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Cambridge Assessment International Education

Cambridge IGCSE™ (9–1)

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CHEMISTRY **0971/32**

Paper 3 Theory (Core) **October/November 2024**

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 **20** pages. Any blank pages are indicated.

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[Turn over

1 **(a)** Fig. 1.1 shows part of the Periodic Table.

I	II											III	IV	V	VI	VII	VIII
							H										He
														N			
Na												Al			S		Ar
K	Ca										Zn					Br	
																I	
	Ba									Au							

Fig. 1.1

Answer the following questions using only the elements in Fig. 1.1.
Each symbol of the element may be used once, more than once or not at all.

Give the symbol of the element that:

(i) is 78% of clean, dry air

..... [1]

(ii) forms an ion with a charge of 3+

..... [1]

(iii) has an atom with only five occupied electron shells

..... [1]

(iv) forms an ion that gives a light green colour in a flame test

..... [1]

(v) is used in food containers because of its resistance to corrosion

..... [1]

(vi) is the metal with the lowest reactivity.

..... [1]

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(b) Helium is a monatomic gas.

(i) State the meaning of the term monatomic.

..... [1]

(ii) Explain in terms of electronic configuration why helium is unreactive.

.....

..... [1]

[Total: 8]

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2 **(a)** Hydrogen chloride has a simple molecular structure.

(i) State **two** physical properties of a compound with a simple molecular structure.

1 .....

2 .....

[2]

(ii) Hydrogen chloride is a molecule with a covalent bond.

Complete this sentence about a covalent bond.

A covalent bond is formed when two atoms share a pair of ..... . [1]

(iii) Complete Fig. 2.1 to show the dot-and-cross diagram for a molecule of hydrogen chloride. Show outer shell electrons only.

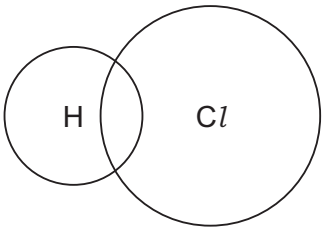

Fig. 2.1

[2]

(b) Zinc chloride has a giant ionic structure of positive and negative ions.

State the general name given to any negative ion.

..... [1]

(c) Diamond is used for jewellery.

(i) State one **other** use of diamond.

..... [1]

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(ii) Choose the correct statement that describes the structure and bonding in diamond.

Tick (✓) **one** box.

simple covalent molecule	☐
giant covalent	☐
simple ionic	☐
giant ionic	☐

[1]

[Total: 8]

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3 **(a)** The list shows some substances present in water from natural sources.

dissolved oxygen
calcium compounds
plastics
harmful microbes

State which **one** of these substances provides essential minerals for aquatic life.

..... [1]

(b) Explain why phosphates present in polluted water are harmful to aquatic life.

.....

..... [1]

(c) Table 3.1 shows the masses of ions, in mg, present in a 1000 cm^3 sample of polluted water.

Table 3.1

name of ion	formula of ion	mass of ion in 1000 cm^3 of polluted water / mg
bromide	Br^-	0.3
calcium	Ca^{2+}	2.5
chloride	Cl^-	3.5
hydrogencarbonate	HCO_3^-	10.0
magnesium	Mg^{2+}	0.8
mercury	Hg^{2+}	0.1
	NO_3^-	0.4
phosphate	PO_4^{3-}	2.0
potassium	K^+	5.9
silicate	SiO_3^{2-}	4.0
sodium	Na^+	12.2
sulfate	SO_4^{2-}	0.5

Answer these questions using the information from Table 3.1.

(i) Name the negative ion present in the highest concentration.

..... [1]

(ii) State the name of the NO_3^- ion.

..... [1]

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(iii) Calculate the mass of phosphate ions present in 200 cm^3 of polluted water.

mass = ... mg [1]

(d) Fig. 3.1 shows some of the stages in the purification of drinking water.

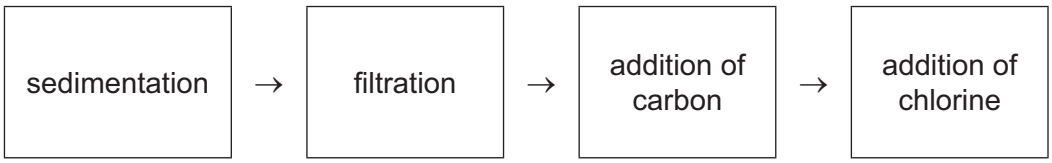

Fig. 3.1

(i) State the purpose of sedimentation.

