Cambridge Assessment International Education

Cambridge IGCSE™ (9–1)

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

9821516833

CHEMISTRY **0971/42**

Paper 4 Theory (Extended) **October/November 2023**

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 **16** pages. Any blank pages are indicated.

1 Table 1.1 gives the electronic configurations of some atoms and ions, **A** to **G**.

Table 1.1

	electronic configuration
A	2,5
B	2,8
C	2,8,2
D	2,8,4
E	2,8,5
F	2,8,6
G	2,8,18,7

Answer the following questions about **A** to **G**.
Each letter may be used once, more than once or not at all.

State which of the atoms or ions, **A** to **G**, could be:

(a) a noble gas atom

..... [1]

(b) an atom of an element in Group VI

..... [1]

(c) an atom with an atomic number of 14

..... [1]

(d) atoms from the same group

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

(e) a halogen atom

..... [1]

(f) an atom of an element which is a good conductor of electricity

..... [1]

(g) a stable ion of a Group V element

..... [1]

(h) an atom that forms an ion with a 2– charge.

..... [1]

[Total: 8]

2 Cobalt and copper are transition elements.

(a) Copper has two naturally occurring isotopes, ^{63}Cu and ^{65}Cu. Cobalt has only one naturally occurring isotope, ^{59}Co.

(i) Complete Table 2.1 to show the number of protons, neutrons and electrons in the ^{59}Co atom and the $^{65}Cu^{2+}$ ion.

Table 2.1

	^{59}Co	$^{65}Cu^{2+}$
protons		
neutrons		
electrons		

[3]

(ii) Table 2.2 shows the relative abundance of the two naturally occurring isotopes of copper.

Table 2.2

isotope	^{63}Cu	^{65}Cu
relative abundance	70%	30%

Calculate the relative atomic mass of copper to **one** decimal place.

relative atomic mass = ... [2]

(b) One physical property of transition elements such as copper and cobalt is that they are hard. Other metals such as lithium are softer.

State **two** other physical properties of copper and cobalt which are significantly different from lithium.

1 .....

2 .....

[2]

[Turn over

(c) Both copper and cobalt can form coloured compounds. Some of these compounds contain water of crystallisation.

(i) Define the term water of crystallisation.

.....

..... [2]

(ii) State the colour and formula of hydrated cobalt(II) chloride crystals.

colour .....

formula .....
[2]

(iii) State the colour change seen when a few drops of water are added to anhydrous copper(II) sulfate.

from ..... to ..... [2]

(iv) State how this colour change can be reversed.

..... [1]

[Total: 14]

3 Iron is manufactured in a blast furnace.

(a) Three of the starting materials added to the blast furnace are coke, iron ore and limestone.

Name the **other** starting material added to the blast furnace.

..... [1]

(b) The source of iron in the blast furnace is Fe_2O_3. Fe_2O_3 is found in iron ore.

(i) Name the main ore of iron which contains Fe_2O_3.

..... [1]

(ii) The iron in Fe_2O_3 is reduced by reaction with carbon monoxide. The unbalanced symbol equation is shown.

Complete the equation.

$$Fe_2O_3 + ...CO \rightarrow .....CO_2 + ...Fe$$ [1]

(iii) State the change in oxidation number of iron in the reaction in **(ii)**.

from ..... to ..... [2]

(iv) Explain how the change of oxidation number shows that iron has been reduced.

..... [1]

(c) The major impurity in iron ore is silicon(IV) oxide. Limestone is added to the blast furnace to remove this impurity.

Write two symbol equations to show how silicon(IV) oxide is removed. For each equation, state the type of chemical reaction that takes place.

equation 1 .....

type of chemical reaction .....

equation 2 .....

type of chemical reaction .....

[4]

[Turn over

(d) Iron is converted to steel by mixing it with carbon and other elements.

(i) State the term given to a substance which is a mixture of a metal and other elements.

..... [1]

(ii) Name **one** element, other than carbon, mixed with iron in the making of stainless steel.

..... [1]

(e) Preventing the rusting of steel is important.

