Cambridge Assessment International Education

Cambridge IGCSE™

CANDIDATE NAME									
CENTRE NUMBER						CANDIDATE NUMBER				

3901701282

CHEMISTRY **0620/31**

Paper 3 Theory (Core) **October/November 2021**

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 **20** pages. Any blank pages are indicated.

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[Turn over

1 **(a)** A list of formulae is shown.

$AlCl_3$
$CaCO_3$
CO
CO_2
$CoCl_2$
$CuSO_4$
$MgCl_2$
N_2
$NaCl$
NH_3
O_2
SO_2

Answer the following questions using these formulae.
Each formula may be used once, more than once or not at all.

State which formula represents:

(i) a compound that changes colour from white to blue when water is added

..... [1]

(ii) a compound that is used to make cement

..... [1]

(iii) an element that forms 78% of clean, dry air

..... [1]

(iv) a compound that contains an ion with a single positive charge

..... [1]

(v) a compound that dissolves in water to form an alkaline solution.

..... [1]

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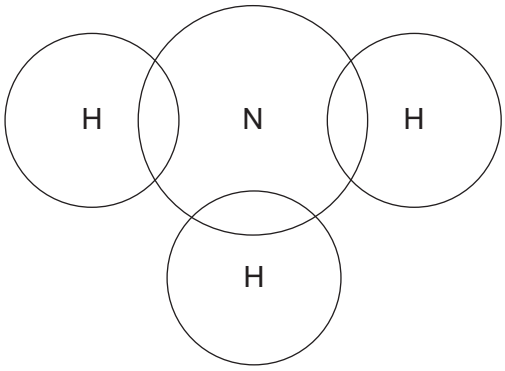
(b) Complete the dot-and-cross diagram to show the electron arrangement in a molecule of ammonia.



[2]

(c) State whether magnesium oxide is a basic oxide or an acidic oxide.
Give a reason for your answer.

.....

..... [1]

[Total: 8]

2 The table shows the masses of some of the ions in 1000 cm^3 of rainwater.

name of ion	formula of ion	mass of ion in 1000 cm^3 of rainwater / mg
	NH_4^+	0.08
calcium	Ca^{2+}	0.13
chloride	Cl^-	1.30
magnesium	Mg^{2+}	0.08
nitrate	NO_3^-	0.70
potassium	K^+	0.08
sodium	Na^+	0.80
	SO_4^{2-}	1.60

(a) Answer these questions using only the information in the table.

(i) State which of the positive ions has the highest concentration.

..... [1]

(ii) Name the compound containing NH_4^+ and SO_4^{2-} ions.

..... [1]

(iii) Calculate the mass of magnesium ions in 400 cm^3 of rainwater.

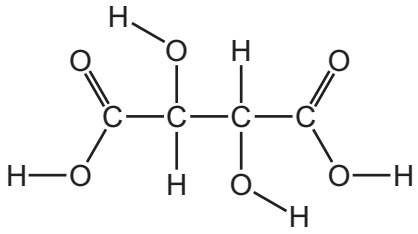
mass = ... mg [1]

(b) Describe a test for chloride ions.

test .....

observations .....
[2]

(c) Small amounts of carboxylic acids are also present in rainwater.
The structure of tartaric acid is shown.



(i) On the structure draw a circle around one alcohol functional group. [1]

(ii) Deduce the formula of tartaric acid to show the number of carbon, hydrogen and oxygen atoms.

..... [1]

(d) Tartaric acid can be converted into compound **A**.
The formula of compound **A** is $C_3H_4O_3$.

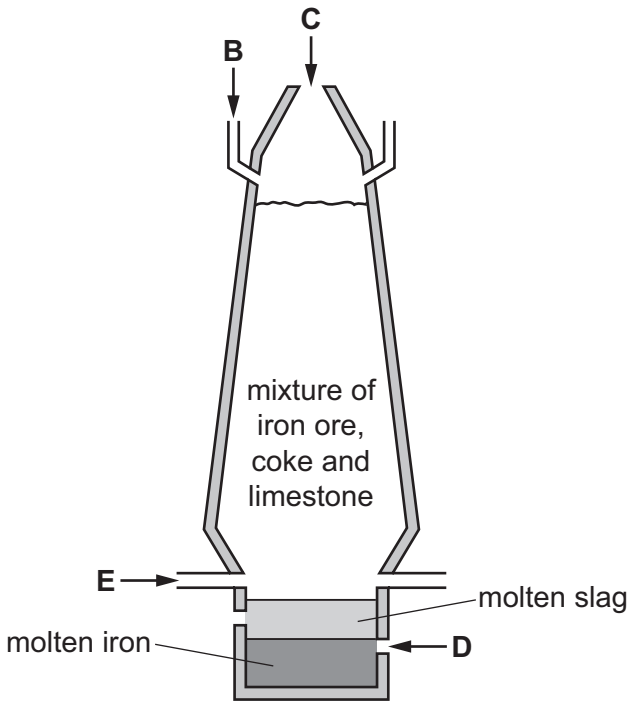
Complete the table to calculate the relative molecular mass of compound **A**.

