



# Cambridge IGCSE™

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## CHEMISTRY

0620/41

Paper 4 Theory (Extended)

May/June 2023

1 hour 15 minutes

You must answer on the question paper.

No additional materials are needed.

### INSTRUCTIONS

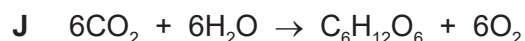
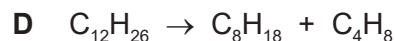
- Answer **all** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen or correction 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 Some symbol equations and word equations, **A** to **J**, are shown.



Use the equations to answer the questions that follow.

Each equation may be used once, more than once, or not at all.

Give the letter, **A** to **J**, for the equation that represents:

(a) a neutralisation reaction ..... [1]

(b) a precipitation reaction ..... [1]

(c) the formation of an ester ..... [1]

(d) photosynthesis ..... [1]

(e) fermentation ..... [1]

(f) cracking. .... [1]

[Total: 6]

2 (a) The symbols of the elements in Period 2 of the Periodic Table are shown.

**Li   Be   B   C   N   O   F   Ne**

Use the symbols of the elements in Period 2 to answer the questions that follow.  
Each symbol may be used once, more than once or not at all.

Give the symbol of the element that:

- (i) makes up approximately 78% of clean, dry air ..... [1]
- (ii) contains atoms with only three electrons in the outer shell ..... [1]
- (iii) contains atoms with only nine protons ..... [1]
- (iv) exists as graphite ..... [1]
- (v) is an alkali metal ..... [1]
- (vi) **only** has an oxidation number of zero. .... [1]

(b) Boron, B, has two isotopes.

- (i) State the meaning of the term isotopes.

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

- (ii) Table 2.1 shows the relative masses and the percentage abundances of the two isotopes of boron.

**Table 2.1**

relative mass of isotope	percentage abundance of isotope
10	20
11	80

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

relative atomic mass = ..... [2]

[Total: 10]

3 This question is about ionic and covalent compounds.

- (a) (i) Sodium reacts with oxygen to form the ionic compound sodium oxide.  
The electronic configurations of an atom of sodium and an atom of oxygen are shown in Fig. 3.1.



Fig. 3.1

Ions are formed by the transfer of electrons from sodium atoms to oxygen atoms.

Complete the dot-and-cross diagrams in Fig. 3.2 to show the electronic configuration of **one** sodium ion and **one** oxide ion. Show the charges on the ions.

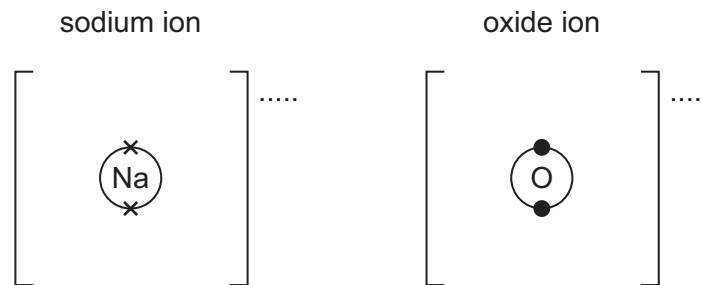


Fig. 3.2

[3]

- (ii) Write the formula of sodium oxide.

..... [1]

(b) Carbon dioxide,  $\text{CO}_2$ , is a covalent compound.

Complete the dot-and-cross diagram in Fig. 3.3 to show the electronic configuration in a molecule of carbon dioxide. Show outer shell electrons only.

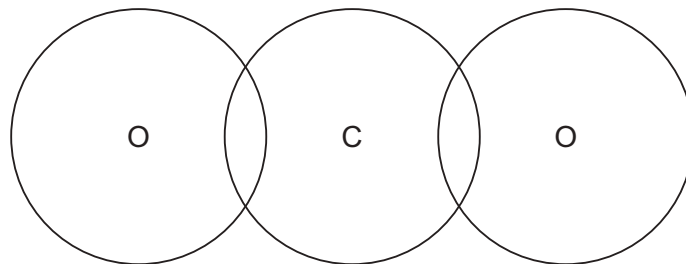


Fig. 3.3

[2]

(c) The melting points of sodium oxide and carbon dioxide are shown in Table 3.1.

**Table 3.1**

	melting point/°C
sodium oxide	1275
carbon dioxide	-78

(i) Explain, in terms of bonding, why sodium oxide has a high melting point.

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

(ii) Carbon dioxide has a low melting point.

State the general term for the weak forces that cause carbon dioxide to have a low melting point.

..... [1]

[Total: 9]

- 4 Oxygen is produced by the decomposition of aqueous hydrogen peroxide. Manganese(IV) oxide,  $\text{MnO}_2$ , is a catalyst for this reaction.

(a) State the meaning of the term catalyst.

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

- (b) A student adds powdered manganese(IV) oxide to aqueous hydrogen peroxide in a conical flask as shown in Fig. 4.1. The mass of the conical flask and its contents is measured at regular time intervals. The mass decreases as time increases.