..... [1]

(ii) State why chlorine is added to drinking water.

..... [1]

(e) Describe how to test for the purity of water using boiling point.

.....

.....

.....

..... [2]

(f) Complete the symbol equation for the reaction of disulfur dichloride, S_2Cl_2, with water.

$$S_2Cl_2 + ...H_2O \rightarrow .....HCl + H_2SO_3 + H_2S$$ [2]

[Total: 11]

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4 **(a)** Fig. 4.1 shows the displayed formula of compound **A**.

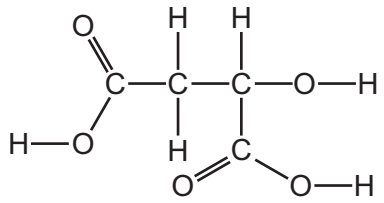

Fig. 4.1

(i) On Fig 4.1 draw a circle around the alcohol functional group. [1]

(ii) Deduce the molecular formula of compound **A**.

..... [1]

(b) Compound **A** reacts with ethanol to produce a compound with the molecular formula $C_8H_{14}O_5$.

Complete Table 4.1 to calculate the relative molecular mass of $C_8H_{14}O_5$.

Table 4.1

type of atom	number of atoms	relative atomic mass	
carbon	8	12	$8 \times 12 = 96$
hydrogen		1	
oxygen		16	

relative molecular mass = ... [2]

(c) Complete the word equation for the complete combustion of ethanol.

ethanol	+	oxygen	→	.....	+	....

[2]

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(d) Table 4.2 shows the names, formulae and boiling points of ethene, propene, butene and pentene.

Table 4.2

name	formula	boiling point / °C
ethene	C_2H_4	–104
propene	C_3H_6	–47
butene	C_4H_8	–6
pentene	C_5H_{10}	+30

Use the information in Table 4.2 to answer these questions.

(i) Name the homologous series that includes ethene, propene, butene and pentene.

..... [1]

(ii) Deduce the general formula of this homologous series.

..... [1]

(iii) State the trend in the boiling point of this homologous series as the number of carbon atoms increases.

..... [1]

(e) Ethene is manufactured by cracking.

(i) Describe the manufacture of ethene by cracking.

.....

.....

.....

.....

..... [3]

(ii) Give a reason for cracking hydrocarbons.

..... [1]

[Total: 13]

5 **(a)** Table 5.1 shows some properties of five halogens.

Table 5.1

halogen	melting point in °C	boiling point in °C	density in liquid state in g / cm^3
fluorine	–220	–188	
chlorine	–101	–35	1.56
bromine	–7	+59	3.12
iodine	+114		3.96
astatine	+302	+337	6.40

Use the information in Table 5.1 to predict:

(i) the boiling point of iodine ..... [1]

(ii) the density of liquid fluorine ..... [1]

(iii) the physical state of chlorine at –20 °C. Give a reason for your answer.

physical state .....

reason .....

.....

[2]

(b) Aqueous chlorine reacts with aqueous lithium bromide.

(i) Complete the word equation for this reaction.

chlorine	+	lithium bromide	→	.....	+	....

[2]

(ii) Explain why aqueous iodine does **not** react with aqueous lithium bromide.

..... [1]

(iii) Describe a test for chlorine.

test .....

observations .....

[2]

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(c) Fluorine reacts with ammonia to produce hydrogen fluoride and nitrogen.

Complete the symbol equation for this reaction.

$$.....F_2 + 2NH_3 \rightarrow .....HF + N_2$$ [2]

[Total: 11]

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6 This question is about metals.

(a) Many metals have high melting points and boiling points.

State three **other** typical physical properties of metals.

1 .....

2 .....

3 .....

[3]

(b) (i) Complete Table 6.1 to show the number of electrons, neutrons and protons in the sodium atom and silver ion shown.

Table 6.1

	number of electrons	number of neutrons	number of protons
$^{23}_{11}Na$	11		
$^{109}_{47}Ag^{+}$		62	

[3]

(ii) Write the electronic configuration of the sodium atom.

