

# **Cambridge IGCSE**<sup>™</sup>

CANDIDATE NAME				
CENTRE NUMBER		CANDIDATE NUMBER		

CHEMISTRY 0620/33

Paper 3 Theory (Core)

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.

1 A list of substances is shown.

ammonia
calcium oxide
carbon monoxide
cobalt(II) chloride
ethane
ethanol
ethene
oxygen
potassium oxide
sodium sulfate
sulfuric acid
water

Answer the following questions using only the substances from the list. Each substance may be used once, more than once or not at all.

Give the name of the substance that:

(a)	is a product of photosynthesis	[1]
(b)	is a member of the alkene homologous series	[1]
(c)	has an ion with a charge of 1–	[1]
(d)	is used to remove sulfur dioxide in flue gas desulfurisation	[1]
(e)	is the product formed in a hydrogen–oxygen fuel cell	[1]
(f)	is used to test for water.	[1]

[Total: 6]

_	Пус	diocarbons are compounds of carbon and flydrogen.	
	(a)	State the meaning of the term compound.	
			[4]

**(b)** Fig. 2.1 shows a fractionating column for separating petroleum into different hydrocarbon fractions.

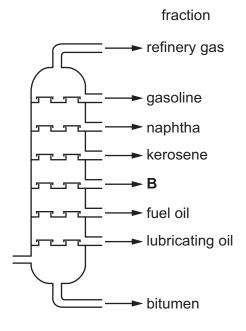


Fig. 2.1

- (i) On Fig. 2.1, draw an **X** inside the column to show where the hydrocarbon with the highest boiling point collects. [1]
- (ii) Name the fraction labelled **B** in Fig. 2.1.

FA'	٦.
11	
L'	J

(iii) State the name of the fraction which has hydrocarbons with the shortest chain length.

.....[1]

(iv) State one use of the naphtha fraction.

.....[1]

[Total: 6]

**3** (a) Table 3.1 shows the average concentrations, in ng/1000 cm³, of air pollutants in four different years.

Table 3.1

	concentration of air pollutant in ng/1000 cm³						
year	carbon monoxide	hydrocarbons	oxides of nitrogen	particulates	sulfur dioxide		
2019	5.3	22.0	15.6	19.0	20.0		
2020	4.1	13.5	14.8	20.1	18.2		
2021	5.8	14.8	22.7	23.5	16.2		
2022	2.6	18.0	10.9	26.2	14.0		

(i)	Name the pollutant which has the highest concentration in 2019.
	[1]
(ii)	Name the pollutant that shows a continuous decrease in concentration from 2019 to 2022.
	[1]
(iii)	Calculate the average mass, in ng, of hydrocarbons in a 200 cm³ sample of polluted air in 2019.
	mass = ng [1]
(b) (i)	State <b>one</b> source of oxides of nitrogen in the air.
	[1]
(ii)	Oxides of nitrogen contribute to acid rain.
	Give one <b>other</b> effect of oxides of nitrogen in the air.
	[1]
(iii)	Unpolluted water has a neutral pH.
	Choose from the list the pH value of a neutral substance.
	Draw a circle around your chosen answer.
	pH1 pH6 pH7 pH14 [1]

(c)	Nitrogen dioxide is an acidic o	xide.		
	Choose an oxide from the list	which is also an ac	dic oxide.	
	Tick (✓) one box.			
	со	pper(II) oxide		
	ma	agnesium oxide		
	ph	osphorus(V) oxide		
	so	dium oxide		[1]
(d)	Sulfur dioxide reacts with oxyg	gen to produce sulfu	ır trioxide.	
	(i) Complete the symbol equ	ation for this reaction	on.	
		SO₂ + <del>=</del>	• 2SO <sub>3</sub>	[2]
	(ii) State the meaning of the	symbol <del>←</del> .		
				[1]
(	(iii) Sulfur trioxide reacts with	calcium oxide to pr	oduce calcium sulfate.	
	Describe a test for sulfate	ions.		
	test			
	observations			
				[2]
				[Total: 12]

