Cambridge Assessment International Education

Cambridge O Level

CANDIDATE NAME	

CENTRE NUMBER						CANDIDATE NUMBER				

5525178556

CHEMISTRY **5070/21**

Paper 2 Theory **October/November 2022**

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 The diagram shows part of the Periodic Table.

I	II											III	IV	V	VI	VII	VIII
														N	O		
Na												Al	Si			Cl	
K	Ca				Cr		Fe		Ni		Zn						
	Sr									Ag							
	Ba																

Answer the following questions using only the symbols of the elements in the diagram.

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

Give the symbol of the element that:

(a) is a catalyst in the hydrogenation of alkenes

..... [1]

(b) is extracted by electrolysis of its oxide dissolved in cryolite

..... [1]

(c) is a metal below copper in the reactivity series

..... [1]

(d) is a gas used in welding

..... [1]

(e) forms an ion with a charge of –1.

..... [1]

[Total: 5]

2 Carbon dioxide is a gas at room temperature.

(a) **(i)** Draw a dot-and-cross diagram to show the arrangement of electrons in a carbon dioxide molecule.

Show only the outer shell electrons.

[2]

(ii) Describe the motion and separation of the particles in a gas.

motion .....

separation .....
[2]

(b) The main processes in the carbon cycle are combustion, respiration and photosynthesis.

(i) Name the products of photosynthesis.

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

(ii) Some of the reactions in photosynthesis involve enzymes.

State the meaning of the term *enzyme*.

.....

..... [1]

(c) Carbon dioxide is formed when hydrocarbons are completely combusted.

(i) Name the other product of the complete combustion of hydrocarbons.

..... [1]

(ii) The paraffin (kerosene) fraction from the fractional distillation of petroleum (crude oil) contains hydrocarbons.

State **one** use of the paraffin (kerosene) fraction.

..... [1]

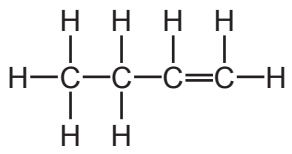
[Total: 8]

3 The alkenes are a homologous series of hydrocarbons.

(a) Give the general formula for the alkenes.

..... [1]

(b) The structure of an alkene is shown.



(i) Name this alkene.

..... [1]

(ii) Explain how this structure shows that alkenes are:

unsaturated .....

.....

hydrocarbons. .....

.....
[2]

(c) Alkenes are produced by cracking some fractions obtained from the fractional distillation of petroleum (crude oil).

State the meaning of the term *cracking*.

.....

..... [2]

(d) Carbon monoxide is formed when alkenes undergo incomplete combustion.

State **one** effect of carbon monoxide on health.

..... [1]

(e) Alkenes react with bromine to form compounds containing carbon, hydrogen and bromine.

(i) A compound contains 22.2% carbon, 3.70% hydrogen and 74.1% bromine by mass.

Calculate the empirical formula of this compound.

empirical formula ..... [2]

(ii) A different compound of carbon, hydrogen and bromine has the empirical formula C_3H_2Br.

The relative molecular mass of this compound is 236.

Deduce the molecular formula of this compound.

molecular formula ..... [1]

[Total: 10]

4 This question is about ammonia and ammonium salts.

(a) Ammonia is manufactured by the Haber process.

(i) Name the catalyst used in the Haber process.

..... [1]

(ii) Explain how a catalyst increases the rate of reaction.

.....

..... [1]

(b) Ammonium phosphate, $(NH_4)_3PO_4$, is a fertiliser.

Calculate the percentage by mass of nitrogen in ammonium phosphate.

Give your answer to **three** significant figures.

percentage by mass = ... [3]

(c) Fertilisers can make soil more acidic.

(i) State the name of a compound used to decrease the acidity of soil.

..... [1]

(ii) Explain how this compound decreases the acidity of soil.

