Cambridge Assessment International Education

Cambridge O Level

CANDIDATE NAME

CENTRE NUMBER | | | | | |

CANDIDATE NUMBER | | | | |

3630920713

CHEMISTRY **5070/22**

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 chlorides to answer the questions.

aluminium chloride
ammonium chloride
cobalt(II) chloride
hydrogen chloride
iron(III) chloride
potassium chloride
silver chloride
sodium chloride

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

State which chloride:

(a) contains a cation with a charge of 2+

..... [1]

(b) reacts with aqueous sodium hydroxide to form a red-brown precipitate

..... [1]

(c) is insoluble in water

..... [1]

(d) reacts with sodium hydroxide when warmed to produce a gas which turns damp red litmus paper blue

..... [1]

(e) when added to water can form an aqueous solution with a pH of 1.

..... [1]

[Total: 5]

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2 This question is about pollutant gases.

(a) Hydrocarbons such as octane are used as fuels for cars.

The list shows the gases present in a car exhaust.

carbon dioxide
carbon monoxide
nitrogen
nitrogen dioxide
octane
water vapour

State which two gases in the list show that incomplete combustion has taken place in this car engine.

1 .....

2 .....
[2]

(b) Describe a test for carbon dioxide.

test .....

observation .....
[2]

(c) Two natural sources of methane in the atmosphere are from leaks of natural gas and waste gases from animals.

Give one other natural source of methane in the atmosphere.

..... [1]

(d) Complete this sentence about the effect of an increase in the concentration of methane in the atmosphere.

Methane is a ..... gas because it absorbs and then re-emits infrared radiation. This contributes to an increase in temperature of the atmosphere which is called ....
[2]

(e) Cars are fitted with catalytic converters to reduce the amount of harmful pollutant gases from car exhausts.

Describe how catalytic converters remove pollutant gases from car exhausts.

.....

.....

.....

.....

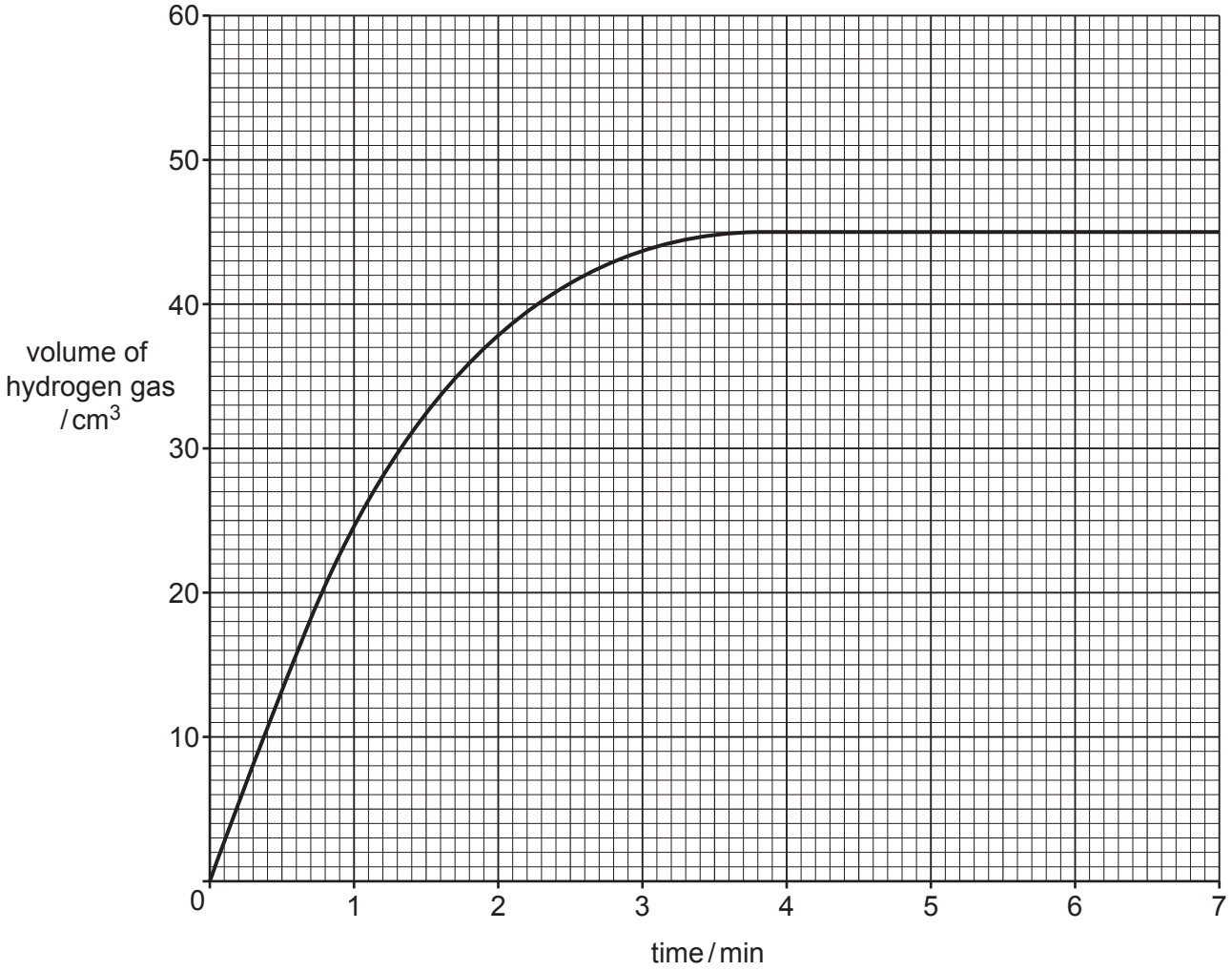
..... [3]

