medical and one industrial use of radioactive isotopes.

.....

..... [2]

(iii) Above 900 °C, zirconium reacts with water to form zirconium(IV) oxide, ZrO_2 , and hydrogen. Write an equation for this reaction.

..... [2]

(iv) In a nuclear accident, water may come in contact with very hot zirconium.
Explain why the presence of hydrogen inside the reactor greatly increases the danger of the accident.

..... [1]

(c) It is possible to determine whether zirconium(IV) oxide is acidic, neutral, basic or amphoteric using an acid and an alkali. Complete the table of possible results. If the oxide is predicted to react write 'R', if it is predicted not to react write 'NR'.

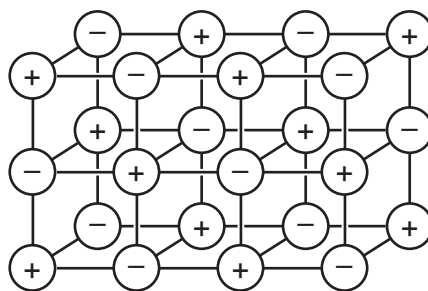
| if the oxide is | predicted result with hydrochloric acid | predicted result with aqueous sodium hydroxide |
|-----------------|---|--|
| acidic | | |
| neutral | | |
| basic | | |
| amphoteric | | |

[4]

[Total: 13]

- 2 (a) The diagram shows the lattice of a typical ionic compound.

For
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- (i) Explain the term *ionic lattice*.

.....
 [2]

- (ii) In this lattice, the ratio of positive ions to negative ions is 1:1.
 In the lattice of a different ionic compound, the ratio of positive ions to negative ions is 1:2.
 Suggest why this ratio varies in different ionic compounds.

..... [1]

- (iii) Give **three** physical properties of ionic compounds.

.....

 [3]

- (b) Strontium oxide is an ionic compound. Draw a diagram which shows its formula, the charges on the ions and the arrangement of the **valency** electrons around the negative ion.

The electron distribution of a strontium atom is 2 + 8 + 18 + 8 + 2.

Use o to represent an electron from a strontium atom.

Use x to represent an electron from an oxygen atom.

[3]

[Total: 9]

3 The main uses of zinc are preventing steel from rusting and making alloys.

(a) The main ore of zinc is zinc blende. Zinc blende consists mainly of zinc sulfide, ZnS. There are two major methods of extracting zinc from its ore. They are the direct reduction of zinc oxide to zinc and by electrolysis. In both methods, zinc oxide is made from the zinc sulfide in the ore.

(i) How is zinc oxide made from zinc sulfide?

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

(ii) Write an equation for the reaction used to reduce zinc oxide to zinc.

..... [1]

(b) In the electrolytic method, zinc oxide reacts with sulfuric acid to form impure aqueous zinc sulfate. This solution contains Ni^{2+} , Co^{2+} and Cu^{2+} ions as impurities.

(i) Write the equation for the reaction between zinc oxide and sulfuric acid.

..... [1]

(ii) Nickel, cobalt and copper are all less reactive than zinc. Explain why the addition of zinc powder removes these ions from the solution.

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

(c) The solution of zinc sulfate is electrolysed using inert electrodes. This electrolysis is similar to that of copper(II) sulfate with inert electrodes.

(i) Write the equation for the reaction at the negative electrode (cathode).

..... [1]

(ii) Complete the equation for the reaction at the positive electrode (anode).



(iii) The electrolyte changes from zinc sulfate to

..... [1]

(d) (i) Brass is an alloy of copper and zinc. Suggest **two** reasons why brass is often used in preference to copper.

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

(ii) Sacrificial protection is a method of rust prevention. Explain in terms of electron transfer why steel, which is in electrical contact with zinc, does not rust.

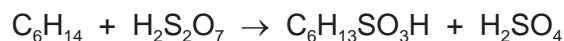
.....
.....
.....
..... [4]

[Total: 15]

- 4 Sulfuric acid is a strong acid. Hexanesulfonic acid is also a strong acid. It has similar properties to sulfuric acid.

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- (a) Sulfonic acids are made from alkanes and oleum, $\text{H}_2\text{S}_2\text{O}_7$.



- (i) Describe how oleum is made from sulfur by the Contact process. Give equations and reaction conditions.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

..... [6]

- (ii) How is concentrated sulfuric acid made from oleum?