type of atom	number of atoms	relative atomic mass	
carbon	3	12	$3 \times 12 = 36$
hydrogen		1	
oxygen		16	

relative molecular mass = ...
[2]

[Total: 9]

3 The diagram shows a blast furnace used in the extraction of iron.



(a) Air is blown into the furnace.

State which letter on the diagram, **B**, **C**, **D** or **E**, shows where air is blown into the furnace.

..... [1]

(b) (i) Complete the chemical equation for the reduction of iron(III) oxide in the blast furnace.

$$Fe_2O_3 + 3C \rightarrow .....Fe + ...CO$$ [2]

(ii) Explain how this equation shows that iron(III) oxide is reduced.

..... [1]

(c) Calcium carbonate (limestone) is added to the blast furnace.
The calcium carbonate undergoes thermal decomposition.

(i) Complete the word equation for this reaction.

calcium carbonate	→	....	+	....

[2]

(ii) One of the products of this reaction reacts with impurities in the iron to form slag.

Use the information in the diagram to suggest how you know that molten slag is less dense than molten iron.

..... [1]

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(d) (i) Use words from the list to complete these sentences about how steel is made from iron.

acidic basic chlorides methane neutral

nitrogen oxides oxygen sulfates

A gas is blown through the molten iron. The name of this gas is ..... .

Acidic gases are formed. These acidic gases react with ....
[3]

(ii) State **one** use of mild steel.

..... [1]

(iii) Metals such as chromium are added to iron to make stainless steel.

The symbol for an isotope of chromium is shown.

$^{53}_{24}Cr$

Deduce the number of electrons, neutrons and protons in one atom of this isotope of chromium.

number of electrons .....

number of neutrons .....

number of protons .....
[3]

(e) Chromium conducts electricity and is shiny.

Give two **other** physical properties of chromium that are characteristic of all metals.

1 .....

2 .....
[2]

[Total: 16]

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[Turn over

4 The table shows some properties of the Group I elements.

element	melting point / °C	density in g / cm^3	observations during reaction with water
lithium	181		slow bubbling no flame
sodium	98		rapid bubbling no flame
potassium	63	0.86	rapid bubbling lilac flame
rubidium		1.53	
caesium	29	1.88	explodes

(a) (i) Complete the table by predicting:

- the melting point of rubidium
- the density of lithium. [2]

(ii) Predict the observations when rubidium reacts with water.

.....

..... [1]

(b) Deduce the electronic structure of potassium.
Use the Periodic Table to help you.

..... [1]

(c) Lithium reacts with water to produce aqueous lithium hydroxide and a gas which 'pops' with a lighted splint.

(i) Name the gas which 'pops' with a lighted splint.

..... [1]

(ii) Choose **one** pH value from the list that best describes the pH of aqueous lithium hydroxide.

Draw a circle around the correct answer.

pH 2 **pH 5** **pH 7** **pH 13** [1]

(iii) Lithium reacts with nitrogen.

Complete the chemical equation for this reaction.

$$\text{.....Li} + N_2 \rightarrow \text{.....}Li_3N$$ [2]

[Total: 8]

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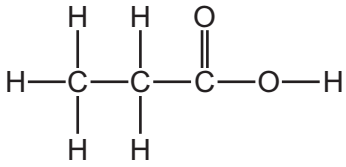
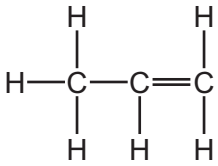
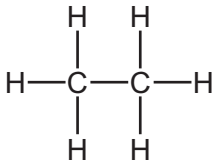
Question 5 starts on the next page.

5 The table shows the structures of some organic compounds.

compound	structure of compound	homologous series
G		carboxylic acid
H		
J		

(a) Complete the table by naming the homologous series.
The first one has been done for you. [2]

(b) Draw the structure of a compound containing two carbon atoms which belongs to the same homologous series as compound **H**.
Show all of the atoms and all of the bonds.

[1]

(c) State which compound in the table is an unsaturated hydrocarbon.
Explain your answer.

.....