[Total: 10]

3 Magnesium ribbon reacts with dilute hydrochloric acid.

$$Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$$

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



The experiment is repeated using a lower concentration of hydrochloric acid.

The volume of acid used and 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 with a lower concentration of hydrochloric acid. [2]

(b) (i) Describe and explain, using ideas about collisions between particles, how the rate of the reaction changes when magnesium powder is used instead of magnesium ribbon.

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 the temperature of the reaction mixture is decreased.

All other conditions are the same.

.....

.....

.....

..... [2]

(c) Calculate the maximum volume, in dm^3, of hydrogen formed when 1.68 g of magnesium react with excess dilute hydrochloric acid at room temperature and pressure.
Give your answer to **three** significant figures.

volume = ... dm^3 [2]

(d) Magnesium is a good reducing agent.

Describe a test for reducing agents.

test .....

observations .....

.....
[2]

[Total: 10]

4 Alkanes are a homologous series of hydrocarbons. The boiling point, melting point and density of alkanes increase as the number of carbon atoms increases.

(a) (i) Give one **other** physical property of alkanes which increases as the number of carbon atoms increases.

..... [1]

(ii) Give two **other** characteristics of a homologous series.

1 .....

2 .....
[2]

(b) Two typical reactions of alkanes are combustion and cracking.

State the name of another typical chemical reaction of alkanes and the reactant needed to react with the alkanes.

type of reaction .....

reactant .....
[2]

(c) Alkenes are produced by cracking alkanes.

(i) State two conditions needed for cracking alkanes.

1 .....

2 .....
[2]

(ii) Tridecane, $C_{13}H_{28}$, can be cracked to produce an alkene with four carbon atoms and one other hydrocarbon only.

Construct an equation for this reaction.

..... [1]

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(d) A hydrocarbon contains 88.9% carbon by mass.

Calculate the empirical formula of this compound.

empirical formula ..... [2]

[Total: 10]

5 Lithium reacts with aqueous zinc iodide.

$$2Li + ZnI_2 \rightarrow 2LiI + Zn$$

(a) Explain, by referring to the equation, why this reaction involves both oxidation and reduction.

.....

.....

..... [2]

(b) Acidified aqueous silver nitrate is added to aqueous zinc iodide.
State the observations made.

..... [1]

(c) **(i)** When aqueous bromine reacts with aqueous zinc iodide a brown solution is formed.

Name the products of this reaction.

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

(ii) Explain why aqueous bromine does not react with aqueous zinc chloride.

..... [1]

[Total: 5]

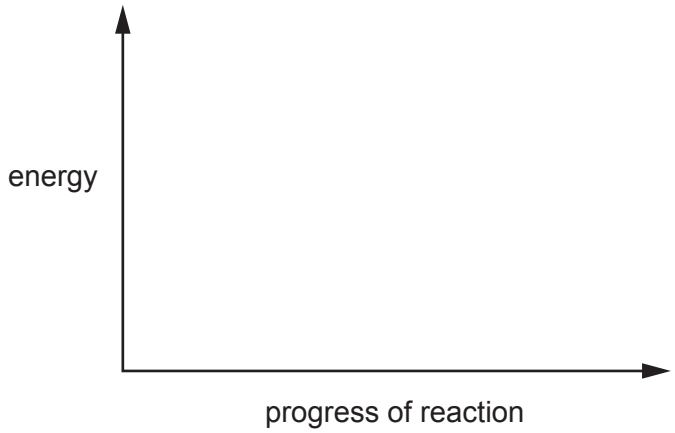
6 Phosphorus reacts with hydrogen to produce phosphine, PH_3.

$$2P + 3H_2 \rightarrow 2PH_3$$

The reaction is endothermic.

(a) Complete the energy profile diagram for this reaction.

Label reactants, products and ΔH.



[2]

(b) Explain, in terms of bond breaking and bond forming, why the reaction is endothermic.

.....

.....

..... [2]

(c) Phosphine reacts with oxygen to form phosphorus(V) oxide, P_4O_{10}, and water.