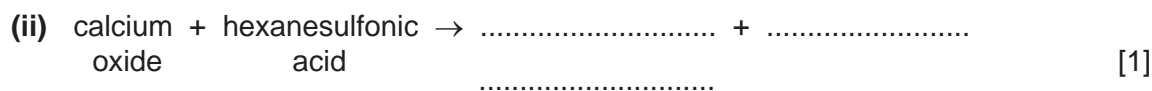
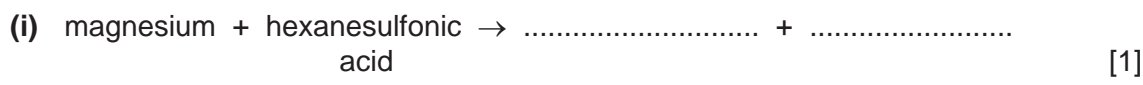
..... [1]

- (b) The formula of the hexanesulfonate ion is $\text{C}_6\text{H}_{13}\text{SO}_3^-$.

The formula of the barium ion is Ba^{2+} . What is the formula of barium hexanesulfonate?

..... [1]

- (c) Complete the following equations.



- (d) (i)** Sulfuric acid is a strong acid.
You are given aqueous sulfuric acid, concentration 0.1 mol/dm^3 , and aqueous hexanesulfonic acid, concentration 0.2 mol/dm^3 . Describe how you could show that hexanesulfonic acid is also a strong acid.

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

- (ii)** Deduce why, for a fair comparison, the two acid solutions must have different concentrations.

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

- (iii)** Explain the terms *strong acid* and *weak acid*.

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

[Total: 17]

- 5 Domestic rubbish is disposed of in landfill sites. Rubbish could include the following items.

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| item of rubbish | approximate time for item to break down |
|---------------------|---|
| newspaper | one month |
| cotton rag | six months |
| woollen glove | one year |
| aluminium container | up to 500 years |
| styrofoam cup | 1000 years |

- (a) Explain why aluminium, a reactive metal, takes so long to corrode.

..... [1]

- (b) Both paper and cotton are complex carbohydrates. They can be hydrolysed to simple sugars such as glucose.

The formula of glucose can be represented as:



Draw the structural formula of a complex carbohydrate, such as cotton.
Include at least **two** glucose units.

[2]

(c) Wool is a protein. It can be hydrolysed to a mixture of monomers by enzymes.

(i) What are enzymes?

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

(ii) Name another substance which can hydrolyse proteins.

..... [1]

(iii) What type of compound are the monomers formed by the hydrolysis of proteins?

..... [1]

(iv) Which technique could be used to identify the individual monomers in the mixture?

..... [1]

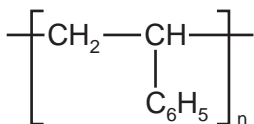
(v) Proteins contain the amide linkage. Name a synthetic macromolecule which contains the same linkage.

..... [1]

(d) (i) What is the scientific term used to describe polymers which do not break down in landfill sites?

..... [1]

(ii) Styrofoam is poly(phenylethene). It is an addition polymer. Its structural formula is given below. Deduce the structural formula of the monomer, phenylethene.



[1]

[Total: 11]

- 6 The alcohols form a homologous series. The first five members are given in the table below.

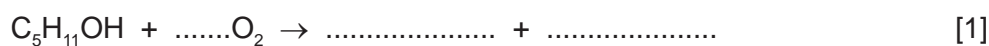
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(a)

| alcohol | formula | heat of combustion in kJ/mol |
|-------------|---|---------------------------------|
| methanol | CH ₃ OH | 730 |
| ethanol | CH ₃ -CH ₂ -OH | 1380 |
| propan-1-ol | | |
| butan-1-ol | CH ₃ -CH ₂ -CH ₂ -CH ₂ -OH | 2680 |
| pentan-1-ol | CH ₃ -CH ₂ -CH ₂ -CH ₂ -CH ₂ -OH | 3350 |

(i) Complete the table. [2]

(ii) Complete the equation for the combustion of pentan-1-ol in excess oxygen.

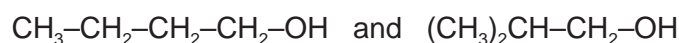


(b) State **three** characteristics of a homologous series other than the variation of physical properties down the series.

.....

 [3]

(c) The following alcohols are isomers.



(i) Explain why they are isomers.

.....

 [2]

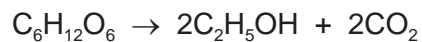
(ii) Draw the structural formula of another isomer of the above alcohols.

[1]

(d) Alcohols can be made by fermentation and from petroleum.