..... [1]

(c) Silver is a transition element. Sodium is in Group I of the Periodic Table.

State **one** difference in the physical properties of silver and sodium.

..... [1]

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(d) Table 6.2 shows the observations when four different metals are heated in oxygen.

Table 6.2

metal	observations when heated in oxygen
cerium	burns rapidly and forms an oxide
copper	forms an oxide layer very slowly and does not burn
lanthanum	forms an oxide layer rapidly and does not burn
silver	does not form an oxide layer and does not burn

Put the four metals in order of their reactivity.
Put the least reactive metal first.

least reactive ⟶ most reactive

[2]

(e) Copper(II) oxide is reduced by carbon monoxide.

$$CuO + CO \rightarrow Cu + CO_2$$

Explain how this equation shows that copper(II) oxide is reduced.

..... [1]

[Total: 11]

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7 This question is about acids, bases and salts.

(a) Crystals of zinc sulfate are made by warming excess solid zinc oxide with dilute sulfuric acid.

$$ZnO(s) + H_2SO_4(aq) \rightarrow ZnSO_4(aq) + H_2O(l)$$

(i) State the meaning of the state symbol (aq).

..... [1]

(ii) State the method used to separate the excess solid zinc oxide from the reaction mixture.

..... [1]

(b) Crystals of sodium nitrate can be made by neutralising an acid with an alkali.

(i) Name the acid and the alkali used.

acid .....

alkali .....
[2]

(ii) Complete the equation for all neutralisation reactions.

$$H^+ + \text{.....} \rightarrow \text{.....}$$ [2]

(iii) Neutralisation reactions are exothermic.

Define the term exothermic.

..... [1]

(iv) Fig. 7.1 shows the reaction pathway diagram for an exothermic reaction.

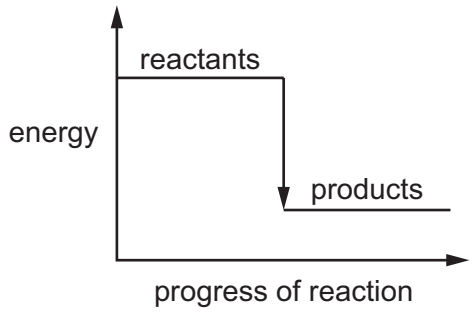

Fig. 7.1

Explain how Fig. 7.1 shows that the reaction is exothermic.

..... [1]

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(c) Methyl orange is an acid–base indicator.

State the colour of methyl orange at pH 2 and at pH 12.

colour at pH 2 .....

colour at pH 12 .....

[2]

[Total: 10]

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8 **(a)** A student investigates the reaction of small pieces of calcium carbonate with excess dilute hydrochloric acid of three different concentrations.
The time taken for each reaction to finish is recorded.

The three concentrations of acid are:
- 0.5 mol / dm^3
- 1.0 mol / dm^3
- 2.0 mol / dm^3.

All other conditions stay the same.

Table 8.1 shows the time taken for each reaction to finish.

Table 8.1

concentration of dilute hydrochloric acid in mol / dm^3	time taken for the reaction to finish in s
	32
	64
	16

(i) Complete Table 8.1 by writing the concentrations in the first column. [1]

(ii) Describe the effect on the time taken for the reaction to finish when the reaction is carried out at a lower temperature.

All other conditions stay the same.

..... [1]

(iii) Describe the effect on the time taken for the reaction to finish when powdered calcium carbonate is used instead of small pieces of calcium carbonate.

All other conditions stay the same.

..... [1]

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(b) Molten calcium chloride is electrolysed using inert electrodes.

(i) Name the products at the positive and negative electrodes.

product at the positive electrode .....

product at the negative electrode .....

[2]

(ii) Choose from the list the substance that is used as an inert electrode.

Draw a circle around your chosen answer.

graphite **iodine** **magnesium** **phosphorus** [1]

(c) Carbon dioxide is a gas at room temperature.

Describe the motion and separation of the particles in carbon dioxide gas.

motion .....

.....

separation .....

.....

[2]

[Total: 8]

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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 –	113 Nh nihonium –	114 Fl flerovium –	115 Mc moscovium –	116 Lv livermorium –	117 Ts tennessine –	118 Og oganesson –

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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