Cambridge Assessment International Education

Cambridge O Level

CANDIDATE NAME									
CENTRE NUMBER						CANDIDATE NUMBER			

7266969403

CHEMISTRY **5070/21**

Paper 2 Theory **October/November 2021**

1 hour 30 minutes

You must answer on the question paper.

No additional materials are needed.

INSTRUCTIONS

- Section A: answer **all** questions.
- Section B: answer **three** 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 75.
- 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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Section A

Answer **all** the questions in this section in the spaces provided.

The total mark for this section is 45.

1 Choose from the following oxides to answer the questions.

aluminium oxide
calcium oxide
iron(II) oxide
magnesium oxide
silicon dioxide
sodium oxide
sulfur dioxide

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

State which oxide:

(a) has a simple molecular structure

..... [1]

(b) is a coloured solid

..... [1]

(c) contains ions with a 3+ charge

..... [1]

(d) is a product of the thermal decomposition of calcium carbonate

..... [1]

(e) contributes to acid rain.

..... [1]

[Total: 5]

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2 Dry air contains nitrogen, oxygen, noble gases and carbon dioxide.

(a) State the percentage of oxygen present in dry air.

..... [1]

(b) Carbon dioxide is removed from a sample of air by passing the air through aqueous sodium hydroxide.

Explain why aqueous sodium hydroxide removes carbon dioxide from air.

.....

.....

..... [2]

(c) Describe how oxygen, nitrogen and the noble gases are separated from each other after carbon dioxide has been removed.

.....

..... [2]

(d) Describe the test for oxygen.

test .....

observation .....
[2]

(e) Ozone, O_3, is formed in the atmosphere by the reaction of nitrogen dioxide with oxygen in the presence of ultraviolet light.

(i) State the type of chemical reaction that takes place when ozone is formed in this way.

..... [1]

(ii) Nitrogen dioxide is formed in internal combustion engines.

State one other source of nitrogen dioxide in the atmosphere.

..... [1]

(f) A layer of ozone is present high in the atmosphere.

State one problem for humans that can arise if the ozone layer is depleted by CFCs.

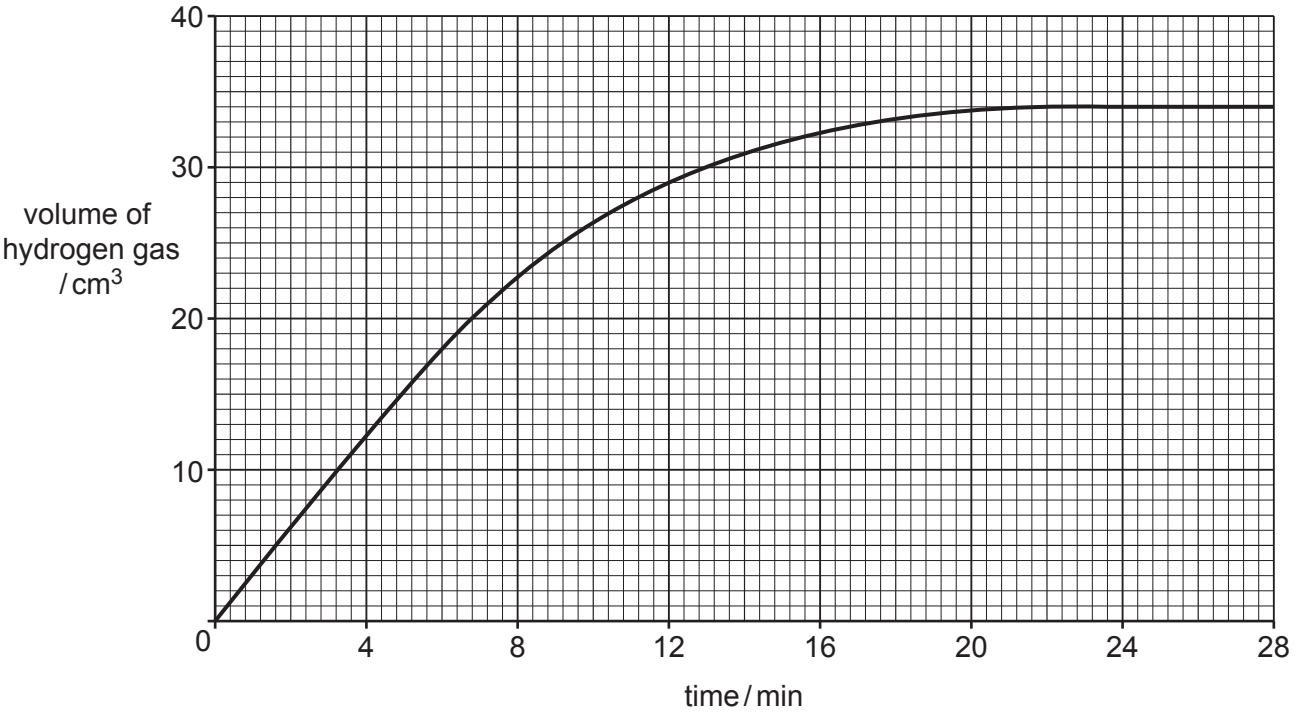
..... [1]