..... [1]

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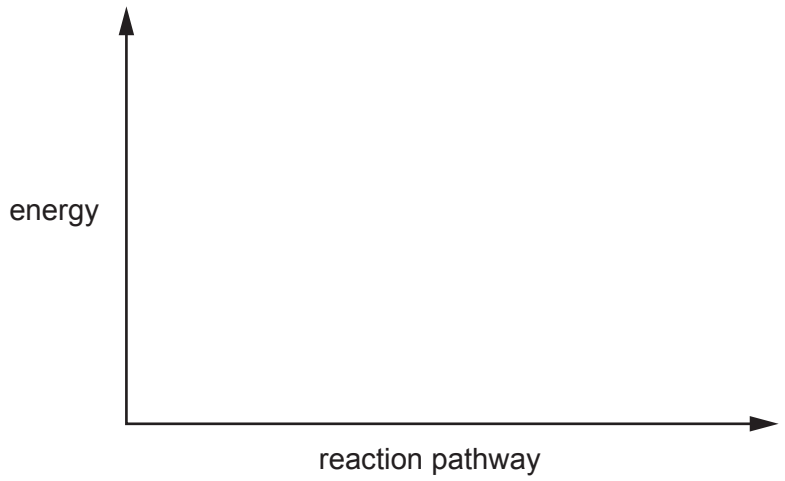
(d) Ammonia is formed by the reduction of nitrogen(I) oxide, N_2O, with hydrogen.

The reaction is exothermic.

$$N_2O + 4H_2 \rightarrow 2NH_3 + H_2O$$

Complete and label the energy profile diagram for this reaction to include:

- the reactants and products
- the enthalpy change of the reaction.



[2]

(e) Copper(II) oxide, CuO, reacts with ammonia.

The products are copper, nitrogen and a liquid which turns blue cobalt(II) chloride paper pink.

Construct the equation for this reaction.

..... [2]

[Total: 11]

5 This question is about metals and metal compounds.

(a) Magnesium reacts with aqueous iron(II) ions.

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

Explain why this reaction involves **both** oxidation and reduction.

Use the equation and ideas about electron transfer in your answer.

.....

.....

.....

..... [2]

(b) Explain why iron conducts electricity.

..... [1]

(c) Explain why magnesium is extracted by electrolysis and not by reduction with carbon.

..... [1]

(d) Describe a chemical test to distinguish between aqueous iron(II) ions and aqueous iron(III) ions.

test .....

observations with aqueous iron(II) ions

.....

observations with aqueous iron(III) ions

.....
[3]

(e) **(i)** Explain why molten magnesium chloride conducts electricity.

..... [1]

(ii) Predict the products formed at the anode and the cathode when molten magnesium chloride is electrolysed.

anode .....

cathode .....
[2]

(f) Food containers can be made from aluminium.

State **one** property of aluminium that makes it suitable for use as a food container.

..... [1]

[Total: 11]

Section B

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

The total mark for this section is 30.

6 This question is about compounds of nitrogen.

(a) The equation represents the equilibrium between N_2O_4 and NO_2 at a high temperature in a closed container.

$$N_2O_4(g) \rightleftharpoons 2NO_2(g)$$

(i) Predict what happens to the position of equilibrium when the pressure is decreased.

Explain your answer.

prediction .....

explanation .....

.....

.....
[2]

(ii) The table shows the concentration of NO_2 in the closed container at three different temperatures.

temperature in °C	concentration of NO_2 in mol / dm^3
100	0.04
150	0.40
200	4.00

State what this information shows about the enthalpy change of the forward reaction.

Explain your answer.

enthalpy change .....

explanation .....

.....

.....
[2]

(b) Nitrogen dioxide, NO_2, is made by heating lead(II) nitrate, $Pb(NO_3)_2$.
The other products are lead(II) oxide and a gas which relights a glowing splint.

(i) Construct the equation for this reaction.

..... [2]

(ii) Nitrogen dioxide contributes to acid rain.

State **one** effect of acid rain on organisms.

..... [1]

(c) Nitric acid, HNO_3, is a strong acid.

(i) State the meaning of the term *strong* in strong acid.

.....

..... [1]

(ii) Suggest a pH value for a concentrated solution of a strong acid.

..... [1]

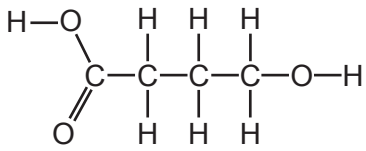
(iii) Complete the ionic equation for the reaction of an acid with an alkali.

$$H^+ + \text{.....} \rightarrow H_2O$$ [1]

[Total: 10]

7 This question is about alcohols and polymers.

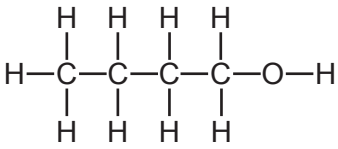
(a) The structure of an organic compound is shown.



