



CANDIDATE
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0620/41

May/June 2023

1 hour 15 minutes

No additional materials are needed.

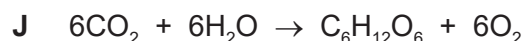
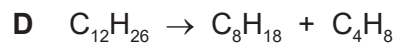
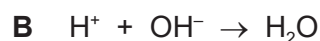
- Answer **all** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen or correction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

- 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.

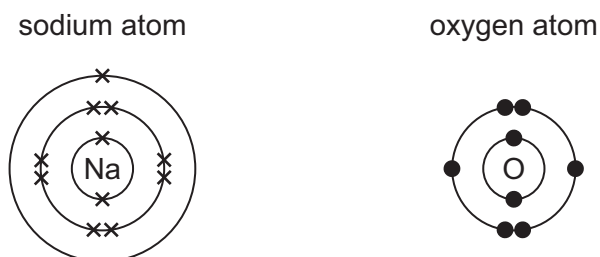


Fig. 3.1

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.

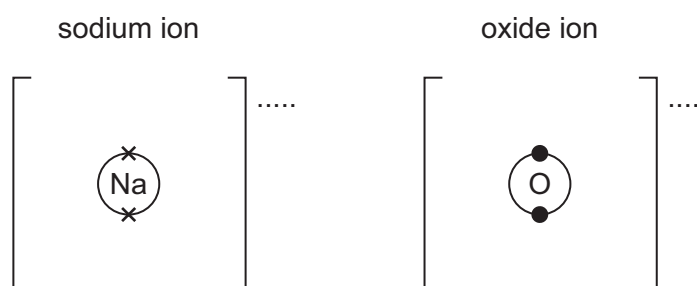


Fig. 3.2

[3]

- (ii) Write the formula of sodium oxide.

..... [1]

- (b) Carbon dioxide, 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.

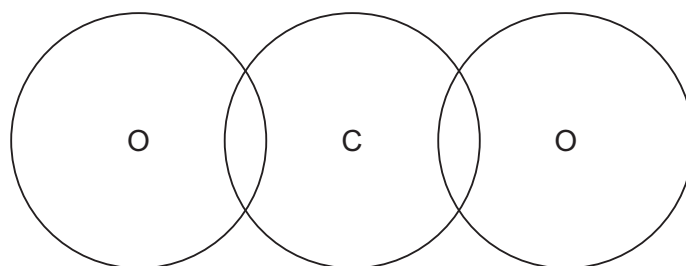


Fig. 3.3

[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, 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.

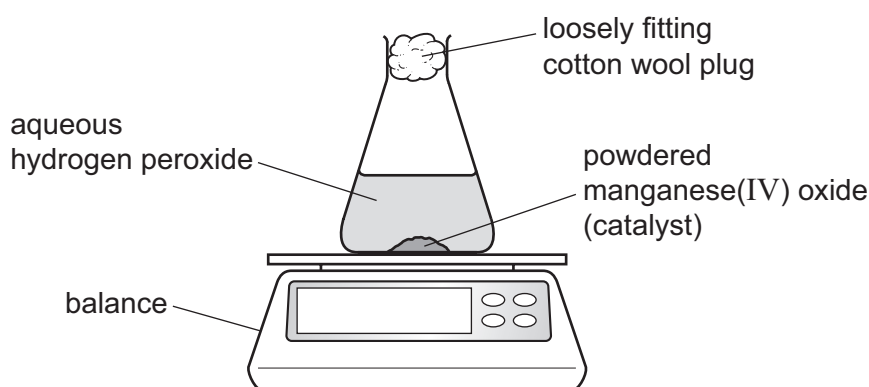


Fig. 4.1

- (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.

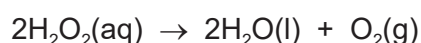
.....

.....

.....

..... [3]

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



50.0 cm³ of a 0.200 mol/dm³ solution of $\text{H}_2\text{O}_2(\text{aq})$ is used.

Calculate the mass of O_2 that forms.
Use the following steps.

- Calculate the number of moles of H_2O_2 used.

..... mol

- Determine the number of moles of O_2 produced.

..... mol

- Calculate the mass of 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, 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, H_2SO_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, FeS_2 , can be used instead of molten sulfur.
The iron pyrites is heated strongly in air.

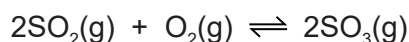
Balance the equation for the reaction occurring when iron pyrites reacts with oxygen in the air.



- (ii) Name Fe_2O_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°C and a pressure of 2 atm.

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

- (i) explain why a temperature greater than 450°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.

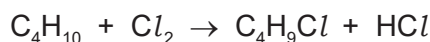
Describe how pure lead(II) sulfate can be obtained from the mixture.

.....
.....
..... [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.

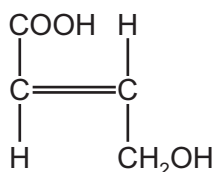


Fig. 7.1

(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 H hydrogen 1																																	
		2 He helium 4																																	
3	Li lithium 7	4	Be beryllium 9	atomic number atomic symbol name relative atomic mass										5	6	7	8	9	10																
11	Na sodium 23	12	Mg magnesium 24											13	14	15	16	17	18																
														Al aluminium 27	Si silicon 28	P phosphorus 31	S sulfur 32	Cl chlorine 35.5	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 —