[Total: 10]

3 Iron powder reacts with dilute sulfuric acid.

$$Fe(s) + H_2SO_4(aq) \rightarrow FeSO_4(aq) + H_2(g)$$

(a) The graph shows the volume of hydrogen gas produced at 20 °C as the reaction proceeds.



(i) State how long it takes from the start of the experiment to collect 18 cm^3 of hydrogen gas.

..... [1]

(ii) The experiment is repeated at 30 °C.

All other conditions are the same.

Draw a line **on the grid** to show how the volume of hydrogen gas produced changes with time when the reaction is done at 30 °C. [2]

(b) (i) Describe and explain, using ideas about collisions between particles, how the rate of the reaction changes when the temperature of the reaction mixture is increased.

All other conditions are the same.

.....

.....

.....

..... [2]

(ii) Describe and explain, using ideas about collisions between particles, how the rate of the reaction changes when larger pieces of iron are used.

All other conditions are the same.

.....

.....

.....

..... [2]

(c) Calculate the maximum volume, in dm^3, of hydrogen formed when 3.36 g of iron react with excess dilute sulfuric acid at room temperature and pressure.
Give your answer to **three** significant figures.

maximum volume = ... dm^3 [2]

(d) Concentrated sulfuric acid is an oxidising agent.

Describe a test for oxidising agents.

test .....

observations .....

.....
[2]

[Total: 11]

4 Alkenes are a homologous series of hydrocarbons.

(a) Alkenes are produced by cracking.

State the meaning of the term *cracking*.

.....

..... [2]

(b) Margarine is manufactured from vegetable oils using a nickel catalyst.

(i) Name the other reactant used in this reaction.

..... [1]

(ii) State the type of chemical reaction which occurs when margarine is manufactured from vegetable oils.

..... [1]

(c) Ethanol is produced by the reaction of ethene with steam.

Construct the equation for this reaction.

[1]

(d) An organic compound contains 54.5% carbon, 9.10% hydrogen and 36.4% oxygen by mass.

Calculate the empirical formula of this compound.

empirical formula ..... [2]

[Total: 7]

5 Magnesium undergoes oxidation when it reacts with aqueous silver nitrate.

$$Mg + 2Ag^{+} \rightarrow Mg^{2+} + 2Ag$$

(a) Explain how this equation shows that magnesium is oxidised.

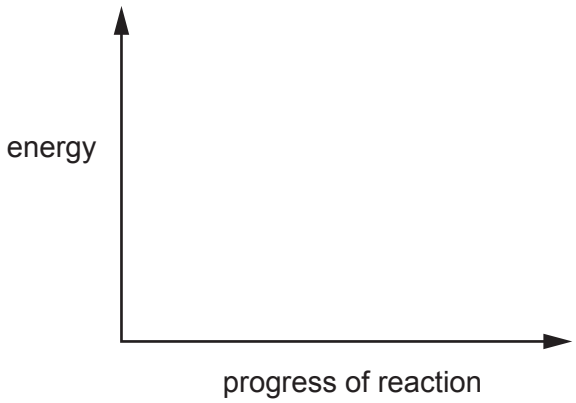
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..... [1]

(b) The reaction of magnesium with silver nitrate is exothermic.

