



Cambridge International Examinations
Cambridge International General Certificate of Secondary Education

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CHEMISTRY (US)

0439/43

Paper 4 Theory (Extended)

May/June 2017

1 hour 15 minutes

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

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

Write in dark blue or black pen.

You may use an HB pencil for any diagrams or graphs.

Do not use staples, paper clips, 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 16.

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 **14** printed pages and **2** blank pages.



1 Six different atoms can be represented as follows.



(a) Answer the following questions using atoms from the list. Each atom may be used once, more than once or not at all.

Select **one** atom from the six shown which

(i) has exactly seven protons,

..... [1]

(ii) has exactly six neutrons,

..... [1]

(iii) has more protons than neutrons,

..... [1]

(iv) has the electronic structure [2,5],

..... [1]

(v) is an atom of an element from Group VII of the Periodic Table,

..... [1]

(vi) is an atom of a noble gas.

..... [1]

(b) Two of the six atoms shown are isotopes of each other.

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

.....
 [2]

(ii) Which **two** of the six atoms shown are isotopes of each other?

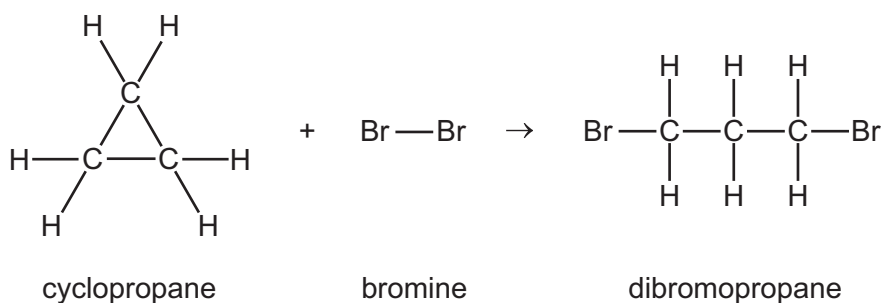
..... [1]

(iii) Why do isotopes have identical chemical properties?

.....
 [1]

[Total: 10]

- 2 Cyclopropane is a colorless gas. Cyclopropane reacts with bromine at room temperature. The chemical equation for the reaction is shown.



- (a) (i) What is the empirical formula of cyclopropane?

..... [1]

- (ii) What color change, if any, would you see when cyclopropane is bubbled into aqueous bromine?

initial color

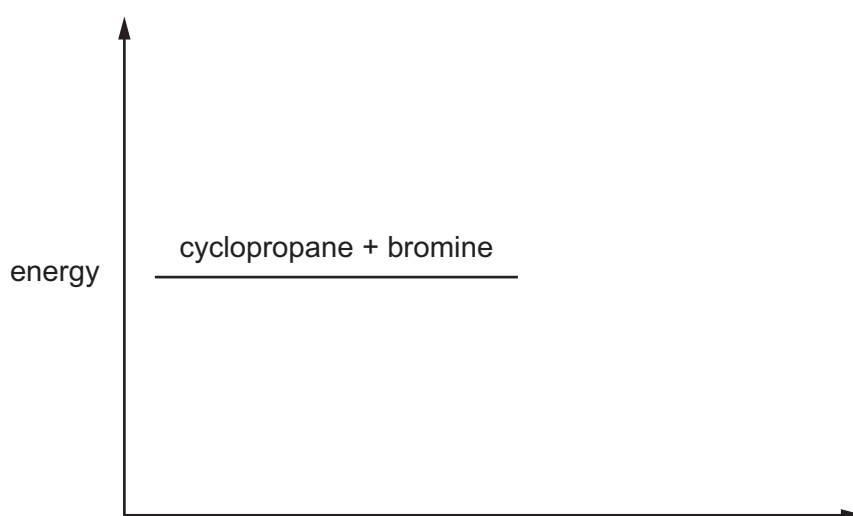
final color

[2]

- (b) The reaction of cyclopropane with bromine is exothermic.

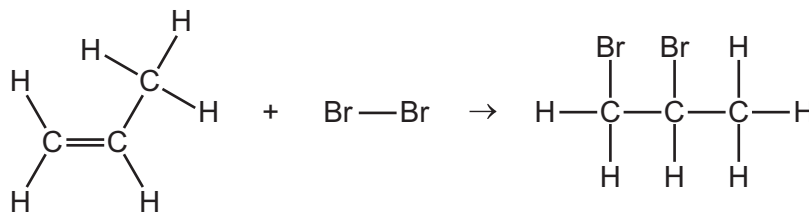
- (i) Complete the energy level diagram for this reaction by

- adding the product of the reaction,
- labeling the energy change, ΔH .



[2]

(ii) Propene also reacts with bromine.