Deduce the molecular formula of this compound.

..... [1]

(b) An isomer of butanol has the structure shown.



(i) State the meaning of the term *isomerism*.

.....

..... [1]

(ii) Draw the structure of a different isomer of butanol.

[1]

(iii) Butanol reacts with ethanoic acid, CH_3COOH, to form an ester.

Name this ester.

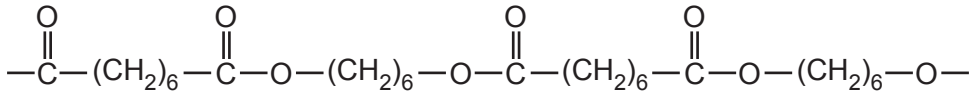
Draw the structure of this ester. Show all of the atoms and all of the bonds.

name of ester .....

structure of ester

[2]

(c) The partial structure of a polyester is shown.



Draw the structures of the two monomers used to make this polyester.

[2]

(d) *Terylene* is a polyester.

(i) State **one** use of *Terylene*.

..... [1]

(ii) Name a naturally occurring molecule which has the same ester linkage as *Terylene*.

..... [1]

(e) Starch is a polymer which can be hydrolysed.

State the meaning of the term *hydrolysis*.

..... [1]

[Total: 10]

8 This question is about metals and metal compounds.

(a) Brass is an alloy of copper and zinc.

Brass is less malleable than either copper or zinc.

Explain, with reference to the structure of metals, why brass is less malleable than either copper or zinc.

You may include a labelled diagram in your answer.

.....

.....

.....

..... [3]

(b) The table shows the reactivity of four metals with cold water and with steam.

metal	reactivity with cold water	reactivity with steam
chromium	none	slow
mercury	none	none
potassium	very fast	explosive
uranium	very slow	slow

Put the four metals in order of increasing reactivity.

least reactive ⟶ most reactive

[1]

(c) The full symbol of an ion of mercury is shown.

$$^{199}_{80}Hg^{2+}$$

Deduce the number of electrons and neutrons in this ion.

number of electrons .....

number of neutrons .....

[2]

(d) The formula of chromium(III) sulfate crystals is $Cr_2(SO_4)_3 \bullet 18H_2O$.

State the name given to the water present in $Cr_2(SO_4)_3 \bullet 18H_2O$.

..... [1]

(e) **(i)** Aqueous bromine reacts with aqueous potassium iodide.

The products of the reaction are aqueous iodine and aqueous potassium bromide.

Construct the ionic equation, including state symbols, for this reaction.

..... [2]

(ii) Explain, in terms of the reactivity of the halogens, why aqueous iodine does **not** react with aqueous potassium bromide.

..... [1]

[Total: 10]

9 **(a)** Zinc powder reacts with dilute hydrochloric acid.

$$Zn + 2HCl \rightarrow ZnCl_2 + H_2$$

When 20.0 cm^3 of dilute hydrochloric acid is added to excess zinc, the volume of hydrogen gas produced at room temperature and pressure is 60.0 cm^3.

(i) Calculate the concentration, in mol / dm^3, of the dilute hydrochloric acid.

concentration ..... mol / dm^3 [3]

(ii) The reaction is repeated using large pieces of zinc instead of zinc powder. All other conditions stay the same.

Describe how the rate of reaction changes.

Explain your answer using ideas about collisions between particles.

.....

.....

..... [2]

(b) Dilute hydrochloric acid is electrolysed.

Construct an ionic equation for the reaction at the cathode.

..... [1]

(c) Zinc is used to prevent iron from rusting.

(i) State the essential conditions needed for rusting.

..... [1]

(ii) Explain how zinc prevents iron from rusting by the method of sacrificial protection.

.....

..... [2]

(iii) Give **one** example of the use of sacrificial protection.

..... [1]

[Total: 10]

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The Periodic Table of Elements

Key

atomic number
atomic symbol
name
relative atomic mass

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 –		

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.).

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