Complete the energy profile diagram for this reaction.

Label reactants, products and ΔH.



[2]

(c) Acidified aqueous silver nitrate is added to a solution containing halide ions.
A yellow precipitate is observed.

State the name of the halide ion present in the solution.

..... [1]

(d) Silver is a metal.

Use your knowledge of the structure of metals to explain why silver is malleable.

.....

.....

..... [2]

(e) The table gives information about the thermal decomposition of some metal carbonates.

metal carbonate	ease of thermal decomposition
calcium carbonate	decomposes at 900 °C
magnesium carbonate	decomposes at 540 °C
sodium carbonate	does not decompose below 1000 °C

Describe how the ease of thermal decomposition depends on the position of these metals in the reactivity series.

.....

..... [1]

[Total: 7]

6 Chlorine reacts with phosphorus to form phosphorus(III) chloride.

$$3Cl_2 + 2P \longrightarrow 2PCl_3$$

The reaction is exothermic.

(a) Explain in terms of bond breaking and bond forming why the reaction is exothermic.

.....

.....

..... [2]

(b) **(i)** When chlorine reacts with aqueous potassium iodide a brown solution is formed.

Name the products of this reaction.

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

(ii) When aqueous bromine is added to potassium chloride there is no reaction.

Explain why there is no reaction.

..... [1]

(c) Phosphorus(III) chloride reacts with water to form a mixture of phosphorous acid, H_3PO_3, and hydrochloric acid.

Construct the equation for this reaction.

..... [1]

[Total: 5]

Section B

Answer **three** questions from this section in the spaces provided.

The total mark for this section is 30.

7 This question is about metals and metal compounds.

(a) Silver is a transition element. Potassium is a metal in Group I of the Periodic Table.

State two differences in the physical properties of silver and potassium.

1 .....

2 .....
[2]

(b) An ion of silver has the symbol

$$^{109}_{47}Ag^{+}$$

Deduce the number of protons, neutrons and electrons in this ion.

number of protons .....

number of neutrons .....

number of electrons .....
[3]

(c) Potassium reacts with water to form a gas which 'pops' with a lighted splint.

Complete the equation for this reaction.

$$\ldots\ldots K + \ldots\ldots H_2O \rightarrow 2KOH + \ldots\ldots\ldots\ldots$$ [1]

(d) When zinc carbonate is warmed in a closed container, an equilibrium mixture is formed.

$$ZnCO_3(s) \rightleftharpoons ZnO(s) + CO_2(g)$$

The forward reaction is endothermic.

(i) Describe and explain the effect, if any, on the position of equilibrium when the temperature is decreased.

.....

.....

..... [2]

(ii) Describe and explain the effect, if any, on the position of equilibrium when the concentration of carbon dioxide is increased.

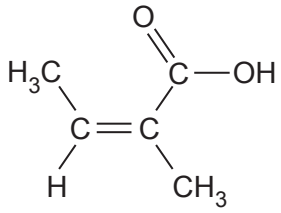
.....

.....

..... [2]

[Total: 10]

8 The structure of angelic acid is shown.



(a) Explain how this structure shows that angelic acid is an unsaturated compound.

..... [1]

(b) Deduce the molecular formula of angelic acid.

..... [1]

(c) Angelic acid is a weak acid.

(i) Define the term *acid*.

..... [1]

(ii) Explain the meaning of the term *weak* as applied to acids.

.....

..... [1]

(d) Angelic acid can be polymerised.

(i) State the name of the type of polymerisation that occurs.

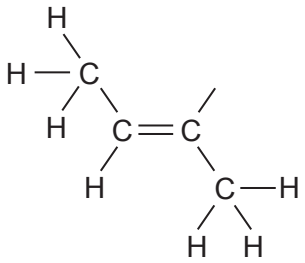
..... [1]

(ii) Draw the partial structure of the polymer of angelic acid. Show two repeat units.