Use the bond energies in the table to calculate the energy change, ΔH , for the reaction.

| | | | | | |
|-----------------------|-----|-----|-------|------|-----|
| | C-H | C-C | Br-Br | C-Br | C=C |
| bond energy in kJ/mol | 412 | 348 | 193 | 285 | 611 |

energy change = kJ/mol [3]

(c) The boiling point of bromine is 59°C and the boiling point of iodine is 184°C.

Explain why iodine has a higher boiling point than bromine.

.....

.....

.....

.....

..... [2]

[Total: 10]

3 Magnesium is a metal.

(a) Describe the structure and bonding in magnesium.

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

(b) Why can magnesium conduct electricity when solid?

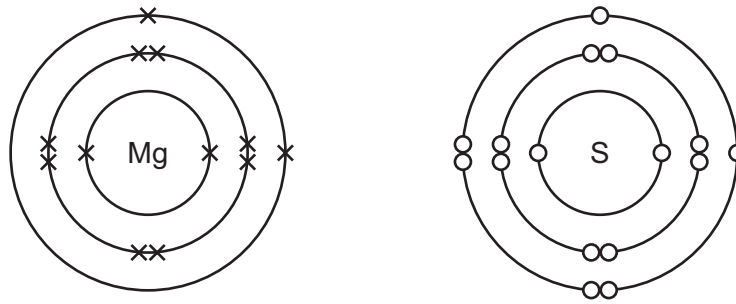
.....
.....
.....
..... [2]

(c) Why is magnesium malleable?

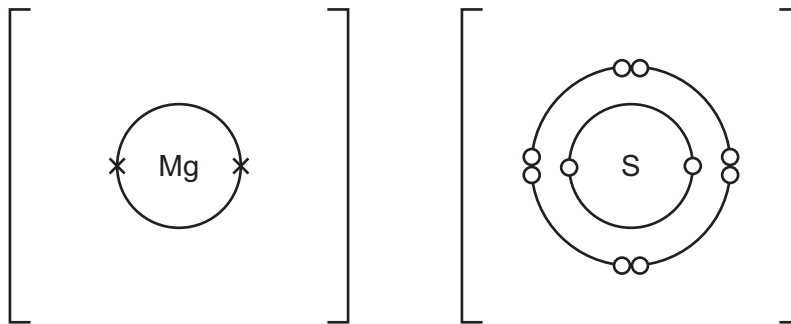
.....
.....
.....
..... [2]

(d) Magnesium reacts with sulfur to form the ionic compound magnesium sulfide, MgS.

The diagrams show the electronic structures of atoms of magnesium and sulfur.



(i) Complete the diagrams to show the electronic structures of the ions in magnesium sulfide. Show the charges on the ions.



[3]

(ii) Ionic compounds, such as magnesium sulfide, do **not** conduct electricity when solid. Magnesium sulfide does **not** dissolve in water. Magnesium sulfide **does** conduct electricity under certain conditions.

State the conditions needed for magnesium sulfide to conduct electricity. Explain why magnesium sulfide conducts electricity under these conditions.

.....

.....

.....

..... [2]

[Total: 12]

4 Gasoline is used as a fuel for cars. It is a mixture of hydrocarbons.

(a) Name the raw material from which gasoline is obtained.

..... [1]

(b) One of the compounds in gasoline is heptane, C_7H_{16} . Heptane is a saturated hydrocarbon.

(i) What is meant by the term *saturated hydrocarbon*?

saturated

.....

hydrocarbon

.....

[3]

(ii) To which homologous series does heptane belong?

..... [1]

(iii) Give **two** characteristics of an homologous series.

1

2

[2]

(iv) Complete the chemical equation for the complete combustion of heptane.



[2]

(c) Car engines produce carbon monoxide and oxides of nitrogen.

(i) Name an environmental problem that is caused by the release of oxides of nitrogen into the air.

..... [1]

(ii) Explain how carbon monoxide and oxides of nitrogen are formed in car engines.

carbon monoxide

.....

oxides of nitrogen

.....

[3]

(iii) State **one** adverse effect of carbon monoxide on human health.

..... [1]

(iv) Describe and explain how catalytic converters remove oxides of nitrogen from car engine exhaust fumes. You are advised to include a chemical equation in your answer.

.....

.....

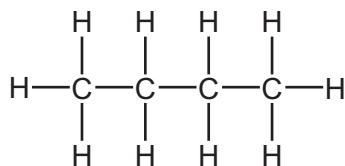
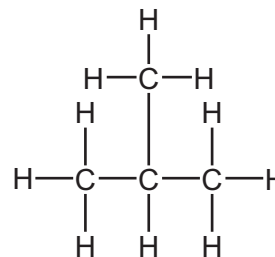
.....

