Cambridge Assessment International Education

Cambridge O Level

CANDIDATE NAME									
CENTRE NUMBER						CANDIDATE NUMBER			

CHEMISTRY **5070/21**

Paper 2 Theory **October/November 2020**

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. Blank pages are indicated.

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 compounds to answer the questions.

aluminium iodide
ethanol
glucose
lead(IV) chloride
lithium bromide
magnesium carbonate
methane
potassium phosphate
silver nitrate
sodium sulfate
sulfur dioxide

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

Which compound:

(a) produces ammonia when its aqueous solution is warmed with aqueous sodium hydroxide and aluminium

..... [1]

(b) contains ions with a 1– charge which are present in many fertilisers

..... [1]

(c) contains ions with a 2+ charge

..... [1]

(d) forms an orange colour when it reacts with chlorine in aqueous solution

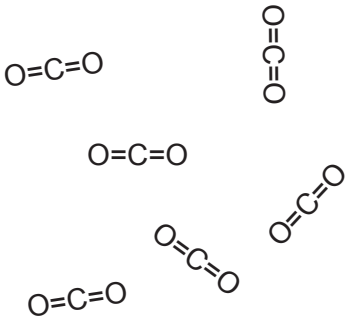
..... [1]

(e) is a hydrocarbon that is formed from the bacterial decay of vegetable matter?

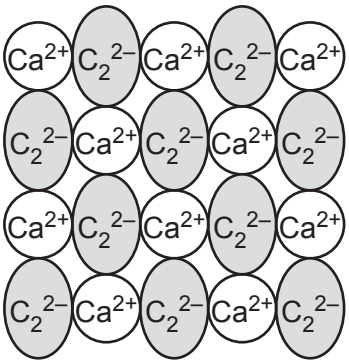
..... [1]

[Total: 5]

2 Part of the structures of carbon dioxide and calcium carbide are shown.



carbon dioxide



calcium carbide

(a) Explain in terms of structure and bonding why carbon dioxide has a low boiling point and calcium carbide has a high boiling point.

.....

.....

.....

.....

.....

..... [3]

(b) Calcium carbide, CaC_2, reacts with water to form ethyne, C_2H_2, and calcium hydroxide.

Construct the equation for this reaction.

..... [1]

(c) Ethyne is an unsaturated hydrocarbon.

State the meaning of the term *hydrocarbon*.

.....

..... [1]

[Turn over

(d) Ethyne is a member of the alkyne homologous series.

The molecular formulae of the first four members of the alkyne homologous series are shown.

C_2H_2
C_3H_4
C_4H_6
C_5H_8

Predict the formula for the fifth member of the alkyne homologous series.

..... [1]

(e) Ethyne reacts with hydrogen in a similar way to ethene reacting with hydrogen.

The reaction between ethyne and hydrogen is exothermic.

(i) What type of chemical reaction occurs when ethyne reacts with hydrogen?

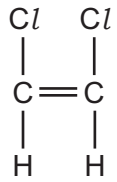
..... [1]

(ii) Predict the molecular formula of a product formed when ethyne reacts with hydrogen.

..... [1]

(f) 1,2-dichloroethene is produced when excess ethyne reacts with chlorine.

The structure of 1,2-dichloroethene is shown.



Deduce the partial structure of the polymer of 1,2-dichloroethene.

Show three repeat units.

[2]

[Total: 10]

3 This question is about copper and copper compounds.

(a) Copper is a metal.

Explain why copper conducts electricity.

..... [1]

(b) Describe a test for copper(II) ions.

test .....

observations .....
[2]

(c) Aqueous copper(II) sulfate is electrolysed using graphite electrodes.

(i) Describe what is observed during this electrolysis:

- at the positive electrode

.....

- at the negative electrode

.....

- in the electrolyte.

.....
[3]

(ii) Graphite conducts electricity.

Give one other reason why graphite electrodes are used in electrolysis.

..... [1]

(d) Aqueous copper(II) sulfate reacts with magnesium.

$$CuSO_4 + Mg \longrightarrow Cu + MgSO_4$$

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

..... [2]

(e) A 2.25 g sample of an oxide of copper contains 0.250 g of oxygen.

