



Cambridge International Examinations
Cambridge International General Certificate of Secondary Education

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CHEMISTRY

0620/42

Paper 4 Theory (Extended)

February/March 2016

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 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.

The syllabus is approved for use in England, Wales and Northern Ireland as a Cambridge International Level 1/Level 2 Certificate.

This document consists of **14** printed pages and **2** blank pages.

2

- 1 (a) The table below gives information about particles.

Complete the table. The first line has been done for you.

| particle | number of protons | number of electrons | electronic configuration | charge on particle |
|----------|-------------------|---------------------|--------------------------|--------------------|
| A | 12 | 10 | 2,8 | 2+ |
| B | | 18 | 2,8,8 | 1- |
| C | 18 | | 2,8,8 | 0 |
| D | 8 | 10 | | |

[4]

- (b) Gallium is a Group III element.

Define the term *element*.

.....

.....

..... [1]

- (c) The following are gallium atoms.



Complete the following table.

| atom | number of protons | number of neutrons | number of electrons |
|-------------------------|-------------------|--------------------|---------------------|
| ${}_{31}^{69}\text{Ga}$ | | | |
| ${}_{31}^{71}\text{Ga}$ | | | |

[3]

[Total: 8]

2 Rubidium, Rb, is a Group I element. It has similar physical and chemical properties to the other elements in Group I.

(a) Predict how many electrons there are in the outer shell of a rubidium atom.

..... [1]

(b) Predict **one** physical property of rubidium which is the same as that of a transition element such as iron.

..... [1]

(c) Predict **two** physical properties of rubidium which are different to those of a transition element such as iron.

.....
 [2]

(d) When rubidium is added to cold water a reaction occurs.

(i) Suggest **two** observations that would be made when rubidium is added to cold water.

.....
 [2]

(ii) What would be the colour of the solution if methyl orange was added to it after the reaction?

..... [1]

(iii) Write a chemical equation for the reaction between rubidium and water.

..... [2]

(iv) Put the Group I elements, caesium, lithium, potassium, rubidium and sodium in their order of reactivity with water. Put the most reactive element first.

most reactive \longrightarrow least reactive

| | | | | |
|--|--|--|--|--|
| | | | | |
|--|--|--|--|--|

[1]

(v) Suggest **one** safety measure that should be used when rubidium is added to cold water.

..... [1]

(e) The phosphate ion has the formula PO_4^{3-} .

Deduce the formula of rubidium phosphate.

..... [1]

[Total: 12]

3 Carbon dioxide and silicon(IV) oxide are oxides of Group IV elements.

(a) Complete the following table.

| | carbon dioxide | silicon(IV) oxide |
|---------------------------|----------------|-------------------|
| formula | | SiO ₂ |
| melting point/°C | -56 | 1610 |
| physical state at 25°C | gas | |
| conduction of electricity | non-conductor | |
| structure | | macromolecular |

[4]

(b) (i) Name the type of bonds that exist between the atoms in silicon(IV) oxide.

..... [1]

(ii) Explain why silicon(IV) oxide has a very high melting point.

.....
 [1]

(iii) Explain, in terms of attractive forces between particles, why carbon dioxide has a very low melting point.

.....
 [1]

(iv) Explain, in terms of particles, why carbon dioxide is a non-conductor of electricity.

.....
 [1]

(c) Suggest a chemical equation for the reaction between sodium hydroxide solution and carbon dioxide.

..... [2]

5

(d) (i) Name the type of chemical reaction in which carbon dioxide is produced from fossil fuels.

..... [1]

(ii) Name the chemical process in which green plants convert carbon dioxide into carbohydrates.

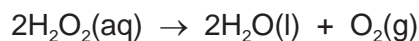
..... [1]

(iii) Name the chemical process in which living things produce carbon dioxide.

..... [1]

[Total: 13]

- 4 Hydrogen peroxide, H_2O_2 , decomposes into water and oxygen in the presence of a catalyst, manganese(IV) oxide.