.....

.....

..... [3]

(d) The formula C_4H_{10} represents two structural isomers, **A** and **B**.

**A****B**

(i) Name isomer **A**.

..... [1]

(ii) What is meant by the term *structural isomers*?

.....

 [2]

(iii) Isomer **B** reacts with chlorine in a substitution reaction.

Give the conditions required for the reaction to occur and draw the structures of **two** possible products, **one** of which is organic and **one** of which is **not** organic.

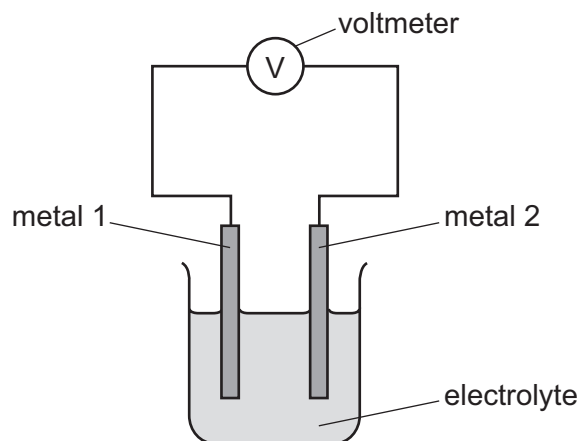
conditions

structures of products

[3]

[Total: 23]

5 The diagram shows a simple cell.



The simple cell was used with different metals as electrodes. The voltages were recorded in the table.

- If the voltage measured is positive then metal 2 is more reactive than metal 1.
- If the voltage measured is negative then metal 1 is more reactive than metal 2.

| | | metal 2 | | | | |
|---------|-----------|-----------|--------|--------|--------------|----------|
| | | beryllium | cobalt | nickel | silver | vanadium |
| metal 1 | beryllium | 0.0V | -1.6V | -1.6V | not measured | -0.7V |
| | cobalt | | 0.0V | 0.0V | -1.1V | 0.9V |
| | nickel | | | 0.0V | -1.1V | 0.9V |
| | silver | | | | 0.0V | 2.0V |
| | vanadium | | | | | 0.0V |

- The more reactive metal is oxidized.
- The bigger the difference in reactivity of the metals, the larger the reading on the voltmeter.

(a) In a simple cell using nickel and silver, the nickel is oxidized.

(i) Define *oxidation* in terms of electrons.

..... [1]

(ii) Nickel forms ions with a charge of +2.

Write an ionic half-equation to show the oxidation of nickel.

..... [1]

(iii) What will happen to the mass of the nickel electrode when the nickel is oxidized?

..... [1]

(b) Use the data in the table to answer the following questions.

(i) Which of the metals in the table is the most reactive?
Explain your answer.

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

(ii) State which **two** different metals have the same reactivity.

..... [1]

(iii) Predict the voltage produced by a simple cell with beryllium as metal 1 and silver as metal 2.

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

(c) Describe how the simple cell in the diagram can be used to show that magnesium is more reactive than beryllium. Explain your answer.

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

[Total: 10]

6 Barium carbonate, BaCO_3 , is an insoluble solid.

(a) When barium carbonate is heated strongly, it undergoes thermal decomposition. One of the products is barium oxide.

(i) Write a chemical equation for the thermal decomposition of barium carbonate.

..... [1]

(ii) Suggest the pH of the solution formed when barium oxide is added to water.

..... [1]

(iii) Barium nitrate decomposes on heating in the same way as magnesium nitrate decomposes.

Name the **two** gaseous products formed when barium nitrate is heated.

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

(b) Aqueous sodium carbonate is added to aqueous barium nitrate.

(i) Write a chemical equation for the reaction of aqueous sodium carbonate with aqueous barium nitrate.

..... [2]

(ii) Describe how a pure sample of barium carbonate could be obtained from the resulting mixture.

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

(c) Barium carbonate reacts with dilute hydrochloric acid.



9.85 g of barium carbonate were added to 250 cm³ of 1.00 mol/dm³ hydrochloric acid. This is an excess of hydrochloric acid.

