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Cambridge Assessment International Education

Cambridge IGCSE™ (9–1)

CANDIDATE NAME	
CENTRE NUMBER	
CANDIDATE NUMBER	

6916921236

CHEMISTRY **0971/41**

Paper 4 Theory (Extended) **May/June 2020**

1 hour 15 minutes

You must answer on the question paper.

No additional materials are needed.

INSTRUCTIONS

- Answer **all** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen or correction fluid.
- Do **not** write on any bar codes.
- You may use a calculator.
- You should show all your working and use appropriate units.

INFORMATION

- The total mark for this paper is 80.
- The number of marks for each question or part question is shown in brackets [ ].
- The Periodic Table is printed in the question paper.

This document has **12** pages. Blank pages are indicated.

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1 This question is about elements **X**, **Y** and **Z**.

(a) An atom of element **X** is represented as $^{34}_{16}\mathbf{X}$.

(i) Name the different types of particles found in the nucleus of this atom of **X**.

.....

..... [2]

(ii) What is the term for the total number of particles in the nucleus of an atom?

..... [1]

(iii) What is the total number of particles in the nucleus of an atom of $^{34}_{16}\mathbf{X}$?

..... [1]

(iv) What is the electronic structure of the ion $\mathbf{X}^{2-}$?

..... [1]

(v) Suggest the formula of the compound formed between aluminium and **X**.

..... [1]

(b) (i) What term is used to describe atoms of the same element with different numbers of particles in the nucleus?

..... [1]

(ii) Identify the atom against which the relative masses of all other atoms are compared.

..... [1]

(iii) What is the name of the amount of any substance that contains 6.02×10^{23} particles?

..... [1]

(iv) The constant 6.02×10^{23} has a name.

What is the name of this constant?

..... [1]

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(c) Part of the definition of relative atomic mass is 'the average mass of naturally occurring atoms of an element'.

Some relative atomic masses are not whole numbers.

Element **Y** has only two different types of atom, ^{69}**Y** and ^{71}**Y**.

The ratio of atoms present in element **Y** is shown.

$$^{69}\mathbf{Y} : {}^{71}\mathbf{Y} = 3 : 2$$

- Calculate the relative atomic mass of element **Y** to **one decimal place**.

relative atomic mass = ...

- Identify element **Y**.

.....
[3]

(d) Element **Z** is in Period 3 and Group V.

(i) Identify element **Z**.

..... [1]

(ii) Explain in terms of electron transfer why **Z** behaves chemically as a non-metal.

.....

..... [2]

[Total: 16]

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2 Magnesium is a metal.

(a) Name and describe the bonding in magnesium.

name .....

description of bonding .....

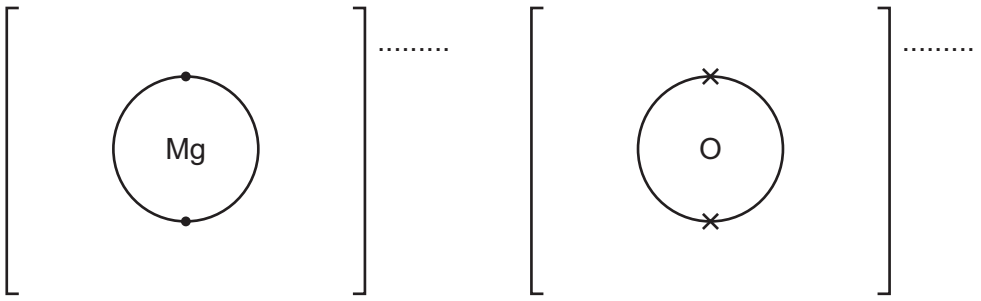
.....

.....

[4]

(b) Magnesium oxide, MgO, is formed when magnesium burns in oxygen.

(i) Complete the dot-and-cross diagram to show the electron arrangement of the ions in magnesium oxide.
The inner shells have been drawn.
Give the charges on the ions.



[3]

(ii) Write the chemical equation for the reaction that occurs when magnesium burns in oxygen.

..... [2]

(c) Magnesium oxide also forms when magnesium nitrate, $Mg(NO_3)_2$, is heated strongly. This is an endothermic reaction.

(i) Write the chemical equation for this reaction.

..... [2]

(ii) What type of reaction is this?