State the chemical name of rust.

..... [1]

(f) Steel can be coated with zinc to prevent rusting. This provides both a barrier method and sacrificial protection.

(i) State the term used for coating steel with zinc.

..... [1]

(ii) Describe another barrier method for preventing rusting.

..... [1]

(iii) Explain how zinc provides sacrificial protection.

.....

..... [2]

[Total: 17]

4 This question is about lead(II) chloride, $PbCl_2$.

(a) A student prepares a sample of insoluble lead(II) chloride, $PbCl_2$, by mixing aqueous solutions of **two** salts in a beaker.

(i) Identify **two** soluble salts suitable for making lead(II) chloride when mixed together.

.....

..... [2]

(ii) Write the ionic equation for the formation of lead(II) chloride by mixing aqueous solutions.

Include state symbols.

..... [3]

(iii) List the steps the student should take in preparing a pure sample of lead(II) chloride from the mixture in the beaker.

.....

.....

..... [3]

(b) The student carries out an electrolysis experiment on molten lead(II) chloride using the apparatus shown in Fig. 4.1. Chlorine gas forms at the anode and escapes from the apparatus.

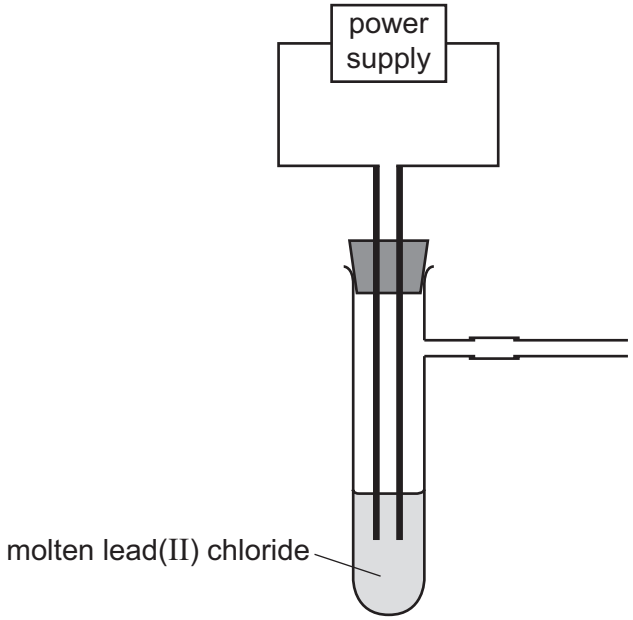

Fig. 4.1

(i) Explain why lead(II) chloride needs to be molten before it will conduct electricity.

.....

..... [1]

(ii) Write the ionic half-equation for the reaction occurring at the anode.

..... [2]

(iii) State the test for chlorine gas.

test .....

observations .....
[2]

(iv) Describe what is observed at the cathode.

..... [1]

[Total: 14]

5 Chemical reactions can involve transfer of thermal energy.

(a) State the term used for the transfer of thermal energy during a reaction.

..... [1]

(b) Tetrachloromethane gas, $CCl_4(g)$, reacts with steam as shown.

$$CCl_4(g) + 2H_2O(g) \rightleftharpoons CO_2(g) + 4HCl(g)$$

The reaction is reversible. The forward reaction is exothermic.

(i) State what happens, if anything, to the rate of the forward reaction if the concentration of CCl_4 is increased.
Explain your answer in terms of collision theory.

.....

.....

.....

..... [3]

(ii) State what happens to the position of equilibrium, if anything, when the pressure is increased.
Explain your answer.

.....