Deduce the empirical formula of this oxide of copper.

[3]

(f) There are several commonly used alloys of copper.

What is the meaning of the term *alloy*?

.....

..... [1]

[Total: 13]

4 This question is about halogens and halogen compounds.

(a) A drop of bromine liquid was placed in a sealed glass jar.

After a time, the colour of the bromine had spread throughout the jar.

Explain this observation in terms of the kinetic particle theory.

.....

.....

.....

.....

..... [3]

(b) Chlorine, bromine and iodine are halogens.

(i) State the trend in the colour of the halogens from chlorine to iodine.

.....

..... [1]

(ii) State the physical state of chlorine and iodine at room temperature and pressure.

chlorine .....

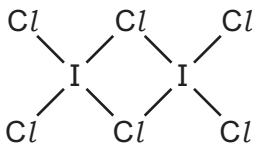
iodine .....
[1]

(iii) Chlorine is used to make other chemicals.

State one other use of chlorine.

..... [1]

(c) The molecular structure of a compound of iodine and chlorine is shown.



Deduce the molecular formula of this compound.

..... [1]

(d) Fluorine reacts with aqueous sodium hydroxide to produce sodium fluoride, NaF, water and oxygen.

$$2F_2 + 4NaOH \rightarrow 4NaF + 2H_2O + O_2$$

Calculate the maximum volume of oxygen produced, in dm^3, at room temperature and pressure, when 0.037 mol of sodium hydroxide react completely with fluorine.

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

volume of oxygen ..... dm^3 [2]

[Total: 9]

5 Platinum and vanadium are both transition elements.

(a) Transition elements are metals which are hard, strong and have high melting points and boiling points.

State two other properties which are typical of transition elements but **not** of all metals.

1 .....

2 .....
[2]

(b) Vanadium(V) oxide, V_2O_5, is a catalyst in the Contact process.

(i) State how a catalyst increases the rate of a chemical reaction.

.....

..... [1]

(ii) State the conditions used in the Contact process.

.....

..... [2]

(c) Vanadium(V) oxide is reduced to vanadium by heating with aluminium.

Complete the equation for this reaction.

$$3V_2O_5 + ...Al \rightarrow .....V + ...Al_2O_3$$ [1]

(d) A fuel cell generates electricity when hydrogen and oxygen react on platinum electrodes.

(i) Name the process used in industry to separate oxygen from air.

..... [1]

(ii) The reaction at one of the electrodes in the fuel cell is shown.

$$O_2 + 2H_2O + 4e^- \rightarrow 4OH^-$$

State whether this is an oxidation or reduction reaction.

Explain your answer.

.....

..... [1]

[Total: 8]

Section B

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

The total mark for this section is 30.

6 **(a)** The table shows some properties of five alcohols.

alcohol	formula	density in g/cm^3	boiling point in °C
methanol	CH_3OH	0.791	65
ethanol	C_2H_5OH	0.789	79
propanol	C_3H_7OH	0.803	97
butanol	C_4H_9OH	0.810	117
pentanol	$C_5H_{11}OH$	0.814	138

(i) What is the general trend in the density of the alcohols as the number of carbon atoms in a molecule increases?

.....

..... [1]

(ii) Describe and explain the change in the boiling point of the alcohols as the number of carbon atoms in a molecule increases.

.....

..... [1]

(b) Ethanol, C_2H_5OH, reacts with butanoic acid, $C_3H_7CO_2H$, to produce an ester.

A few drops of a strong acid are added to catalyse the reaction.

(i) What does the term *strong* mean, when applied to acids?

.....

..... [1]

(ii) Name and draw the structure of the ester produced when ethanol reacts with butanoic acid, showing all of the atoms and all of the bonds.

name .....

structure

[2]

(c) Ethanol can be oxidised to ethanoic acid in the laboratory.

State the reagents and conditions used in this reaction.

reagent .....

conditions .....

[2]

(d) Concentrated ethanoic acid, CH_3CO_2H, reacts with calcium.

The products are calcium ethanoate and hydrogen.

