Cambridge IGCSE™

CANDIDATE NAME									
CENTRE NUMBER						CANDIDATE NUMBER				

1831070697

CHEMISTRY **0620/42**

Paper 4 Theory (Extended) **February/March 2022**

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 **16** pages. Any blank pages are indicated.

1 This question is about the first 30 elements in the Periodic Table.

Name the element which:

(a) is 78% of clean, dry air ..... [1]

(b) has atoms with an electronic structure of 2,8,1 ..... [1]

(c) is extracted from hematite ..... [1]

(d) forms an oxide with a giant covalent structure ..... [1]

(e) is the gas with the slowest rate of diffusion at room temperature

..... [1]

(f) has an anhydrous chloride which turns pink when water is added

..... [1]

(g) has aqueous ions which form a white precipitate when added to aqueous silver ions

..... [1]

(h) forms a blue hydroxide which dissolves in aqueous ammonia

.....[1]

(i) is added to molten iron to remove impurities in the steel making process

..... [1]

(j) is used to galvanise iron. ..... [1]

[Total: 10]

2 A student adds excess large pieces of magnesium carbonate, $MgCO_3$, to dilute hydrochloric acid, HCl, and measures the volume of carbon dioxide gas, CO_2, given off.

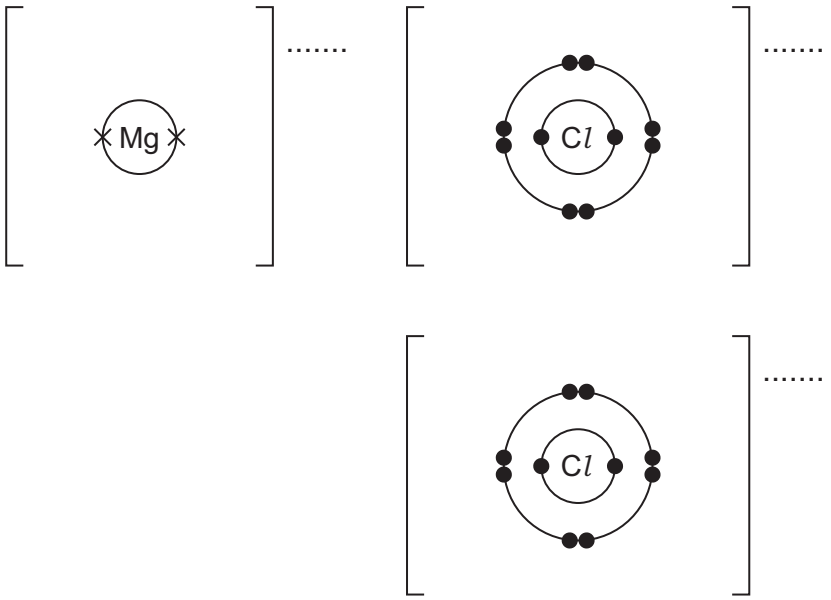
(a) Add the missing state symbols to the chemical equation for the reaction.

$$MgCO_3 \text{ ..... } + 2HCl \text{ ..... } \rightarrow MgCl_2(aq) + H_2O \text{ ..... } + CO_2 \text{ .....}$$ [1]

(b) Complete the dot-and-cross diagram to show the electron arrangement of the ions in magnesium chloride.

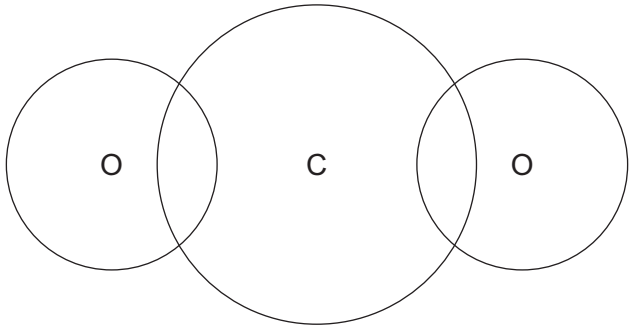
The inner shells have been drawn.

Give the charges on the ions.



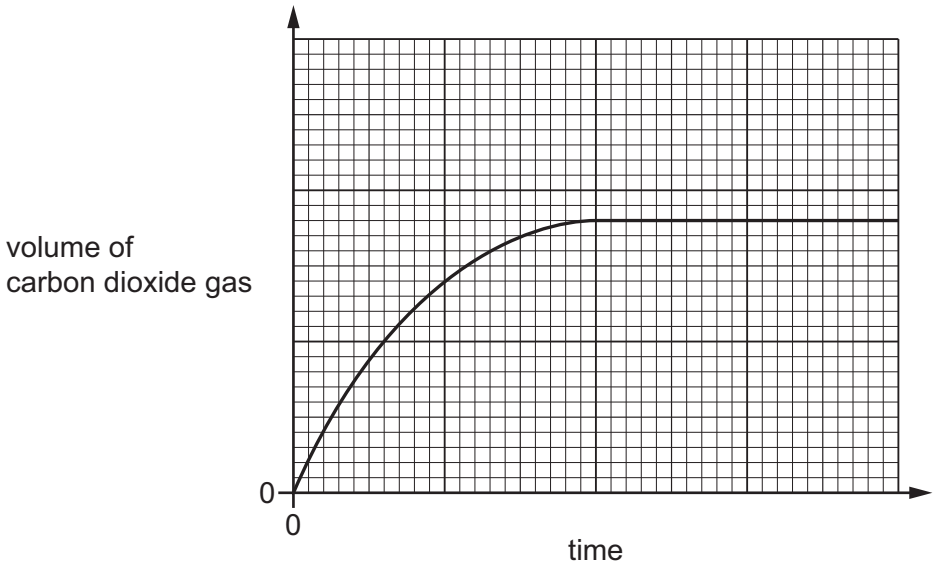
[3]