..... [2]

[Turn over

(iii) Fig. 5.1 shows an incomplete reaction pathway diagram for the forward reaction.

$$CCl_4(g) + 2H_2O(g) \rightleftharpoons CO_2(g) + 4HCl(g)$$

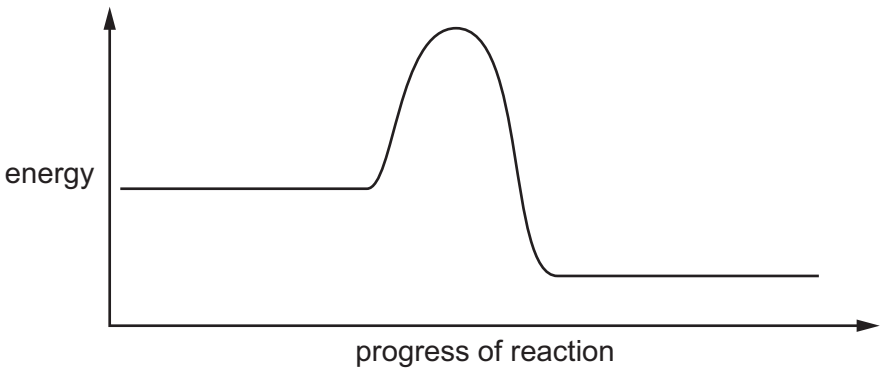

Fig. 5.1

On Fig. 5.1:

- insert the formulae of the reactants and products
- draw an arrow, labelled E_a, to show the activation energy
- draw an arrow, labelled ΔH, to show the transfer of energy in the reaction.

[3]

(iv) Define the term activation energy.

.....

..... [2]

(v) State **one** way in which the activation energy of a reaction can be changed.

..... [1]

(c) The equation for the reaction between tetrachloromethane gas and steam can be represented as shown in Fig. 5.2.

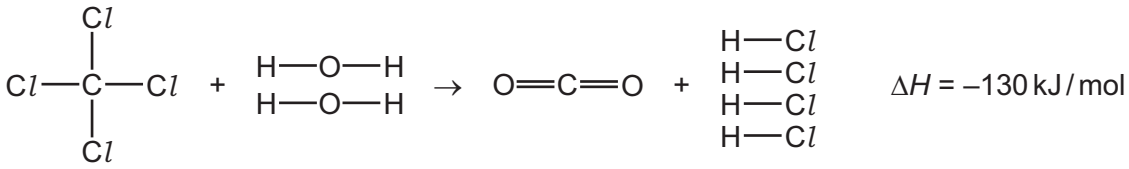

Fig. 5.2

Table 5.1 shows some bond energies.

Table 5.1

bond	C–C*l*	H–O	C=O
bond energy in kJ / mol	340	460	805

Use the bond energies in Table 5.1 and the ΔH value for the reaction to calculate the H–C*l* bond energy using the following steps.

- Calculate the energy needed to break the bonds in the reactants.

..... kJ

- Calculate the energy released when the bonds in carbon dioxide form.

..... kJ

- Calculate the H–C*l* bond energy.

..... kJ / mol
[4]

[Total: 16]

6 A homologous series is a family of organic compounds whose members have similar chemical properties.

(a) Give **two** characteristics that are the **same** for all members of a homologous series.

1 .....

2 .....
[2]

(b) In terms of structure, state how one member of a homologous series differs from the next member of that homologous series.

..... [1]

(c) **A**, **B** and **C** are organic compounds.

A has the molecular formula $C_{12}H_{24}$.

B has the name tetradecane.

C has three carbon atoms and is in the homologous series with the general formula $C_nH_{2n+1}COOH$.

(i) Name the homologous series each organic compound belongs to.

A .....

B .....

C .....
[3]

(ii) Name **C** and draw its displayed formula.

name .....

displayed formula

[2]

(d) Amino acids are a homologous series where each member has the general structure shown in Fig. 6.1.

The R side chain contains carbon and hydrogen atoms only.

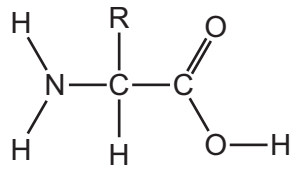

Fig. 6.1

(i) An amino acid has a relative molecular mass of 103.

Deduce the formula of the R side chain in this amino acid.

Show your working.

..... [2]

(ii) State the name given to the natural polyamides formed from amino acid monomers.

..... [1]

[Total: 11]

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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.).