(i) Calculate how many moles of barium carbonate were used in this experiment.

moles of barium carbonate = mol [2]

(ii) Deduce how many moles of carbon dioxide were made when all the barium carbonate had reacted.

moles of carbon dioxide = mol [1]

(iii) Calculate the volume of carbon dioxide formed in (c)(ii) at room temperature and pressure, in dm³.

volume of carbon dioxide = dm³ [1]

(iv) Calculate how many moles of hydrochloric acid there were **in excess**.

excess moles of hydrochloric acid = mol [2]

[Total: 15]

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The Periodic Table of Elements

| | | Group | | | | | | | |
|--|---------------------------|-----------------------|--------------------------|-----------------------|------------------------|------------------------|------------------------|---------------------------|-------------------------|
| I | II | III | IV | V | VI | VII | VIII | | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| H hydrogen 1 | He helium 4 | B boron 11 | C carbon 12 | N nitrogen 14 | O oxygen 16 | F fluorine 19 | Ne neon 20 | | |
| Key | | | | | | | | | |
| atomic number atomic symbol name relative atomic mass | | | | | | | | | |
| 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| Li lithium 7 | Be beryllium 9 | B boron 11 | C carbon 12 | N nitrogen 14 | O oxygen 16 | F fluorine 19 | Ne neon 20 | Na sodium 23 | Mg magnesium 24 |
| 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
| Na sodium 23 | Mg magnesium 24 | Al aluminum 27 | Si silicon 28 | P phosphorus 31 | S sulfur 32 | Cl chlorine 35.5 | Ar argon 40 | K potassium 39 | Ca calcium 40 |
| 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 |
| K potassium 39 | Ca calcium 40 | Sc scandium 45 | Ti titanium 48 | V vanadium 51 | Cr chromium 52 | Mn manganese 55 | Fe iron 56 | Co cobalt 59 | Ni nickel 59 |
| 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 | 46 |
| Rb rubidium 85 | Sr strontium 88 | Y yttrium 89 | Zr zirconium 91 | Nb niobium 93 | Mo molybdenum 96 | Tc technetium — | Ru ruthenium 101 | Rh rhodium 103 | Pd palladium 106 |
| 55 | 56 | 57–71 | 72 | 73 | 74 | 75 | 76 | 77 | 78 |
| Cs cesium 133 | Ba barium 137 | lanthanoids | Hf hafnium 178 | Ta tantalum 181 | W tungsten 184 | Re rhenium 186 | Os osmium 190 | Ir iridium 192 | Pt platinum 195 |
| 87 | 88 | 89–103 | 104 | 105 | 106 | 107 | 108 | 109 | 110 |
| Fr francium — | Ra radium — | actinoids | Rf rutherfordium — | Db dubnium — | Sg seaborgium — | Bh bohrium — | Hs hassium — | Mt meitnerium — | Ds darmstadtium — |
| 81 | 82 | 83 | 84 | 85 | 86 | 87 | 88 | 89 | 90 |
| Tl thallium 204 | Pb lead 207 | Bi bismuth 209 | Po polonium — | At astatine — | Rn radon — | Ac actinium — | Th thorium 232 | Pa protactinium 231 | U uranium 238 |
| 91 | 92 | 93 | 94 | 95 | 96 | 97 | 98 | 99 | 100 |
| Th thorium 232 | Pa protactinium 231 | Np neptunium — | Pu plutonium — | Am americium — | Cm curium — | Bk berkelium — | Cf californium — | Es einsteinium — | Fm fermium — |
| 101 | 102 | 103 | 104 | 105 | 106 | 107 | 108 | 109 | 110 |
| Md mendelevium — | No nobelium — | Lr lawrencium — | — | — | — | — | — | — | — |
| 109 | 110 | 111 | 112 | 113 | 114 | 115 | 116 | 117 | 118 |
| — | — | — | Cn copernicium — | Nh nihonium — | Fl flerovium — | Mc moscovium — | Lv livermorium — | — | — |

lanthanoids

actinoids

| | | | | | | | | | | | | | | |
|------------------------|----------------------|---------------------------|------------------------|-----------------------|-----------------------|-----------------------|-------------------------|----------------------|-------------------------|------------------------|---------------------|------------------------|------------------------|-----------------------|
| 57 | 58 | 59 | 60 | 61 | 62 | 63 | 64 | 65 | 66 | 67 | 68 | 69 | 70 | 71 |
| La lanthanum 139 | Ce cerium 140 | Pr praseodymium 141 | Nd neodymium 144 | Pm promethium — | Sm samarium 150 | Eu europium 152 | Gd gadolinium 157 | Tb terbium 159 | Dy dysprosium 163 | Ho holmium 165 | Er erbium 167 | Tm thulium 169 | Yb ytterbium 173 | Lu lutetium 175 |
| 89 | 90 | 91 | 92 | 93 | 94 | 95 | 96 | 97 | 98 | 99 | 100 | 101 | 102 | 103 |
| Ac actinium — | Th thorium 232 | Pa protactinium 231 | U uranium 238 | Np neptunium — | Pu plutonium — | Am americium — | Cm curium — | Bk berkelium — | Cf californium — | Es einsteinium — | Fm fermium — | Md mendelevium — | No nobelium — | Lr lawrencium — |

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