	1							
	2							
)	Fig. 4.1 show	s the physic	cal states o	of nitrogen.				
	[	P. I			Α	.,	7	
		solid nitrogen	•	liquid nitrogen	<b>4</b>	nitrogen gas		
	l				J B			
				Fig. 4.1				
	Name the ch	anges of ph	ysical state	es <b>A</b> and <b>B</b> .				
			•					
	Α							
	A B							
:)	В						and separation o	 of
:)	B  Describe soli	id nitrogen a						of
	B  Describe soli particles.	id nitrogen a	and nitroge	en gas in tern	ns of the	arrangement	and separation o	 of
	Describe soli particles.	id nitrogen a	and nitroge	en gas in tern	ns of the	arrangement	and separation o	
	Describe soli particles. solid nitroger arrangement	id nitrogen a	and nitroge	en gas in tern	ns of the	arrangement	and separation o	
	Describe soli particles. solid nitroger arrangement	id nitrogen a	and nitroge	en gas in tern	ns of the	arrangement	and separation o	
	Describe soli particles. solid nitroger arrangement separation	id nitrogen a	and nitroge	en gas in tern	ns of the	arrangement	and separation o	
	Describe soli particles. solid nitroger arrangement separation nitrogen gas	id nitrogen a	and nitroge	en gas in tern	ns of the	arrangement	and separation o	
	Describe soli particles. solid nitroger arrangement separation nitrogen gas	id nitrogen a	and nitroge	en gas in tern	ns of the	arrangement	and separation o	
	Describe soli particles. solid nitroger arrangement separation nitrogen gas arrangement	id nitrogen a	and nitroge	en gas in tern	ns of the	arrangement	and separation o	

(d) A sealed gas syringe contains  $80\,\mathrm{cm^3}$  of nitrogen gas.

reasing the pressure affects the volume of nitrogen gas in the gas syringe when are remains constant.	
[1]	
[Total: 9]	

- **5** This question is about metals.
  - (a) Table 5.1 shows some properties of the Group I metals.

Table 5.1

metal	melting point in °C	boiling point in °C	atomic volume in cm³/mol	observations on reaction with water
lithium	181	1342	12.9	bubbles form slowly but no flame
sodium	98	883	23.7	
potassium	63	760		bubbles form very rapidly and flame seen
rubidium		686	55.8	explodes

Use the information in Table 5.1 to predict:

(i)	the melting point of rubidium	[1]
(ii)	the atomic volume of potassium	[1]
(iii)	the observations when sodium reacts with water	
		[1]
(iv)	the physical state of sodium at 1300 °C. Give a reason for your answer.	
	physical state	
	reason	
		[2]

(b)	Iron	is extracted in a blast furnace by reduction of iron(III) oxide.	
	(i)	In the first step, carbon burns in air to form carbon dioxide.	
		State the percentage of oxygen in clean, dry air.	
			[1]
	(ii)	In the second step, carbon monoxide is produced by the reaction of carbon dioxide v carbon.	vith
		$CO_2 + C \rightarrow 2CO$	
		Choose the correct statement about this reaction.	
		Tick (✓) one box.	
		the carbon dioxide is oxidised and the carbon is reduced	
		both carbon dioxide and carbon are oxidised	
		the carbon dioxide is reduced and the carbon is oxidised	
		both carbon dioxide and carbon are reduced	[4]
(	(iii)	In the third step, iron(III) oxide is reduced by carbon monoxide. The reaction is exothermic.	[1]
		State the meaning of the term exothermic.	
			[2]
(c)		cium carbonate is added to the blast furnace. calcium carbonate breaks down as shown.	
		high temperature calcium carbonate ────────────────────────────────────	
	(i)	Name the type of chemical reaction that takes place.	
			[1]
	(ii)	Complete this sentence about the calcium oxide that is produced in the blast furnace.	
		Calcium oxide reacts with impurities in the iron ore to form	[1]

(d) Table 5.2 gives the observations when four different metals react with air.

Table 5.2

metal	observations
cerium	forms an oxide layer slowly without heating
copper	forms an oxide layer only when heated
gold	does not form an oxide layer even when heated
rubidium	forms an oxide layer quickly without heating

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

least reactive —		-	most reactive

[2]

[Total: 13]

**6** Hydrogen peroxide, H<sub>2</sub>O<sub>2</sub>, breaks down slowly at 40 °C to produce oxygen gas and water.

$$2H_2O_2 \rightarrow 2H_2O + O_2$$

A student investigates the breakdown of hydrogen peroxide at 40 °C in the presence of a catalyst.

(a) Fig. 6.1 shows the volume of oxygen gas released as the reaction proceeds.

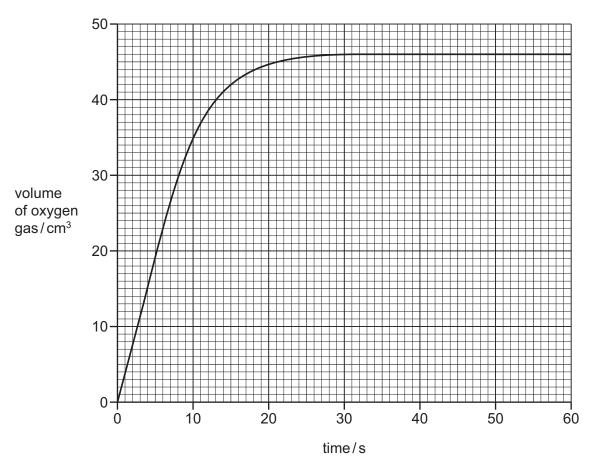


Fig. 6.1

(i) Deduce the volume of oxygen gas released after 15 seconds.