..... [1]

(iii) Name **two** other compounds of magnesium that form magnesium oxide when heated.

.....

..... [2]

[Total: 14]

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3 Sulfur dioxide, SO_2, is used in the manufacture of sulfuric acid.

(a) In the first stage of the process, sulfur dioxide is obtained from sulfur-containing ores.

Name **one** of these ores.

..... [1]

(b) The next stage of the process is a reaction which can reach equilibrium.

The equation for this stage is shown.

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$$

(i) Describe **two** features of an equilibrium.

.....

..... [2]

(ii) Name the catalyst used in this stage.

..... [1]

(iii) Why is a catalyst used?

..... [1]

(iv) Explain, in terms of particles, why a high temperature increases the rate of this reaction.

.....

.....

.....

.....

..... [3]

(v) In this stage, only a moderate temperature of 450 °C is used.

What does this suggest about the forward reaction?

..... [1]

(vi) Calculate the percentage by mass of sulfur in sulfur trioxide, SO_3.

percentage = ... [2]

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(c) Concentrated sulfuric acid is a dehydrating agent which can chemically remove water from substances.

Both hydrated copper(II) sulfate crystals and sucrose (a sugar), $C_{12}H_{22}O_{11}$, can be completely dehydrated by concentrated sulfuric acid.

Name the solid product formed in each case.

hydrated copper(II) sulfate crystals .....

sucrose .....
[2]

(d) When propan-1-ol is heated with concentrated sulfuric acid as a catalyst an unsaturated hydrocarbon of relative molecular mass 42 is formed and one other product.

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

..... [1]

(ii) Write the chemical equation for this reaction.

..... [2]

(iii) Name the unsaturated hydrocarbon formed.

..... [1]

[Total: 17]

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4 This question is about reactions of bases and acids.

(a) Ammonia is a gas at room temperature.

What is the test for ammonia gas? Describe the positive result of this test.

test .....

result .....
[2]

(b) Ammonia reacts with water to form ions.

$$NH_3 + H_2O \rightleftharpoons NH_4^+ + OH^-$$

(i) How does this equation show that ammonia, NH_3, behaves as a base?

..... [1]

(ii) Aqueous ammonia is described as a weak base.

Suggest the pH of aqueous ammonia.

pH = ... [1]

(iii) Describe what is seen when aqueous ammonia is added to aqueous copper(II) sulfate, until no further change is seen.

.....

.....

..... [3]

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(c) Aqueous sodium hydroxide, NaOH(aq), is a strong alkali that reacts with dilute sulfuric acid exothermically.

(i) What type of reaction is this?

..... [1]

(ii) Complete the equation for the reaction between aqueous sodium hydroxide and dilute sulfuric acid.

$2NaOH + H_2SO_4 \rightarrow$ ..... + ...

[2]

(d) A student wanted to find the concentration of some dilute sulfuric acid by titration. The student found that 25.0 cm^3 of 0.0400 mol / dm^3 NaOH(aq) reacted exactly with 20.0 cm^3 of H_2SO_4(aq).

(i) Name a suitable indicator to use in this titration.

..... [1]

(ii) Calculate the concentration of the H_2SO_4(aq) in mol / dm^3 using the following steps.

- Calculate the number of moles of NaOH in 25.0 cm^3.

moles = ...

- Deduce the number of moles of H_2SO_4 that reacted with the 25.0 cm^3 of NaOH(aq).

moles = ...

- Calculate the concentration of H_2SO_4(aq) in mol / dm^3.

concentration = ... mol / dm^3

[3]

(iii) Calculate the concentration of the 0.0400 mol / dm^3 NaOH(aq) in g / dm^3.

concentration = ... g / dm^3 [2]

[Total: 16]

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5 Ethanol is manufactured by two different processes.

(a) For each process, name the organic reactant and state the type of reaction.

organic reactant ..... type of reaction .....

organic reactant ..... type of reaction .....

[4]

(b) Alcohols can be oxidised to form carboxylic acids.