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(i) Ethanol is made from sugars by fermentation.



The mass of one mole of glucose, $\text{C}_6\text{H}_{12}\text{O}_6$, is 180 g.

Calculate the maximum mass of ethanol which could be obtained from 72 g of glucose.

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

(ii) Describe how ethanol is made from petroleum.

petroleum (alkanes) → ethene → ethanol

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

[Total: 15]

DATA SHEET
The Periodic Table of the Elements

| Group | | I | II | III | IV | V | VI | VII | 0 | | | | | |
|-----------------------------------|------------------------------------|------------------------------------|------------------------------------|--|-------------------------------------|-------------------------------------|--------------------------------------|-------------------------------------|---------------------------------------|---------------------------------------|------------------------------------|--|-------------------------------------|---------------------------------------|
| | | 1 H Hydrogen 1 | | | | | | | 2 He Helium 2 | | | | | |
| 7 Li Lithium 3 | 9 Be Beryllium 4 | | | | 11 B Boron 5 | 12 C Carbon 6 | 13 Al Aluminium 13 | 14 Si Silicon 14 | 15 P Phosphorus 15 | 16 S Sulfur 16 | 17 Cl Chlorine 17 | 18 Ar Argon 18 | | |
| 23 Na Sodium 11 | 24 Mg Magnesium 12 | | | 27 Fe Iron 26 | 28 Ni Nickel 28 | 29 Cu Copper 29 | 30 Zn Zinc 30 | 31 Ga Gallium 31 | 32 Ge Germanium 32 | 33 As Arsenic 33 | 34 Se Selenium 34 | 35 Br Bromine 35 | 36 Kr Krypton 36 | |
| 39 K Potassium 19 | 40 Ca Calcium 20 | 48 Ti Titanium 22 | 51 V Vanadium 23 | 55 Mn Manganese 25 | 59 Co Cobalt 27 | 59 Ni Nickel 28 | 64 Cu Copper 29 | 65 Zn Zinc 30 | 70 Ga Gallium 31 | 73 Ge Germanium 32 | 75 As Arsenic 33 | 79 Se Selenium 34 | 84 Kr Krypton 36 | |
| 85 Rb Rubidium 37 | 88 Sr Strontium 38 | 91 Zr Zirconium 40 | 93 Nb Niobium 41 | 101 Ru Ruthenium 44 | 103 Rh Rhodium 45 | 106 Pd Palladium 46 | 108 Ag Silver 47 | 112 Cd Cadmium 48 | 115 In Indium 49 | 119 Sn Tin 50 | 122 Sb Antimony 51 | 128 Te Tellurium 52 | 131 Xe Xenon 54 | |
| 133 Cs Caesium 55 | 137 Ba Barium 56 | 178 Hf Hafnium 72 | 181 Ta Tantalum 73 | 186 Re Rhenium 75 | 190 Os Osmium 76 | 195 Pt Platinum 78 | 197 Au Gold 79 | 201 Hg Mercury 80 | 204 Tl Thallium 81 | 207 Pb Lead 82 | 209 Bi Bismuth 83 | 210 Po Polonium 84 | 210 Rn Radon 86 | |
| 87 Fr Francium | 88 Ra Radium | 89 Ac Actinium | | | | | | | | | | | | |
| | | | 140 Ce Cerium 58 | 141 Pr Praseodymium 59 | 144 Nd Neodymium 60 | 152 Eu Europium 63 | 157 Gd Gadolinium 64 | 159 Tb Terbium 65 | 162 Dy Dysprosium 66 | 165 Ho Holmium 67 | 167 Er Erbium 68 | 169 Tm Thulium 69 | 173 Yb Ytterbium 70 | 175 Lu Lutetium 71 |
| | | | 232 Th Thorium 90 | 238 U Uranium 92 | 238 Np Neptunium 93 | 238 Am Americium 95 | 238 Cm Curium 96 | 238 Bk Berkelium 97 | 238 Cf Californium 98 | 238 Es Einsteinium 99 | 238 Fm Fermium 100 | 238 Md Mendelevium 101 | 238 No Nobelium 102 | 238 Lr Lawrencium 103 |

The volume of one mole of any gas is 24 dm³ at room temperature and pressure (r.t.p.).

*58-71 Lanthanoid series
†90-103 Actinoid series

| | | |
|--------------------------|-------------------|----------------------------|
| a | X | b |
| Key | | |
| a = relative atomic mass | x = atomic symbol | b = proton (atomic) number |

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