[2]

(e) Angelic acid reacts with methanol, CH_3OH, to form an ester.

Complete the structure of this ester to show all the atoms and all the bonds.



[1]

(f) Construct the equation for the complete combustion of methanol.

..... [2]

[Total: 10]

9 This question is about ammonia and nitrates.

(a) State the source of the hydrogen and nitrogen used in the manufacture of ammonia by the Haber process.

source of hydrogen .....

source of nitrogen .....
[2]

(b) Ammonia is formed when aqueous ammonium sulfate is heated with sodium hydroxide.

$$(NH_4)_2SO_4 + 2NaOH \rightarrow 2NH_3 + Na_2SO_4 + 2H_2O$$

A student adds 4.50 g of sodium hydroxide to 50.0 cm^3 of 1.25 mol / dm^3 aqueous ammonium sulfate.

Show by calculation that the ammonium sulfate is in excess.

[3]

(c) When dilute sodium hydroxide is electrolysed, the hydroxide ions are converted to oxygen and water at the anode.

Construct the ionic equation for the reaction taking place at the anode.

..... [1]

(d) The first stage in the test for nitrate ions is to heat aluminium and sodium hydroxide with a solution containing nitrate ions.

State the type of chemical reaction which occurs when a solution containing nitrate ions is heated with aluminium and sodium hydroxide.

..... [1]

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(e) Nitrates from fertilisers cause eutrophication when they are leached from soils into rivers.

Describe the process of eutrophication.

.....

.....

.....

.....

..... [3]

[Total: 10]

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10 This question is about elements in Group IV of the Periodic Table.

(a) The table shows some properties of the Group IV elements.

element	density at room temperature in g / cm^3	melting point in °C	boiling point in °C
carbon (diamond)		3550	4827
silicon	2.34	1410	2355
germanium	5.35	937	2830
tin		232	2260
lead	11.34	328	1740

(i) Predict the density of tin.

..... [1]

(ii) Describe the general trend in the boiling points of the Group IV elements.

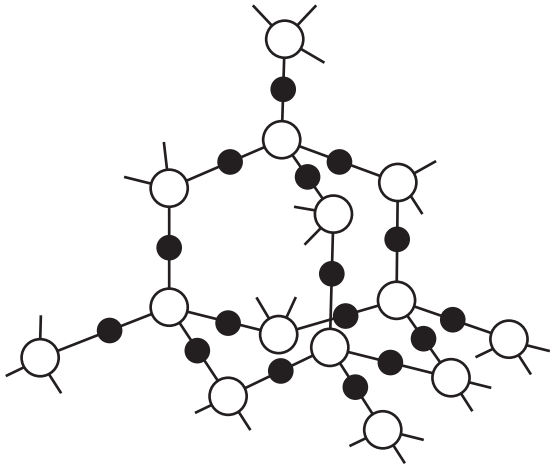
..... [1]

(iii) Predict the state of silicon at 1600 °C.
Give a reason for your answer.

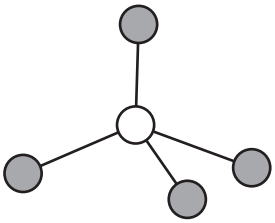
.....

..... [1]

(b) The structure of two compounds of silicon, **P** and **Q**, are shown.



P



Q

● oxygen atom

○ silicon atom

● chlorine atom

(i) Explain in terms of structure and bonding why compound **P** has a high melting point and compound **Q** has a low melting point.

compound **P** .....

.....

.....

compound **Q** .....

.....

.....

[4]

(ii) Draw a dot-and-cross diagram for a molecule of compound **Q**.

Show only the outer shell electrons.

[1]

(c) A compound of carbon, hydrogen and silicon has the formula $Si(CH_3)_4$.

Calculate the percentage by mass of **carbon** in this compound.

[2]

[Total: 10]

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The Periodic Table of Elements

Group I	Group II											Group III	Group IV	Group V	Group VI	Group VII	Group 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.).