(ii) The student repeats the experiment at 20 °C.

All other conditions stay the same.

Draw a line on the grid in Fig. 6.1 to show how the volume of oxygen changes when a temperature of 20 °C is used. [2]

(b) (i)	The stud	dent repeats the	expe	eriment without a	catalys	st.								
	All other	r conditions stay	the s	same.										
	Describ	e how the rate o	of reac	ction differs when	no ca	talyst is used.								
		[1]												
(ii)	The stud	dent repeats the	expe	eriment using a lov	wer co	oncentration of hyd	drogen peroxide.							
	All other	r conditions stay	the s	same.										
	Describe is used.	e how the rate o	f reac	tion differs when a	a lowe	r concentration of	hydrogen peroxide							
							[1]							
					the pro	esence of an alkal	i.							
(i)	State th	e meaning of the	e tern	n alkali.										
							[1]							
(ii)	Give the	e formula of the	ion th	at is present in all	alkali	ne solutions.								
		[1]												
(iii)	State th	e colour of meth	nyl ora	ange in an alkaline	e solut	tion.								
	[1]													
(iv)	Aqueous ammonia is an alkali.													
	Complete the word equation for the reaction of aqueous ammonia with hydrochloric acid.													
		ammonia	+	hydrochloric acid	$\rightarrow$									
							[1]							
							[Total: 9]							

7	Ethanoic aci	d and	methacry	ylic acid	are both	carbox	ylic acids.

(a) Complete the word equation for the reaction of ethanoic acid with calcium.

	ethanoic acid	+	calcium	$\rightarrow$		+		
--	------------------	---	---------	---------------	--	---	--	--

(b) Ethanoic acid can be reduced to ethanol.

(')	Name the nomologous series that includes ethanol.

(ii) Ethanol can be manufactured by fermentation.

Describe **two** conditions needed for fermentation.

Name the homologous series that includes ethanol

(c) Fig. 7.1 shows the displayed formula of methacrylic acid.

Fig. 7.1

(i) On Fig. 7.1, draw a circle around the functional group which reacts with aqueous bromine. [1]

[2]

[2]

(ii) State the colour of aqueous bromine.

[1]
-----

(iii) Deduce the molecular formula of methacrylic acid.

(d) Methacrylic acid can be converted to methyl methacrylate. The molecular formula of methyl methacrylate is  $C_5H_8O_2$ .

Complete Table 7.1 to calculate the relative molecular mass of methyl methacrylate.

Table 7.1

atom	number of atoms	relative atomic mass	
carbon	5	12	5 × 12 = 60
hydrogen		1	
oxygen		16	

	relative molecular mass =[2]
(e)	Methyl methacrylate can be polymerised to produce a plastic.
	Describe <b>two</b> environmental problems caused by plastics.
	1
	2
	[2]

**(f)** Poly(ethene) is a polymer.

Draw the displayed formula of the monomer used to make poly(ethene).

[1]

[Total: 13]

- 8 Potassium chloride is an ionic compound.
  - (a) Complete Fig. 8.1 to show:
    - the electronic configuration of a potassium ion
    - the charge on the ion.

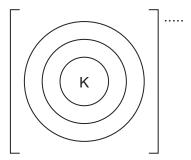


Fig. 8.1

[2]

**(b)** Deduce the number of protons and neutrons in the chloride ion shown.

<sup>37</sup>C*l*−

number of protons	
number of neutrons	
	[2]

- (c) Molten potassium chloride is electrolysed using graphite electrodes.
  - (i) Define the term electrolysis.

......[2]

(ii) State the names of the products at each electrode and give the observations at the positive electrode.

observations at the positive electrode

[3]

	10	
(d)	Graphite electrodes are inert.	
	Name one <b>other</b> inert electrode.	
		[1]
(e)	Graphite and diamond are two forms of carbon.	
	Fig. 8.2 shows the structure of diamond.	
	Fig. 8.2	
	(i) Name the type of bonding in diamond.	
		[1]
	(ii) Use Fig. 8.2 to explain why diamond is used in cutting tools.	