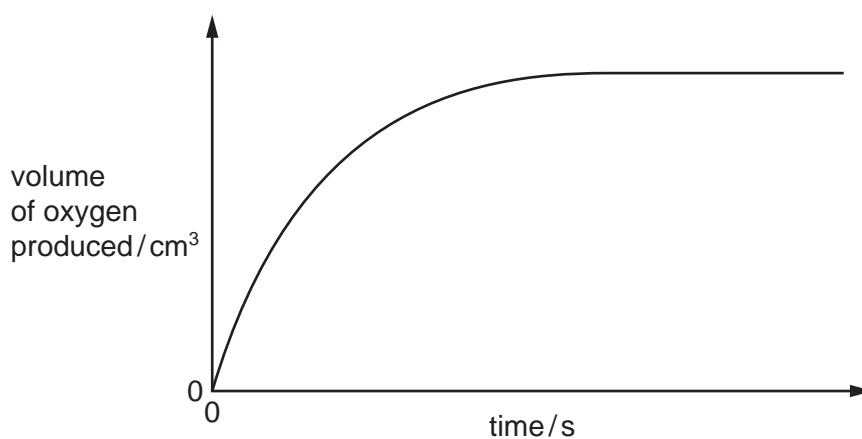
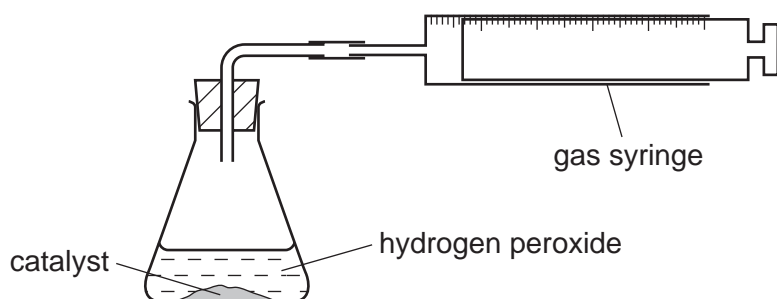


- (a) What is meant by the term *catalyst*?

.....
 [2]

- (b) A student studies the rate of decomposition of hydrogen peroxide using the apparatus shown. The student uses 20 cm^3 of 0.1 mol/dm^3 hydrogen peroxide and 1.0 g of manganese(IV) oxide.

The student measures the volume of oxygen given off at regular time intervals until the reaction stops. A graph of the results is shown.



- (i) When is the rate of reaction highest?

..... [1]

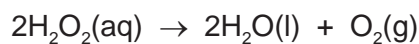
- (ii) Suggest **one** method of increasing the rate of reaction using the same amounts of hydrogen peroxide and manganese(IV) oxide.

..... [1]

(c) (i) Calculate the number of moles of hydrogen peroxide used in this experiment.

..... mol [1]

(ii) Use your answer to **(c)(i)** and the equation to calculate the number of moles of oxygen produced in the reaction.



..... mol [1]

(iii) Calculate the volume (at r.t.p.) of oxygen produced.

..... dm³ [1]

(iv) What would be the effect on the volume of oxygen produced if the mass of catalyst was increased?

..... [1]

(v) Deduce the volume of oxygen that would be produced if 20 cm³ of 0.2 mol/dm³ hydrogen peroxide was used instead of 20 cm³ of 0.1 mol/dm³ hydrogen peroxide.

..... dm³ [1]

8

- (d) The student carries out a second experiment to investigate whether another substance, copper(II) oxide, is a better catalyst than manganese(IV) oxide.

Describe how the second experiment is carried out. You should state clearly how you would make sure that the catalyst is the only variable.

.....

.....

.....

.....

.....

..... [3]

[Total: 12]

5 This question is about compounds of nitrogen.

- (a) (i) Describe the Haber Process giving reaction conditions and a chemical equation. Reference to rate and yield is not required.

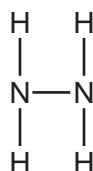
.....

 [5]

- (ii) Give **one** use of ammonia.

..... [1]

(b) The diagram shows the structure of a hydrazine molecule.



Draw the electron arrangement of a hydrazine molecule. Show the outer shell electrons only.

[2]

(c) Hydrazine is a base.

- (i) Define the term *base*.

..... [1]

- (ii) Complete the chemical equation to show that hydrazine acts as a base when added to water.



10

(d) Nitrogen dioxide is an atmospheric pollutant.

(i) State **one** environmental problem caused by nitrogen dioxide.

..... [1]

(ii) Explain how oxides of nitrogen, such as nitrogen dioxide, are formed in car engines.

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

[Total: 13]

6 Iron pyrite, FeS_2 , is known as Fool's Gold because it is a shiny yellow solid which is similar in appearance to gold. Iron pyrite is an ionic compound. Gold is a metallic element.

(a) Iron pyrite, FeS_2 , contains positive and negative ions. The positive ion is Fe^{2+} .

Deduce the formula of the negative ion.

..... [1]

(b) A student is provided with a sample of iron pyrite and a sample of gold.

Suggest how the student could distinguish between the two substances.

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

(c) Sulfur dioxide is produced on a large scale by heating iron pyrite strongly in air. The iron pyrite reacts with oxygen in the air producing iron(III) oxide, Fe_2O_3 , and sulfur dioxide.

(i) Construct a chemical equation for the reaction between iron pyrite and oxygen.

..... [2]

(ii) Give **one** use of sulfur dioxide.

..... [1]

[Total: 6]

7 (a) Alkanes and alkenes are examples of hydrocarbons.

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

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

(ii) Give the general formula of straight-chain

alkanes,

alkenes. [2]

(b) A compound X contains carbon, hydrogen and oxygen only.

X contains 54.54% of carbon by mass, 9.09% of hydrogen by mass and 36.37% of oxygen by mass.

(i) Calculate the empirical formula of compound X.