(c) Complete the dot-and-cross diagram to show the electron arrangement in a molecule of carbon dioxide.
Show outer shell electrons only.



[2]

(d) The graph shows how the volume of carbon dioxide gas changes with time.



(i) Describe how the graph shows that the rate of this reaction decreases as time increases.

.....

..... [1]

(ii) Explain, in terms of particles, why the rate of this reaction decreases as time increases.

.....

..... [2]

(iii) The student repeats the experiment using powdered $MgCO_3$ instead of large pieces.

All other conditions stay the same.

On the grid, draw the line expected when powdered $MgCO_3$ is used instead of large pieces. [2]

(e) Determine the volume of CO_2 gas given off when excess $MgCO_3$ is added to 25.0 cm^3 of 0.400 mol/dm^3 HCl at room temperature and pressure.

$$MgCO_3 + 2HCl \rightarrow MgCl_2 + H_2O + CO_2$$

Use the following steps.

- Calculate the number of moles of HCl in 25.0 cm^3 of 0.400 mol/dm^3 of acid.

..... mol

- Determine the number of moles of CO_2 gas given off.

..... mol

- Calculate the volume of CO_2 gas given off in cm^3.

..... cm^3
[3]

[Total: 14]

3 Nitrogen dioxide, NO_2, is an atmospheric pollutant and is formed in car engines.

(a) Explain how nitrogen dioxide is formed in car engines.

.....

..... [2]

(b) Nitrogen dioxide causes respiratory problems.

State one **other** adverse effect of nitrogen dioxide.

..... [1]

(c) Nitrogen dioxide emissions can be reduced by adding an aqueous solution of urea, $(NH_2)_2CO$, to car exhaust gases.

The heat of the exhaust gases breaks down the urea into simpler substances.

(i) Name the type of reaction which occurs when a substance is heated and breaks down into simpler substances.

..... [1]

(ii) One molecule of urea breaks down to form one molecule of ammonia and one other molecule.

Complete the chemical equation to show the formula of the other molecule formed in this reaction.

$$(NH_2)_2CO \rightarrow NH_3 + ...$$ [1]

(iii) State the test for ammonia.

test .....

observations .....
[2]

(d) The ammonia formed reacts with nitrogen dioxide to form nitrogen and water.

(i) Balance the equation for this reaction.

$$.....NO_2 + ...NH_3 \rightarrow .....N_2 + 12H_2O$$ [2]

(ii) State how the equation shows that the nitrogen in nitrogen dioxide is reduced.

..... [1]

(iii) This reaction is a redox reaction.

State the meaning of the term *redox*.

..... [1]

(e) 135 moles of urea, $(NH_2)_2CO$, is stored in the tank of a car.

Calculate the mass, in kg, of the stored $(NH_2)_2CO$.

mass of $(NH_2)_2CO$ = ... kg
[2]

(f) Another oxide of nitrogen formed in car engines is nitrogen monoxide, NO. A catalytic converter removes NO by reacting it with a gas formed by incomplete combustion of the fuel. Two non-toxic gases are formed.

(i) Name the gas formed by incomplete combustion of the fuel.

..... [1]

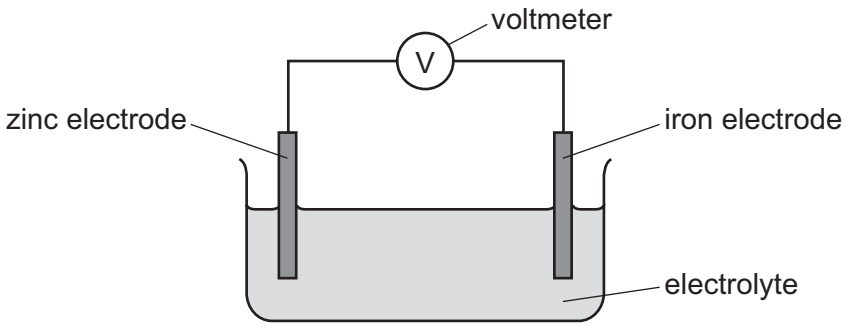
(ii) Name the **two** non-toxic gases formed.

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

[Total: 15]

4 This question is about chemical reactions and electricity.

(a) The diagram shows the apparatus used in the production of electrical energy in a simple cell.



The zinc electrode dissolves in the electrolyte forming $Zn^{2+}(aq)$ ions.