(i) Construct the equation for this reaction.

..... [1]

(ii) State and explain how the rate of this reaction changes when the experiment is repeated using dilute ethanoic acid.

All other conditions stay the same.

Include in your answer ideas about collisions between particles.

.....

.....

..... [2]

[Total: 10]

[Turn over

7 Aluminium is extracted by the electrolysis of molten aluminium oxide.

(a) **(i)** Explain why aluminium is extracted by electrolysis and not by reduction with carbon.

..... [1]

(ii) The electrolyte is a mixture of aluminium oxide and cryolite.

Explain the purpose of the cryolite.

.....

..... [1]

(iii) At the positive electrode (anode) oxide ions are converted to oxygen.

Construct the equation for this reaction.

..... [1]

(b) Aluminium can also be produced on a small scale by reacting aluminium oxide with magnesium.

$$Al_2O_3 + 3Mg \longrightarrow 2Al + 3MgO$$

(i) Use this equation to explain why the Al_2O_3 is reduced.

.....

..... [1]

(ii) Calculate the maximum mass of aluminium formed when 25.5 g of aluminium oxide reacts with excess magnesium.

mass of aluminium = ... g [2]

(c) Aluminium is a metal.

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

.....

.....

..... [2]

(d) When aluminium is heated in chlorine, aluminium chloride is formed.

The reaction is exothermic.

Explain, in terms of bond making and bond breaking, why this reaction is exothermic.

.....

.....

..... [2]

[Total: 10]

8 **(a)** Dilute nitric acid reacts with aqueous barium hydroxide.

$$2HNO_3(aq) + Ba(OH)_2(aq) \rightarrow Ba(NO_3)_2(aq) + 2H_2O(l)$$

(i) A student titrates 25.0 cm^3 of dilute nitric acid with 0.0450 mol/dm^3 barium hydroxide using methyl orange as an indicator.

A volume of 34.0 cm^3 of aqueous barium hydroxide reacts exactly with the dilute nitric acid.

Calculate the concentration of the dilute nitric acid.

concentration of nitric acid ..... mol/dm^3 [3]

(ii) Describe how to prepare pure dry crystals of barium nitrate from aqueous barium nitrate.

.....

.....

.....

.....

..... [3]

(b) Barium nitrate decomposes when heated to form barium oxide, BaO, nitrogen dioxide, NO_2, and oxygen.

Construct the equation for this reaction.

..... [1]

(c) Nitrogen dioxide is an atmospheric pollutant which causes 'acid rain'.

Describe one effect of acid rain on buildings.

.....

..... [1]

(d) Hydrazine, $H_2N - NH_2$, is a colourless liquid.

(i) Draw a dot-and-cross diagram for a molecule of hydrazine.

Include only the outer shell electrons.

[1]

(ii) The melting point of hydrazine is 2 °C.
The boiling point of hydrazine is 114 °C.

Use this information to suggest why hydrazine is a solid at 0 °C.

.....

..... [1]

[Total: 10]

9 Calcium is a metal in Group II of the Periodic Table.

(a) Calcium can be used as a reducing agent.

Describe a test for reducing agents.

test .....

observations .....

[2]

(b) An ion of calcium has the symbol

$$^{44}_{20}Ca^{2+}$$

Deduce the number of electrons and neutrons in this ion.

number of electrons .....

number of neutrons .....

[2]

(c) When calcium carbonate is heated in a closed container, an equilibrium mixture is formed.

$$CaCO_3(s) \rightleftharpoons CaO(s) + CO_2(g)$$

The forward reaction is endothermic.

(i) Describe and explain the effect, if any, on the position of equilibrium when a hole is made in the container.

.....

.....

..... [2]

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

.....

.....

..... [2]

(d) When heated, calcium oxide reacts with chlorine to form calcium chloride and a gas which relights a glowing splint.

Complete the equation for this reaction.

$$2CaO + \text{.....} \rightarrow \text{.....}CaCl_2 + \text{.....}$$ [1]

(e) Calcium chloride is soluble in water.

Name one **other** calcium salt which is soluble in water.

..... [1]

[Total: 10]

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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.).