..... [1]

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(d) State which compound in the table reacts with aqueous sodium hydroxide.
Explain your answer.

.....

..... [1]

(e) State the names of the **two** compounds formed during the complete combustion of compound **J**.

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

(f) Compound **H** can be polymerised.

(i) State the general name given to the small units which join together to form a polymer.

..... [1]

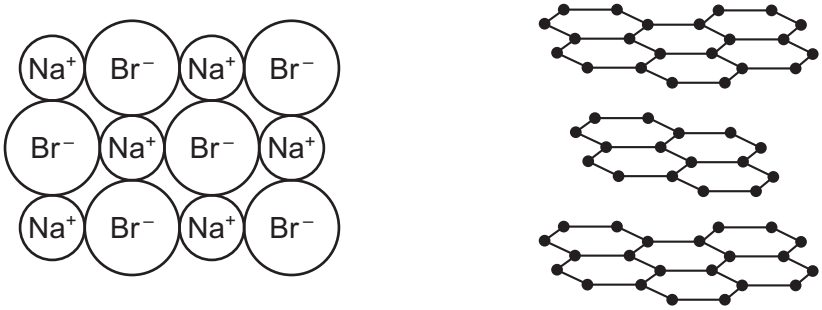
(ii) *Terylene* is also a polymer.

Give **one** use of *Terylene*.

..... [1]

[Total: 9]

6 The diagram shows part of the structures of sodium bromide and graphite at room temperature and pressure.



(a) Describe the physical properties of these substances in terms of:

- volatility

sodium bromide .....

graphite .....

- solubility in water

sodium bromide .....

graphite .....

- electrical conductivity when solid.

sodium bromide .....

graphite .....

[5]

(b) When dilute sulfuric acid is electrolysed using inert electrodes, oxygen gas is produced at the positive electrode.

Name the gas produced at the negative electrode.

..... [1]

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(c) Aqueous sodium bromide reacts with aqueous chlorine.

(i) Complete the word equation for this reaction.

sodium bromide	+	chlorine	→	....	+	.....

[2]

(ii) Explain in terms of the reactivity of the halogens why aqueous sodium chloride does **not** react with aqueous bromine.

.....

..... [1]

[Total: 9]

7 This question is about nitrogen and compounds of nitrogen.

(a) When nitrogen is cooled to below –196 °C it changes state from gas to liquid.

(i) Name the change of state from gas to liquid.

..... [1]

(ii) Use the kinetic particle theory to describe the differences between nitrogen gas and liquid nitrogen in terms of:

- the separation of the particles

.....

.....

.....

- the motion of the particles.

.....

.....

.....

[4]

(b) Oxides of nitrogen are pollutants in the air.

(i) State **one** source of oxides of nitrogen in the air.

..... [1]

(ii) Oxides of nitrogen contribute to acid rain.

Give **one** adverse effect of acid rain on buildings.

..... [1]

(c) Nitric acid contains the nitrate ion.

(i) Use words from the list to complete the sentences to describe the test for nitrate ions.

aluminium **ammonia** **chloride** **copper**

hydroxide **iron** **oxygen** **sulfate**

Put the sample in a test-tube then add aqueous sodium ..... .

Then add ..... .

Warm gently. A gas is produced. The name of this gas is ..... .

[3]

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(ii) Nitric acid reacts with calcium carbonate.

Complete the word equation for this reaction.

nitric acid	+	calcium carbonate	→	....	+	....	+	.....

[3]