(i) Draw an arrow on the diagram to show the direction of electron flow. [1]

(ii) Write the ionic half-equation for the reaction that occurs when the zinc electrode dissolves.

..... [2]

(b) The reading on the voltmeter can be increased if either zinc or iron is replaced by another metal.

(i) Name a metal that can replace zinc and increase the reading on the voltmeter.

..... [1]

(ii) Name a metal that can replace iron and increase the reading on the voltmeter.

..... [1]

(c) Fuel cells are used to generate electricity.

(i) Name the reactants in a fuel cell.

..... [1]

(ii) Name the waste product of a fuel cell.

..... [1]

(d) Electricity can be used to break down aqueous or molten ionic compounds.

(i) Name the process which uses electricity to break down aqueous or molten ionic compounds.

..... [1]

(ii) Explain why the ionic compound needs to be aqueous or molten.

..... [1]

(e) Brine is concentrated aqueous sodium chloride.

(i) Name **three** substances which are manufactured by passing electricity through brine.

1 .....

2 .....

3 .....

[3]

(ii) Name a different substance formed when molten sodium chloride is used instead of concentrated aqueous sodium chloride.

..... [1]

[Total: 13]

[Turn over

5 This question is about alkanes and alkenes.

(a) Short-chain alkanes and alkenes can be formed from long-chain alkanes in a chemical reaction.

(i) Name the type of chemical reaction which forms short-chain alkanes and alkenes from long-chain alkanes.

..... [1]

(ii) Decane has 10 carbon atoms. It forms ethane and ethene as the only products in this type of chemical reaction.

Write the chemical equation for this reaction.

..... [3]

(b) Ethane reacts with chlorine at room temperature to form chloroethane, C_2H_5Cl, and one other product.

(i) Name the other product formed.

..... [1]

(ii) State the condition needed for this reaction to take place.

..... [1]

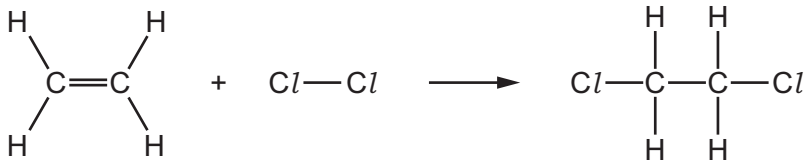
(c) Ethene reacts with chlorine at room temperature to form dichloroethane, $C_2H_4Cl_2$.

$$C_2H_4 + Cl_2 \rightarrow C_2H_4Cl_2$$

(i) State why this is an addition reaction.

..... [1]

(ii) The chemical equation for this reaction can be represented as shown.



The energy change for the reaction is –180 kJ / mol.

Use the bond energies in the table to calculate the bond energy of a C–C*l* bond, in kJ / mol.

bond	C–H	C=C	C*l*–C*l*	C–C
bond energy in kJ / mol	410	610	240	350

Use the following steps.

step 1 Calculate the energy needed to break bonds.

energy needed to break bonds = ... kJ

step 2 Use your answer in **step 1** and the energy change for the reaction to determine the energy released when bonds are formed.

energy released when bonds form = ... kJ

step 3 Use your answer in **step 2** and bond energy values to determine the energy of a C–C*l* bond.

bond energy of a C–C*l* bond = ... kJ / mol
[4]

[Total: 11]

6 The names of four esters are listed.

methyl propanoate

ethyl propanoate

propyl propanoate

butyl propanoate

(a) Esters are a family of organic compounds with similar chemical properties. They can be represented by the formula $C_nH_{2n}O_2$.

(i) State the name given to a family of organic compounds with similar chemical properties.

..... [1]

(ii) Explain why members of a family of organic compounds have similar chemical properties.

..... [1]

(iii) State the name given to a formula such as $C_nH_{2n}O_2$.

..... [1]

(iv) Determine the value of '*n*' in butyl propanoate.

..... [1]

(b) All four of the esters in the list are liquids at room temperature.

Name the technique used to separate ethyl propanoate from a mixture of the four esters.

..... [2]

(c) All four esters can be made by reacting different alcohols with the same substance.

(i) Name this substance and draw its structure. Show all of the atoms and all of the bonds.

name .....

structure

[2]

(ii) Name the alcohol used to make methyl propanoate.

..... [1]

(d) Other esters, not in the list, have the same molecular formula as propyl propanoate, but different structures.

(i) State the term used to describe substances with the same molecular formula but different structures.

..... [1]

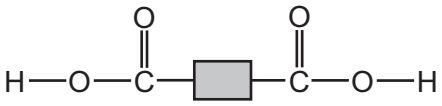
(ii) Name **two** esters with the same molecular formula as propyl propanoate.

1 .....

2 .....

[2]

(e) Polyesters can be made from the two different molecules shown.



and

(i) Complete the diagram to show a section of the polyester made from these two molecules. Include all of the atoms and all of the bonds in the linkages.

[3]

(ii) Name the type of polymerisation that takes place when this polymer forms.

..... [1]

(iii) Name a polyester.

..... [1]

[Total: 17]

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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.).