Cambridge Assessment International Education

Cambridge IGCSE™

CANDIDATE NAME									
CENTRE NUMBER						CANDIDATE NUMBER				

1787085567

CHEMISTRY **0620/41**

Paper 4 Theory (Extended) **October/November 2020**

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. Blank pages are indicated.

© UCLES 2020

1 **(a)** This question is about elements.

aluminium
carbon
iron
hydrogen
oxygen
silicon
sodium
sulfur

Answer the following questions about these elements.

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

(i) Name the element that can be used as a fuel.

..... [1]

(ii) Name the element that forms an oxide with a similar structure to diamond.

..... [1]

(iii) Name the element that forms an amphoteric oxide.

..... [1]

(iv) Name the element that has oxidation states of +2 and +3.

..... [1]

(v) Name the element extracted from bauxite.

..... [1]

(vi) Name the element that has atoms with the electronic structure 2,6.

..... [1]

© UCLES 2020

(b) Iron rusts when it is in contact with oxygen and water.

(i) Explain how sacrificial protection prevents rusting.

.....

.....

.....

..... [2]

(ii) State one **other** method of rust prevention.

..... [1]

[Total: 9]

2 Zinc is extracted from an ore containing zinc sulfide.

(a) State the name of this zinc ore.

..... [1]

(b) This ore is converted to zinc oxide, ZnO.

Zinc oxide is then reacted with carbon.

(i) Write a chemical equation for the reaction of zinc oxide with carbon.

..... [1]

(ii) State what type of chemical change happens to the zinc in zinc oxide in this reaction.

Explain your answer.

chemical change .....

explanation .....

.....

.....

[2]

(iii) Explain why aluminium is **not** extracted from aluminium oxide by heating with carbon.

.....

..... [1]

(iv) Suggest an alternative method for the extraction of zinc from zinc oxide.

..... [1]

(c) Brass is an alloy of zinc.

Explain, in terms of particles, why brass is harder than pure zinc.

.....

.....

.....

.....

..... [3]

[Total: 9]

© UCLES 2020

3 **(a)** Aqueous ammonium sulfate, $(NH_4)_2SO_4$, is warmed with aqueous sodium hydroxide.

The pungent-smelling gas ammonia, NH_3, is produced.

Balance the equation for this reaction.

$$(NH_4)_2SO_4 + ...NaOH \rightarrow .....NH_3 + ...H_2O + Na_2SO_4$$ [1]

(b) A 2.8 g sample of impure ammonium sulfate is found to contain 0.7 g of impurities.

Calculate the percentage of ammonium sulfate in this sample.

percentage of ammonium sulfate = ... % [1]

(c) Describe a test for ammonia gas.

test .....

result .....
[2]

(d) Ammonia gas is prepared at the front of a laboratory.

The pungent smell of ammonia spreads throughout the laboratory slowly.

(i) Name the process that occurs when ammonia gas spreads throughout the laboratory.

..... [1]

(ii) Explain, using ideas about particles, why ammonia gas spreads throughout the laboratory.

.....

.....

.....

..... [2]

(iii) Explain why carbon dioxide gas, CO_2, will spread throughout the laboratory at a slower rate than ammonia gas, NH_3.

.....

..... [1]

© UCLES 2020

[Turn over

(e) Ammonia is produced in the Haber process.

The equation for the reaction is shown.

$$N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$$

(i) In the Haber process, a temperature of 450 °C and a pressure of 200 atmospheres are used in the presence of finely-divided iron.

A larger equilibrium yield of ammonia would be produced if a lower temperature and a higher pressure are used.

Explain why a lower temperature and a higher pressure are **not** used.

lower temperature .....

.....

higher pressure .....

.....

[2]

(ii) State the role of iron in the Haber process.

..... [1]

(f) Ammonia is a weak base.

(i) Explain the meaning of the term *base*.

.....

..... [1]

(ii) Suggest the pH of aqueous ammonia.

..... [1]

[Total: 13]

© UCLES 2020

4 Air is a mixture of gases.

(a) State the percentage of clean dry air which is oxygen. Give your answer to the nearest whole number.

..... % [1]

(b) Oxygen and nitrogen are useful gases that can be obtained from air.

(i) Name the process used to separate oxygen and nitrogen from liquid air.

..... [2]

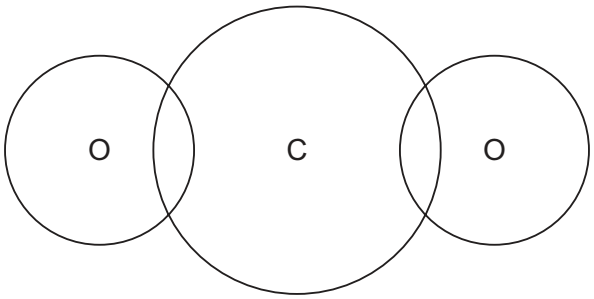
(ii) State the property of oxygen and nitrogen that allows these gases to be separated using this process.