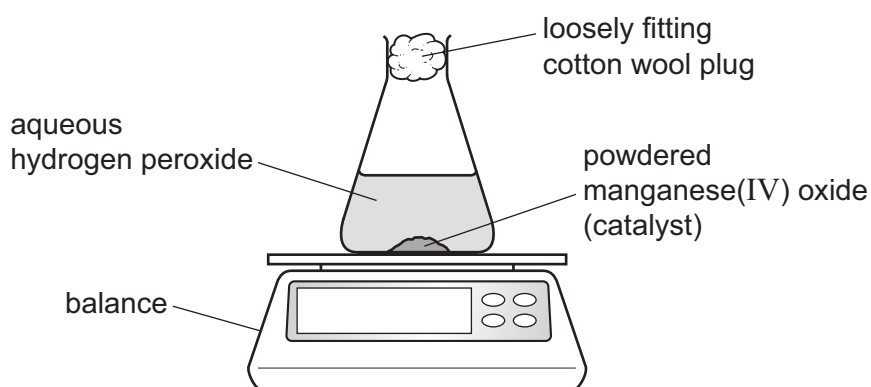


Fig. 4.1

- (i) State why the mass of the conical flask and its contents decreases as time increases.

..... [1]

- (ii) The rate of reaction is highest at the start of the reaction. The rate decreases and eventually becomes zero.

Explain why the rate of reaction is highest at the start of the reaction.

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

- (iii) Explain why the rate of reaction eventually becomes zero.

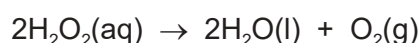
.....  
 ..... [1]

- (c) The experiment is repeated at an increased temperature.  
All other conditions stay the same.

Explain in terms of collision theory why the rate of reaction is higher at an increased temperature.

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

- (d) The equation for the decomposition of aqueous hydrogen peroxide,  $\text{H}_2\text{O}_2(\text{aq})$ , is shown.



50.0 cm<sup>3</sup> of a 0.200 mol/dm<sup>3</sup> solution of  $\text{H}_2\text{O}_2(\text{aq})$  is used.

Calculate the mass of  $\text{O}_2$  that forms.  
Use the following steps.

- Calculate the number of moles of  $\text{H}_2\text{O}_2$  used.

..... mol

- Determine the number of moles of  $\text{O}_2$  produced.

..... mol

- Calculate the mass of  $\text{O}_2$  produced.

..... g  
[3]

- (e) State the effect on the mass of oxygen produced if the mass of powdered manganese(IV) oxide catalyst is increased.

..... [1]

- (f) Oxygen can also be produced by the decomposition of mercury(II) oxide,  $\text{HgO}$ .  
The only products of this decomposition are mercury and oxygen.

Write a symbol equation for this decomposition.

..... [2]

[Total: 14]

5 This question is about electricity and chemical reactions.

- (a) The electrolysis of concentrated aqueous potassium bromide using graphite electrodes forms:
- hydrogen at the cathode
  - bromine at the anode.

The electrolyte becomes aqueous potassium hydroxide.

- (i) State what is meant by the term electrolysis.

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

- (ii) State why graphite is suitable for use as an electrode.

..... [1]

- (iii) Write an ionic half-equation for the formation of hydrogen at the cathode.

..... [2]

- (iv) Name the type of particle responsible for the transfer of charge in the conducting wires.

..... [1]

- (v) Name the type of particle responsible for the transfer of charge in aqueous potassium bromide.

..... [1]

- (vi) State the names of the products formed when electricity is passed through **dilute** aqueous potassium bromide using graphite electrodes.

at the anode .....

at the cathode .....

[2]

- (b) Bauxite is an ore containing aluminium.

Aluminium is extracted by electrolysis of purified bauxite in molten cryolite using carbon electrodes.

- (i) Name the aluminium compound in purified bauxite.

..... [1]

- (ii) State **two** reasons why cryolite is used in this electrolysis.

1 .....

2 .....

[2]



- (iii) The anode is made from carbon.

Explain why the carbon anode has to be replaced regularly.

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

- (c) Hydrogen–oxygen fuel cells can be used to produce electricity in vehicles.

- (i) Write the symbol equation for the overall reaction in a hydrogen–oxygen fuel cell.

..... [2]

- (ii) State **one** advantage of using hydrogen–oxygen fuel cells instead of petrol in vehicle engines.

..... [1]

[Total: 16]

- 6 This question is about sulfur and compounds of sulfur.

Sulfur is converted into sulfuric acid,  $\text{H}_2\text{SO}_4$ , by the Contact process.

The process involves four stages.