Complete the equation for this reaction.

$$..... PH_3 + ... O_2 \rightarrow P_4O_{10} + ... H_2O$$ [1]

[Total: 5]

Section B

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

The total mark for this section is 30.

7 Sodium is a metal in Group I of the Periodic Table. Diamond (carbon) is a non-metal which is a good conductor of heat.

(a) State two **differences** in the physical properties of sodium and diamond.

1 .....

2 .....
[2]

(b) An ion of sodium has the symbol

$$^{23}_{11}Na^{+}$$

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

number of protons .....

number of neutrons .....

number of electrons .....
[3]

(c) Sodium reacts with nitrogen to form sodium nitride.
Complete the equation for this reaction.

..... Na + ... $\rightarrow$ ..... Na_3N [1]

(d) When carbon is heated with steam in a closed container an equilibrium mixture is formed.

$$C(s) + H_2O(g) \rightleftharpoons CO(g) + H_2(g)$$

The forward reaction is endothermic.

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

.....

.....

..... [2]

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

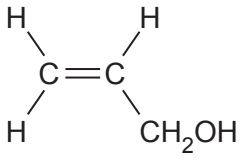
.....

.....

..... [2]

[Total: 10]

8 The structure of an organic compound, **T**, is shown.



(a) Deduce the molecular formula of compound **T**.

..... [1]

(b) Compound **T** is a colourless liquid.

State the colour change when excess compound **T** is added to aqueous bromine.

from ..... to ..... [1]

(c) Compound **T** can be oxidised to a carboxylic acid.

Suggest a suitable oxidising agent for this reaction.

..... [1]

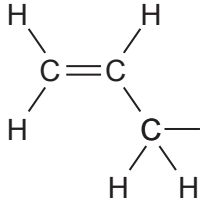
(d) Compound **T** can be polymerised.

Draw the partial structure of the polymer of compound **T**. Show two repeat units.

[2]

(e) Compound **T** reacts with methanoic acid, HCOOH, to form an ester.

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



[1]

(f) Methanoic acid is a weak acid. Hydrochloric acid is a strong acid.

(i) Give the formula of the positive ion that is present in all acids.

..... [1]

(ii) Explain why the rate of reaction of 1.0 mol / dm^3 methanoic acid with magnesium is less than the rate of reaction of 1.0 mol / dm^3 hydrochloric acid with magnesium.

.....

..... [1]

(g) Construct the equation for the reaction of methanoic acid with magnesium.

..... [2]

[Total: 10]

9 This question is about sulfuric acid and sulfates.

(a) **(i)** Sulfur is one of the raw materials used in the Contact process to make sulfuric acid. Name two other raw materials used to make sulfuric acid.

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

(ii) Name the catalyst used in the Contact process.

..... [1]

(b) The electrolysis of dilute sulfuric acid using inert electrodes produces oxygen at the anode.

(i) Define the term *electrolysis*.

.....

.....

..... [2]

(ii) Construct the equation for the reaction taking place at the cathode.

..... [1]

(c) Dilute sulfuric acid reacts with sodium hydroxide.

$$H_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2H_2O$$

A student adds 0.76 g of solid sodium hydroxide to 45 cm^3 of 0.20 mol / dm^3 sulfuric acid.

Show by calculation that the sodium hydroxide is in excess.

[3]

(d) Aqueous sodium hydroxide is warmed with ammonium sulfate.
State the names of the three products formed in this reaction.

1 .....

2 .....

3 .....
[2]

[Total: 10]

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

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

element	density at room temperature in g/cm^3	melting point in °C
nitrogen	1.17×10^{-3}	–210
phosphorus	2.34	44
arsenic	5.73	
antimony		631
bismuth	9.80	272

Use the information in the table to:

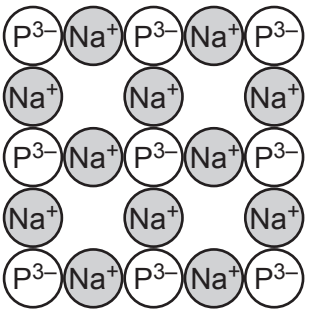
(i) predict the density of antimony

..... [1]

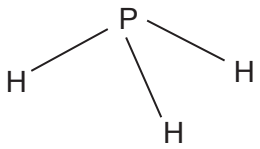
(ii) suggest why it is difficult to predict the melting point of arsenic.

..... [1]

(b) The structure of two compounds of phosphorus, **R** and **S**, are shown.



R



S

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

compound **R** .....

.....

.....

compound **S** .....

.....

.....

[4]

(ii) Explain why compound **R** conducts electricity when molten.

..... [1]

(iii) Draw a dot-and-cross diagram for a molecule of compound **S**.

Show only the outer shell electrons.

[1]

(c) An oxide of phosphorus has the formula P_4O_{10}.

Calculate the percentage by mass of phosphorus 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.).