..... [1]

(c) Carbon dioxide, CO_2, is a covalent molecule.

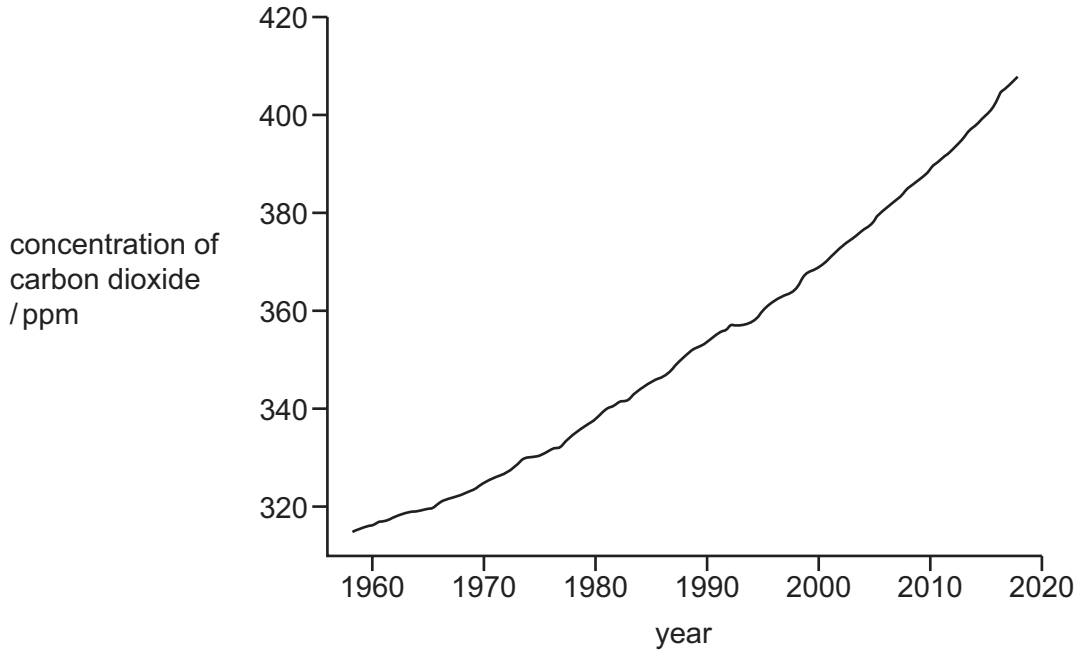
Complete the diagram to show the electron arrangement in one molecule of CO_2.

Show only the outer electrons.



[2]

(d) The graph shows the concentration of carbon dioxide in the atmosphere over a 60-year period, measured in parts per million (ppm).



The data shown in the graph is of global concern.

Explain why.

.....

.....

.....

.....

.....

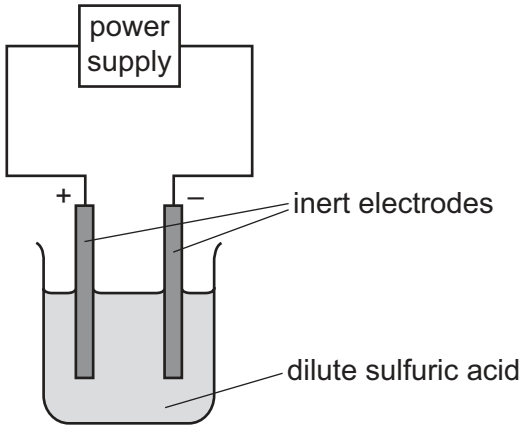
..... [3]

(e) Name the process in the carbon cycle by which plants remove carbon dioxide from the atmosphere.

..... [1]

[Total: 10]

5 **(a)** Dilute sulfuric acid is electrolysed using the apparatus shown in the diagram.



(i) State what is meant by the term *electrolysis*.

.....

.....

..... [2]

(ii) Explain why inert electrodes are used.

.....

..... [1]

(iii) Name the products formed at each electrode.

negative electrode .....

positive electrode .....

[2]

(iv) Write an ionic half-equation for the reaction at the negative electrode.

..... [2]

(b) Sulfuric acid is manufactured using the Contact process. This manufacture involves four stages.

(i) **Stage 1** involves the combustion of sulfur to form sulfur dioxide.

Write the chemical equation for **stage 1**.

..... [1]

(ii) The equation for **stage 2** is shown.

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$$

The reaction can reach equilibrium.

Explain what is meant by the term *equilibrium*.

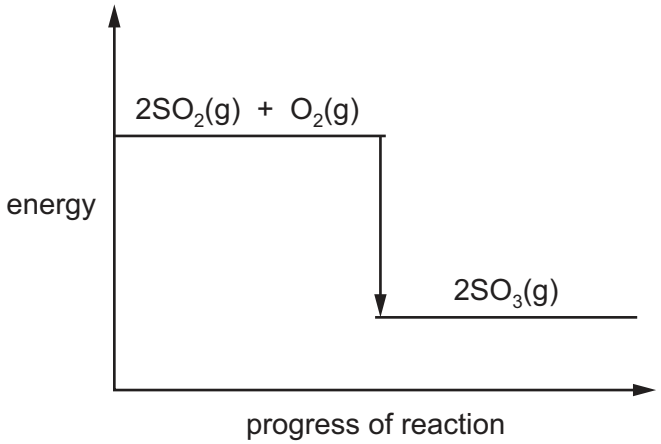
.....