[2]

(ii) Compound X has a relative molecular mass of 88.

Deduce the molecular formula of compound X.

[2]

(c) An ester has the molecular formula $C_3H_6O_2$.

Name and give the structural formulae of **two** esters with the molecular formula $C_3H_6O_2$.

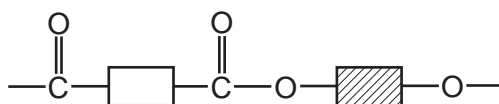
| | | |
|--------------------|--|--|
| name of ester | | |
| structural formula | | |

[4]

(d) Name the ester produced from the reaction of propanoic acid and methanol.

..... [1]

(e) A polyester is represented by the structure shown.



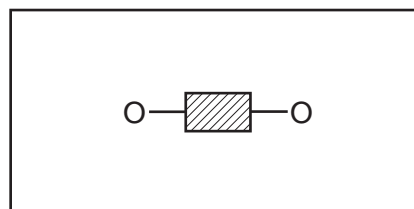
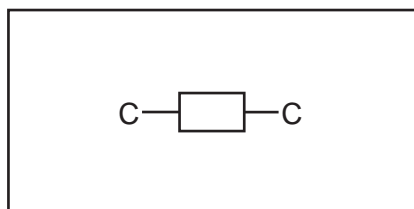
(i) What type of polymerisation is used for the production of polyesters?

..... [1]

(ii) Which simple molecule is removed when the polyester is formed?

..... [1]

(iii) Complete the diagrams below to show the structures of the monomers used to produce the polyester. Show all atoms and bonds.



[2]

[Total: 16]

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The Periodic Table of Elements

| | | Group | | | | | | | | | | | | | | | | |
|-----------------------------------|------------------------------------|--|--|------------------------------------|-------------------------------------|------------------------------------|-------------------------------------|-------------------------------------|---------------------------------------|--------------------------------------|--------------------------------------|------------------------------------|--------------------------------------|-------------------------------------|-------------------------------------|----------------------------------|----------------------------------|--|
| I | II | III | IV | V | VI | VII | VIII | | | | | | | | | | | |
| 3 Li lithium 7 | 4 Be beryllium 9 | 1 H hydrogen 1 | 5 B boron 11 | 6 C carbon 12 | 7 N nitrogen 14 | 8 O oxygen 16 | 9 F fluorine 19 | 10 Ne neon 20 | | | | | | | | | | |
| 11 Na sodium 23 | 12 Mg magnesium 24 | Key atomic number atomic symbol name relative atomic mass | | | | | | | | | | | | | | | | |
| 19 K potassium 39 | 20 Ca calcium 40 | | | | | | | | | 13 Al aluminium 27 | 14 Si silicon 28 | 15 P phosphorus 31 | 16 S sulfur 32 | 17 Cl chlorine 35.5 | 18 Ar argon 40 | | | |
| 37 Rb rubidium 85 | 38 Sr strontium 88 | 21 Sc scandium 45 | 22 Ti titanium 48 | 23 V vanadium 51 | 24 Cr chromium 52 | 25 Mn manganese 55 | 26 Fe iron 56 | 27 Co cobalt 59 | 28 Ni nickel 59 | 29 Cu copper 64 | 30 Zn zinc 65 | 31 Ga gallium 70 | 32 Ge germanium 73 | 33 As arsenic 75 | 34 Se selenium 79 | 35 Br bromine 80 | 36 Kr krypton 84 | |
| 55 Cs caesium 133 | 56 Ba barium 137 | 39 Y yttrium 89 | 40 Zr zirconium 91 | 41 Nb niobium 93 | 42 Mo molybdenum 96 | 43 Tc technetium — | 44 Ru ruthenium 101 | 45 Rh rhodium 103 | 46 Pd palladium 106 | 47 Ag silver 108 | 48 Cd cadmium 112 | 49 In indium 115 | 50 Sn tin 119 | 51 Sb antimony 122 | 52 Te tellurium 128 | 53 I iodine 127 | 54 Xe xenon 131 | |
| 87 Fr francium — | 88 Ra radium — | 57–71 lanthanoids | 72 Hf hafnium 178 | 73 Ta tantalum 181 | 74 W tungsten 184 | 75 Re rhenium 186 | 76 Os osmium 190 | 77 Ir iridium 192 | 78 Pt platinum 195 | 79 Au gold 197 | 80 Hg mercury 201 | 81 Tl thallium 204 | 82 Pb lead 207 | 83 Bi bismuth 209 | 84 Po polonium — | 85 At astatine — | 86 Rn radon — | |
| | | 89–103 actinoids | 104 Rf rutherfordium — | 105 Db dubnium — | 106 Sg seaborgium — | 107 Bh bohrium — | 108 Hs hassium — | 109 Mt meitnerium — | 110 Ds darmstadtium — | 111 Rg roentgenium — | 112 Cn copernicium — | 114 Fl flerovium — | 116 Lv livermorium — | | | | | |

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

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