**stage 1** Molten sulfur is converted into sulfur dioxide.

**stage 2** Sulfur dioxide reacts with oxygen to form sulfur trioxide.

**stage 3** Sulfur trioxide combines with concentrated sulfuric acid to form oleum,  $\text{H}_2\text{S}_2\text{O}_7$ .

**stage 4** Oleum reacts to form concentrated sulfuric acid.

- (a) (i) In **stage 1**, iron pyrites,  $\text{FeS}_2$ , can be used instead of molten sulfur.  
The iron pyrites is heated strongly in air.

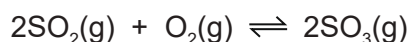
Balance the equation for the reaction occurring when iron pyrites reacts with oxygen in the air.



- (ii) Name  $\text{Fe}_2\text{O}_3$ . Include the oxidation number of iron.

..... [1]

- (b) The equation for **stage 2** is shown.



The forward reaction is exothermic.

The reaction is carried out at a temperature of  $450^\circ\text{C}$  and a pressure of 2 atm.

Using explanations that do **not** involve cost:

- (i) explain why a temperature greater than  $450^\circ\text{C}$  is **not** used

..... [1]

- (ii) explain why a pressure lower than 2 atm is **not** used.

..... [1]

- (c) When sulfuric acid reacts with ammonia the salt produced is ammonium sulfate.

Write the symbol equation for this reaction.

..... [2]

(d) Lead(II) sulfate is an insoluble salt.

Lead(II) sulfate can be made from aqueous ammonium sulfate using a precipitation reaction.

(i) Name a solution that can be added to aqueous ammonium sulfate to produce a precipitate of lead(II) sulfate.

..... [1]

(ii) Write an ionic equation for this precipitation reaction. Include state symbols.

..... [3]

(iii) The precipitate of lead(II) sulfate forms in an aqueous solution.

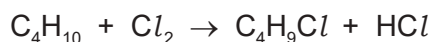
Describe how pure lead(II) sulfate can be obtained from the mixture.

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

[Total: 13]

7 This question is about organic compounds.

(a) Butane reacts with chlorine in a photochemical reaction.



(i) State the meaning of the term photochemical.

..... [1]

(ii) An organic compound with the formula  $\text{C}_4\text{H}_9\text{Cl}$  is formed when one molecule of butane reacts with one molecule of chlorine.

Draw the displayed formulae of **two** possible structural isomers with the formula  $\text{C}_4\text{H}_9\text{Cl}$  formed in this reaction.

[2]

(b) The structure of compound **A** is shown in Fig. 7.1.

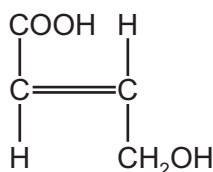


Fig. 7.1

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

..... [1]

(ii) There are three functional groups in compound **A**.

Name the homologous series of compounds that contain the following functional groups:

$-\text{C}=\text{C}-$  .....

$-\text{OH}$  .....

$-\text{COOH}$ . .....

[3]

(iii) State what is observed when compound **A** is added to:

aqueous bromine .....

aqueous sodium carbonate. ....

[2]

(iv) Compound **A** can be used as a single monomer to produce two different polymers.

Draw **one** repeat unit of the addition polymer formed from compound **A**.

[2]

(v) Compound **A** can be converted into a dicarboxylic acid.

Name the type of condensation polymer formed from a dicarboxylic acid and a diol.

..... [1]

[Total: 12]



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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	11	12	13	14	15	16	17	18																		
Li lithium 7	Be beryllium 9	B boron 11	C carbon 12	Al aluminium 13	Si silicon 14	P phosphorus 15	S sulfur 16	Cl chlorine 17	Ar argon 18	K potassium 19	Ca calcium 20	Sc scandium 21	Ti titanium 22	V vanadium 23	Cr chromium 24	Mn manganese 25	Fe iron 26	Co cobalt 27	Ni nickel 28	Cu copper 29	Zn zinc 30	Ga gallium 31	Ge germanium 32	As arsenic 33	Se selenium 34	Br bromine 35	Kr krypton 36								
37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57-71 lanthanoids	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86
Rb rubidium 85	Sr strontium 88	Y yttrium 89	Zr zirconium 90	Nb niobium 91	Mo molybdenum 92	Tc technetium 93	Ru ruthenium 94	Rh rhodium 95	Pd palladium 96	Ag silver 97	Cd cadmium 98	In indium 99	Sn tin 100	Sb antimony 101	Te tellurium 102	I iodine 103	Xe xenon 104	Cs caesium 133	Ba barium 137	La lanthanum 139	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 210	At astatine 210	Rn radon 222
87	88	89-103 actinoids	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	Fr francium 87	Ra radium 88	Ac actinium 89	Rf rutherfordium 104	Db dubnium 105	Sg seaborgium 106	Bh bohrium 107	Hs hassium 108	Mt meitnerium 109	Ds darmstadtium 110	Rg roentgenium 111	Cn copernicium 112	Nh nihonium 113	Fl flerovium 114	Mc moscovium 115	Lv livermorium 116	Ts tennessine 117	Og oganesson 118

1  
H  
hydrogen  
1

**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.).