.....

.....

..... [2]

(iii) The energy level diagram for the forward reaction in **stage 2** is shown.



Explain what the diagram shows about the energy changes in the forward reaction.

.....

.....

.....

..... [2]

(c) In **stage 3** sulfur trioxide, SO_3, is converted to oleum, $H_2S_2O_7$.

In **stage 4** oleum reacts to form sulfuric acid, H_2SO_4.

State what oleum reacts with in **stage 4**.

..... [1]

(d) A sample of sulfuric acid, H_2SO_4, has a concentration of $0.75\,mol/dm^3$.

Calculate the concentration of sulfuric acid in g/dm^3.

..... g/dm^3 [2]

[Total: 15]

© UCLES 2020

[Turn over

6 **(a)** Ethane, propane and butane are members of the same homologous series.

(i) Name this homologous series.

..... [1]

(ii) State **two** ways members of the same homologous series are similar.

1 .....

2 .....
[2]

(b) One mole of ethane, C_2H_6, contains 6.02×10^{23} molecules.

Calculate how many molecules are in 15 g of ethane.

number of ethane molecules = ... [1]

(c) Propane reacts with chlorine.

(i) Write the formula of the product which does not contain carbon.

..... [1]

(ii) Draw the structure of an organic product formed. Show all of the atoms and all of the bonds.

[1]

(iii) State the name of this type of reaction.

..... [1]

© UCLES 2020

(d) (i) Aqueous bromine was added to a sample of ethene.

Give the colour change seen.

from ..... to ..... [2]

(ii) Explain, in terms of bonding, why there is no colour change when aqueous bromine is added to ethane.

.....

..... [1]

(e) There are two structural isomers with the formula C_4H_{10}.

(i) Draw the structures of both of these isomers, showing all of the atoms and all of the bonds.

[2]

(ii) Butane is formed when longer chain hydrocarbons are cracked.

Complete the chemical equation to show the other product when butane is formed by cracking.

$$C_6H_{14} \rightarrow C_4H_{10} + ...$$ [1]

(f) A compound contains 85.7% carbon and 14.3% hydrogen by mass.

(i) Calculate the empirical formula of this compound.

Show your working.

..... [2]

(ii) The molecular mass of the compound is 112.

Calculate the molecular formula of this compound.

..... [1]

[Total: 16]

7 **(a)** Ethanol can be manufactured by two different methods.

Method 1: fermentation of a sugar, $C_6H_{12}O_6$

$$C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2$$

Method 2: reaction of ethene with steam

$$C_2H_4 + H_2O \rightarrow C_2H_5OH$$

(i) Give **one** advantage of using fermentation compared with Method 2.

.....

..... [1]

(ii) Give **one** disadvantage of using fermentation compared with Method 2.

.....

..... [1]

(b) Ethanol reacts with acidified potassium manganate(VII) to form water and a product that turns litmus red.

(i) State the name of the product that turns the litmus red.

..... [1]

(ii) State the type of reaction that ethanol undergoes when it reacts with acidified potassium manganate(VII).

..... [1]

(c) Ethanol reacts with methanoic acid to form an ester.

(i) Name the ester formed in this reaction.

..... [1]

(ii) Draw the structure of the ester formed.
Show all of the atoms and all of the bonds.

[1]

(d) The table shows the melting points of ethanol and sodium chloride.

substance	melting point / °C
ethanol	–114
sodium chloride	801

The difference in melting points is due to differences in attractive forces between particles in these substances.

Name the type of attractive force in each substance, which is responsible for the difference in melting points.

ethanol .....

sodium chloride .....
[2]

[Total: 8]

© UCLES 2020

BLANK PAGE

BLANK PAGE

BLANK PAGE

Permission to reproduce items where third-party owned material protected by copyright is included has been sought and cleared where possible. Every reasonable effort has been made by the publisher (UCLES) to trace copyright holders, but if any items requiring clearance have unwittingly been included, the publisher will be pleased to make amends at the earliest possible opportunity.

To avoid the issue of disclosure of answer-related information to candidates, all copyright acknowledgements are reproduced online in the Cambridge Assessment International Education Copyright Acknowledgements Booklet. This is produced for each series of examinations and is freely available to download at www.cambridgeinternational.org after the live examination series.

Cambridge Assessment International Education is part of the Cambridge Assessment Group. Cambridge Assessment is the brand name of the University of Cambridge Local Examinations Syndicate (UCLES), which itself is a department of the University of Cambridge.

© UCLES 2020

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.).