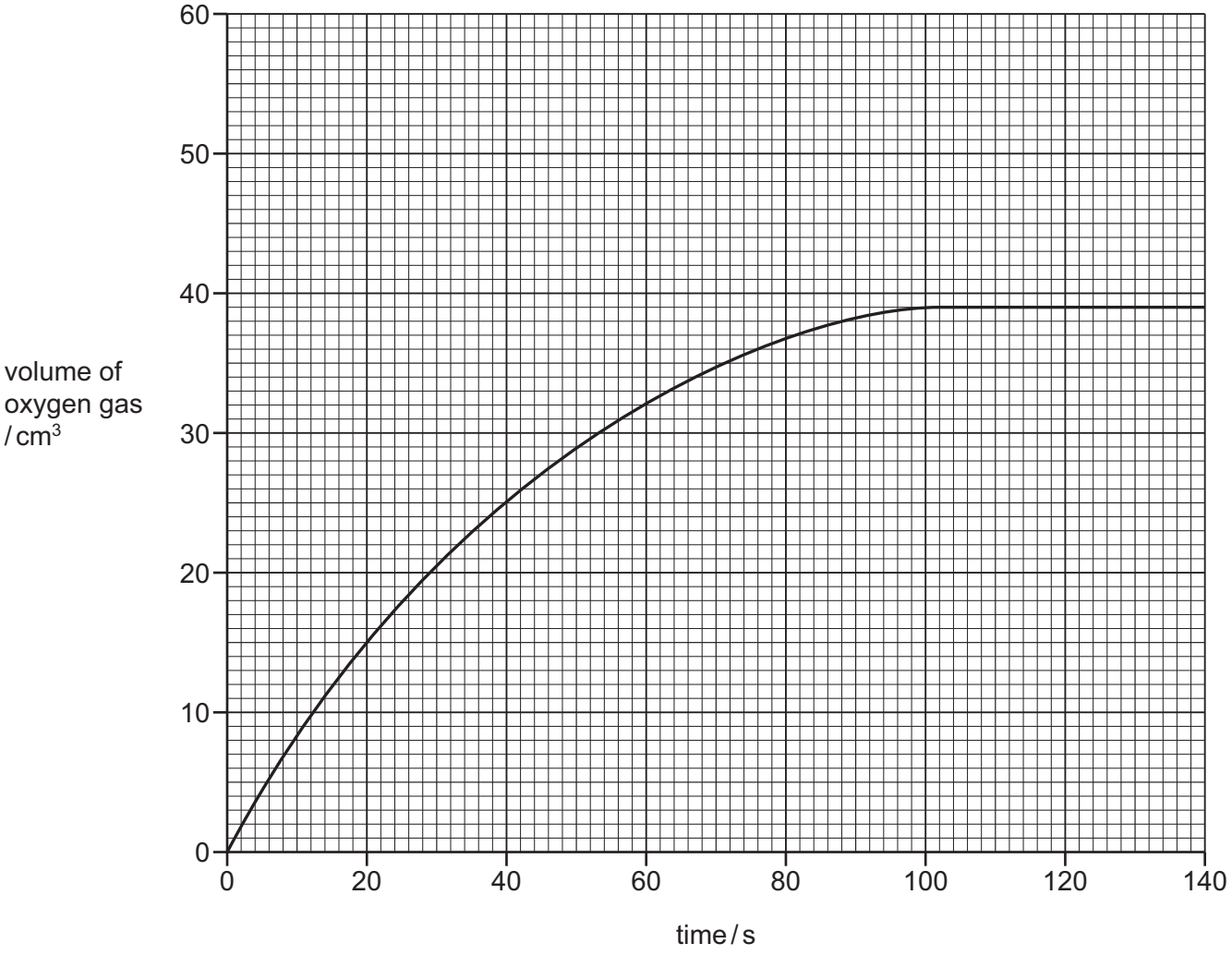
[Total: 13]

8 The rate of decomposition of aqueous hydrogen peroxide, H_2O_2, is increased by an enzyme.

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

The rate of reaction is found by measuring the volume of oxygen gas given off as the reaction proceeds.

The results are shown on the graph.



(a) (i) Deduce the volume of oxygen gas released when the reaction is complete.

volume = ... cm^3 [1]

(ii) Deduce the volume of oxygen gas produced 50 seconds from the start of the reaction.

volume = ... cm^3 [1]

(b) The experiment was repeated using hydrogen peroxide of a higher concentration.

All other conditions stayed the same.

Draw a line **on the grid** to show how the volume of oxygen changes with time when hydrogen peroxide of a higher concentration is used. [2]

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(c) Describe the effect each of the following has on the rate of decomposition of hydrogen peroxide.

- The reaction is carried out at a lower temperature.

All other conditions stay the same.

.....

- The reaction is carried out without an enzyme.

All other conditions stay the same.

.....

[2]

(d) Some metal oxides catalyse the decomposition of hydrogen peroxide.

The table shows the time taken to produce 20 cm^3 of oxygen gas using three different metal oxide powders as catalysts.

All other conditions stay the same.

metal oxide	time taken to produce 20 cm^3 of oxygen gas / s
iron(III) oxide	26
lead(IV) oxide	12
manganese(IV) oxide	15

(i) Put the three oxides in order of their ability to catalyse the reaction.
Put the **best** catalyst first.

best catalyst ⟶ worst catalyst

[1]

(ii) The experiments with the metal oxide catalysts used powdered oxide.

Describe the effect on the rate of decomposition of hydrogen peroxide when large pieces of catalyst are used instead of powdered catalyst.

All other conditions stay the same.

..... [1]

[Total: 8]

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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 –		114 Fl flerovium –		116 Lv livermorium –		

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.).