......[1]

[Total: 12]

## **BLANK PAGE**

## **BLANK PAGE**

### **BLANK PAGE**

Permission to reproduce items where third-party owned material protected by copyright is included has been sought and cleared where possible. Every reasonable effort has been made by the publisher (UCLES) to trace copyright holders, but if any items requiring clearance have unwittingly been included, the publisher will be pleased to make amends at the earliest possible opportunity.

To avoid the issue of disclosure of answer-related information to candidates, all copyright acknowledgements are reproduced online in the Cambridge Assessment International Education Copyright Acknowledgements Booklet. This is produced for each series of examinations and is freely available to download at www.cambridgeinternational.org after the live examination series.

Cambridge Assessment International Education is part of Cambridge Assessment. Cambridge Assessment is the brand name of the University of Cambridge Local Examinations Syndicate (UCLES), which is a department of the University of Cambridge.

The Periodic Table of Elements

₹	F 2	helium 4	10	Ne	neon 20	18	Ar	argon 40	36	궃	krypton 84	54	Xe	xenon 131	98	R	radon	118	Og	oganesson -
₹			6	ш	fluorine 19	17	Cl	chlorine 35.5	35	Ŗ	bromine 80	53	Н	iodine 127	85	¥	astatine -	117	<u>S</u>	tennessine -
>			8	0	oxygen 16	16	ഗ	sulfur 32	34	Se	selenium 79	52	<u>a</u>	tellurium 128	84	Ъ	moloud –	116	_	livermorium –
>			7	z	nitrogen 14	15	₾	phosphorus 31	33	As	arsenic 75	51	Sb	antimony 122	83	<u>B</u>	bismuth 209	115	Mc	moscovium -
≥			9	ပ	carbon 12	14	S	silicon 28	32	Ge	germanium 73	20	Sn	tin 119	82	Pb	lead 207	114	ŀΙ	flerovium -
≡			5	М	boron 11	13	Αl	aluminium 27	31	Ga	gallium 70	49	In	indium 115	81	11	thallium 204	113	R	mihonium –
						•			30	Zu	zinc 65	48	g	cadmium 112	80	Нg	mercury 201	112	ű	copernicium -
									29	Cn	copper 64	47	Ag	silver 108	62	Αn	gold 197	111	Rg	roentgenium -
dnoib									28	z	nickel 59	46	Pd	palladium 106	78	₹	platinum 195	110	Ds	darmstadtium -
5									27	ဝိ	cobalt 59	45	格	rhodium 103	77	'n	iridium 192	109	Ħ	meitnerium -
	- I	hydrogen 1									iron 56		Ru	ruthenium 101	9/	Os	osmium 190	108	Hs	hassium -
									25	Mn	manganese 55	43	ပ	technetium -	75	Re	rhenium 186	107	Bh	bohrium –
				pol	ass						chromium 52		Mo	molybdenum 96	74	≯	tungsten 184	106	Sg	seaborgium -
		Key	atomic number	atomic symbo	name relative atomic mass				23	>	vanadium 51	41	g	niobium 93	73	Б	tantalum 181	105	g O	dubnium -
				ato	rela				22	j	titanium 48	40	Zr	zirconium 91	72	Έ	hafnium 178	104	Ÿ	rutherfordium -
									21	Sc	scandium 45	39	>	yttrium 89	57–71	lanthanoids		89–103	actinoids	
=			4	Be	beryllium 9	12	Mg	magnesium 24	20	Ca	calcium 40	38	ഗ്	strontium 88	56	Ba	barium 137	88	Ra	radium -
_			3	:=	lithium 7	7	Na	sodium 23	19	¥	potassium 39	37	В	rubidium 85	55	S	caesium 133	87	ቷ	francium -

71	Γn	lutetium 175	103	۲	lawrendum -
70	Υp	ytterbium 173	102	8	nobelium
69	Tm	thulium 169	101	Md	mendelevium -
89	ш	erbium 167	100	Fm	fermium -
29	운	holmium 165	66	Es	einsteinium
99	۵	dysprosium 163	86	ŭ	californium -
65	Д	terbium 159	97	BK	berkelium -
64	Gd	gadolinium 157	96	Cm	curium
63	En	europium 152	92	Am	americium -
62	Sm	samarium 150	94	Pn	plutonium
61	Pm	promethium	93	ď	neptunium
09	PN	neodymium 144	92	$\supset$	uranium 238
69	Ą	praseodymium 141	91	Ра	protactinium 231
28	Oe	cerium 140	06	드	thorium 232
22	Гa	lanthanum 139	68	Ac	actinium -

lanthanoids

actinoids

The volume of one mole of any gas is 24 dm<sup>3</sup> at room temperature and pressure (r.t.p.).