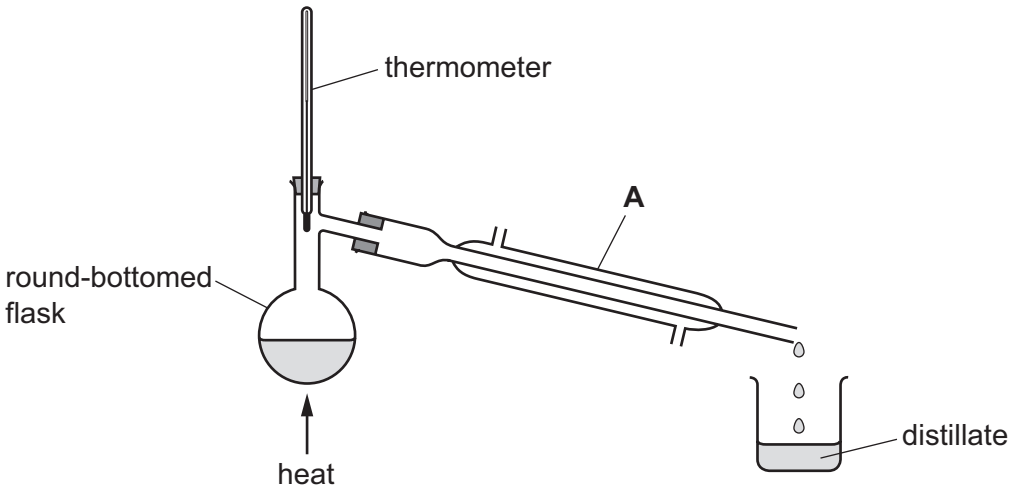
Name a suitable oxidising agent for this reaction.

..... [1]

(c) Alcohols can be partially oxidised to form aldehydes.

Aldehydes are a homologous series of organic compounds.

Partial oxidation is achieved by reacting an alcohol with the oxidising agent in distillation apparatus as shown.



(i) Name apparatus **A**.

..... [1]

(ii) On the diagram, use **one** arrow to show where water enters apparatus **A**. [1]

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(d) The table shows some information about aldehydes.

(i) Complete the table.

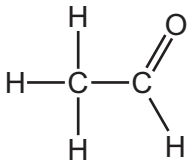
name	.....	ethanal	propanal	butanal
molecular formula	CH_2O	C_2H_4O	C_3H_6O	.....

[2]

(ii) Deduce the general formula of aldehydes.

..... [1]

(e) The structural formula of ethanal is shown.

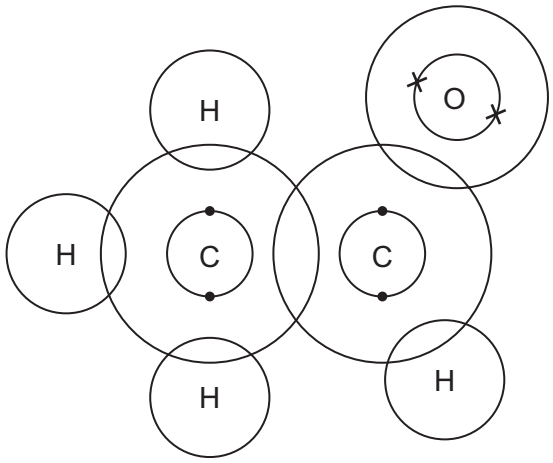


The C=O group in aldehydes is at the end of the carbon chain.
This is a reactive part of the molecule.

(i) What is the name given to the reactive part of any organic molecule?

..... [1]

(ii) Complete the dot-and-cross diagram to show the electron arrangement of a molecule of ethanal. Inner shells have been drawn.



[3]

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(f) Propanone belongs to a homologous series called ketones. Ketones have the same C=O group as aldehydes but the C=O group is not at the end of the carbon chain. Propanone has the same molecular formula as propanal, C_3H_6O.

(i) What term is used to describe molecules with different structures but with the same molecular formula?

..... [1]

(ii) Suggest the structure of propanone, C_3H_6O. Show all of the atoms and all of the bonds.

[2]

[Total: 17]

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The Periodic Table of Elements

Group																	
I	II											III	IV	V	VI	VII	VIII
							1 H hydrogen 1										2 He helium 4
3 Li lithium 7	4 Be beryllium 9											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											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
19 K potassium 39	20 Ca calcium 40	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
37 Rb rubidium 85	38 Sr strontium 88	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
55 Cs caesium 133	56 Ba barium 137	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 –
87 Fr francium –	88 Ra radium –	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 –		

Key

atomic number
atomic symbol
name
relative atomic mass

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 dm^3 at room temperature and pressure (r.t.p.).

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