



# Cambridge IGCSE™

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**CHEMISTRY**

**0620/42**

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
<b>A</b>	2,5
<b>B</b>	2,8
<b>C</b>	2,8,2
<b>D</b>	2,8,4
<b>E</b>	2,8,5
<b>F</b>	2,8,6
<b>G</b>	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]

## 3

2 Cobalt and copper are transition elements.

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

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

Table 2.1

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

[3]

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

Table 2.2

isotope	$^{63}\text{Cu}$	$^{65}\text{Cu}$
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]

4

(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]

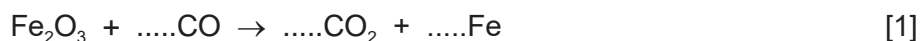
(b) The source of iron in the blast furnace is  $\text{Fe}_2\text{O}_3$ .  $\text{Fe}_2\text{O}_3$  is found in iron ore.

(i) Name the main ore of iron which contains  $\text{Fe}_2\text{O}_3$ .

..... [1]

(ii) The iron in  $\text{Fe}_2\text{O}_3$  is reduced by reaction with carbon monoxide. The unbalanced symbol equation is shown.

Complete the equation.



(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]

**(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,  $\text{PbCl}_2$ .

(a) A student prepares a sample of insoluble lead(II) chloride,  $\text{PbCl}_2$ , 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.

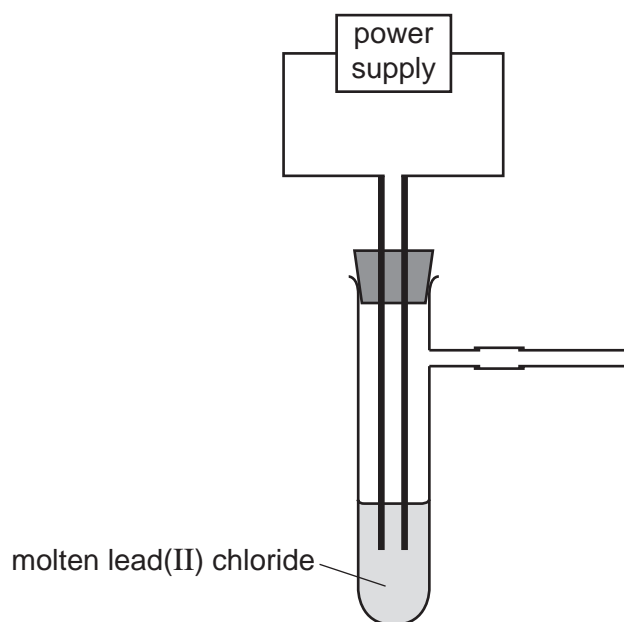


Fig. 4.1

- (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]

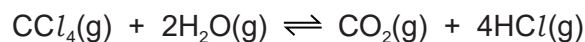


5 Chemical reactions can involve transfer of thermal energy.

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

..... [1]

(b) Tetrachloromethane gas,  $\text{CCl}_4(\text{g})$ , reacts with steam as shown.



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  $\text{CCl}_4$  is increased.

Explain your answer in terms of collision theory.

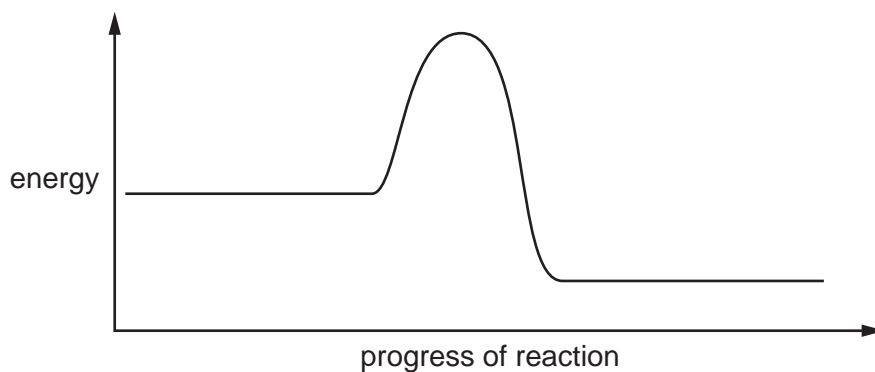
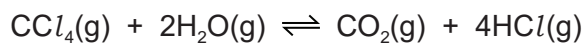
.....  
.....  
.....  
..... [3]

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

Explain your answer.

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

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



**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  $\Delta H$ , 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.

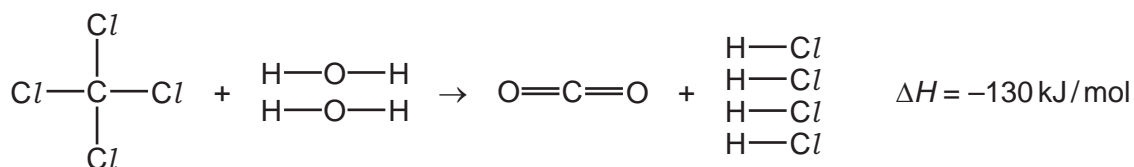


Fig. 5.2

Table 5.1 shows some bond energies.

Table 5.1

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

Use the bond energies in Table 5.1 and the  $\Delta H$  value for the reaction to calculate the H–Cl 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–Cl 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.

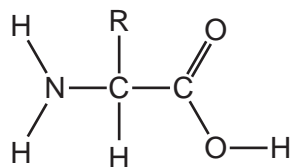


Fig. 6.1

- (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	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	Al aluminium 13	Si silicon 28	P phosphorus 31	S sulfur 32	Cl chlorine 35.5	Ar argon 40	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	Cu copper 64	Zn zinc 65	Ga gallium 70	Ge germanium 73	As arsenic 75	Se selenium 79	Br bromine 80	Kr krypton 84	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	Ag silver 108	Cd cadmium 112	In indium 115	Sn tin 119	Sb antimony 122	Te tellurium 128	I iodine 127	Xe xenon 131	Cs caesium 133	Ba barium 137	La lanthanoids 57–71	Hf hafnium 178	Ta tantalum 181	W tungsten 184	Re rhenium 186	Os osmium 190	Ir iridium 192	Pt platinum 195	Au gold 197	Hg mercury 201	Tl thallium 204	Pb lead 207	Bi bismuth 209	Po polonium —	At astatine —	Rn radon —	Fr francium —	Ra radium —	Ac actinoids 89–103	Rf rutherfordium —	Db dubnium —	Sg seaborgium —	Bh bohrium —	Hs hassium —	Mt meitnerium —	Ds darmstadtium —	Rg roentgenium —	Cn copernicium —	Nh nihonium —	Ni nickelium —	Fl flerovium —	Mc moscovium —	Lv livermorium —	Ts tennessine —	Og oganeson —

## 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<sup>3</sup> at room temperature and pressure (r.t.p.).