Cambridge Assessment International Education
Cambridge International General Certificate of Secondary Education

CANDIDATE NAME	

CENTRE NUMBER						CANDIDATE NUMBER				

* 2 3 3 8 4 0 2 7 2 9 *

CHEMISTRY **0620/41**

Paper 4 Theory (Extended) **October/November 2019**

1 hour 15 minutes

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your centre number, candidate number and name on all the work you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Answer **all** questions.
Electronic calculators may be used.
A copy of the Periodic Table is printed on page 16.
You may lose marks if you do not show your working or if you do not use appropriate units.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

This syllabus is regulated for use in England, Wales and Northern Ireland as a Cambridge International Level 1/Level 2 Certificate.

This document consists of **16** printed pages.

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1 This question is about ions and ionic compounds.

(a) Choose from the following list of ions to answer the questions.

Br^-	Ca^{2+}	Cl^-	Cr^{3+}	Cu^{2+}
K^+	Li^+	Na^+	SO_3^{2-}	SO_4^{2-}

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

State which ion:

(i) gives a lilac colour in a flame test ..... [1]

(ii) forms a grey-green precipitate with aqueous ammonia ..... [1]

(iii) forms a white precipitate with aqueous sodium hydroxide ..... [1]

(iv) forms a cream precipitate with acidified aqueous silver nitrate ..... [1]

(v) forms a white precipitate with acidified aqueous barium nitrate. ..... [1]

(b) Describe how to do a flame test on a sample of a salt.

.....

.....

.....

..... [2]

(c) Magnesium phosphate contains magnesium ions, Mg^{2+}, and phosphate ions, PO_4^{3-}.

Deduce the formula of magnesium phosphate.

..... [1]

[Total: 8]

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2 **(a)** Sulfur exists as a number of different isotopes.

What is meant by the term *isotopes*?

.....

.....

..... [2]

(b) A sulfide ion has the symbol shown.

$$^{34}_{16}S^{2-}$$

(i) How many neutrons are contained in this sulfide ion?

..... [1]

(ii) How is a sulfide ion, S^{2-}, formed from a sulfur atom?

..... [1]

(iii) Which element forms an ion with a 2+ charge that has the same number of electrons as a S^{2-} ion?

..... [1]

(c) The manufacture of sulfuric acid by the Contact process occurs in four stages.

stage 1 Molten sulfur is burned in air to produce sulfur dioxide gas.

stage 2 Sulfur dioxide is reacted with oxygen to form sulfur trioxide.

stage 3 Sulfur trioxide is combined with concentrated sulfuric acid to form oleum, $H_2S_2O_7$.

stage 4 Oleum is added to water to form sulfuric acid.

(i) Complete the chemical equation for **stage 1** by adding the appropriate state symbols.

$$S(.....) + O_2(.....) \rightarrow SO_2(.....)$$ [1]

(ii) Name the catalyst used in **stage 2** and state the temperature used.

catalyst .....

temperature ..... °C

[2]

(iii) Write chemical equations for the reactions in **stage 3** and **stage 4**.

stage 3 .....

stage 4 .....

[2]

(d) Sulfur dioxide is a toxic gas.

(i) State one **environmental** reason why sulfur dioxide should **not** be released into the atmosphere.

..... [1]

(ii) Describe the test for sulfur dioxide.

test .....

.....

observations .....

.....

[2]

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(e) Sulfur dioxide reacts with aqueous sodium sulfite to produce a compound with the following composition by mass: 29.1% Na, 40.5% S and 30.4% O.

Calculate the empirical formula of this compound.

empirical formula = ... [3]

[Total: 16]

3 This question is about metals and metal oxides.

(a) Most metals have a high melting point.

State **one** other physical property that all metals have.

..... [1]

(b) Iron often rusts.

Name the **two** substances, other than iron, that must be present for iron to rust.

1 .....

2 .....
[1]

(c) Iron can be obtained by heating iron(III) oxide with zinc powder.

$$Fe_2O_3 + 3Zn \rightarrow 2Fe + 3ZnO$$

(i) What can be deduced about the reactivity of zinc from this reaction?

..... [1]

(ii) The ionic equation for this reaction is shown.

$$2Fe^{3+} + 3Zn \rightarrow 2Fe + 3Zn^{2+}$$

Identify the oxidising agent in this reaction. Explain your answer in terms of electron transfer.

oxidising agent .....

explanation .....

.....
[2]

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(d) Zinc oxide is amphoteric.

Describe **two** simple experiments to show that zinc oxide is amphoteric.
Name the reagents you would use and describe the observations you would make.

reagent 1 .....

observation .....

reagent 2 .....

observation .....
[3]

[Total: 8]

4 Insoluble salts can be made by precipitation reactions.

A student mixed solutions of some soluble salts.

The results the student obtained are shown in the table.

		second salt solution		
		$Co(NO_3)_2(aq)$	$AgNO_3(aq)$	$Pb(NO_3)_2(aq)$
first salt solution	NaI(aq)	no change	yellow precipitate	yellow precipitate
	$Na_2CO_3(aq)$	purple precipitate	yellow precipitate	white precipitate
	$Na_2SO_4(aq)$	no change	white precipitate	white precipitate

All sodium salts are soluble in water.
Use only results from the table to answer the following questions.

(a) Name:

(i) an insoluble cobalt salt ..... [1]

(ii) an insoluble yellow lead salt. ..... [1]

(b) Write the chemical equation for the reaction in which silver carbonate is formed.

..... [2]

(c) Write the ionic equation for the reaction in which lead(II) iodide is formed.

..... [2]

(d) Aqueous silver nitrate produces a yellow precipitate with both iodide ions and carbonate ions. When testing an unknown solution for iodide ions, the aqueous silver nitrate is acidified.

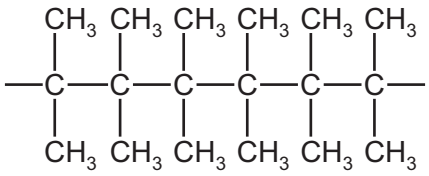
Explain why the aqueous silver nitrate is acidified.

.....

..... [1]

[Total: 7]

5 **(a)** Part of the structure of synthetic polymer **A** is shown.



(i) What type of synthetic polymer is **A**?

..... [1]

(ii) Deduce the empirical formula of polymer **A**.

..... [1]

(iii) Draw the structure of the monomer from which polymer **A** is made.

[2]

(b) The formula C_4H_{10} represents two different structural isomers.

(i) What is meant by the term *structural isomers*?

.....

.....

..... [2]

(ii) Draw the structures of **two** structural isomers with the formula C_4H_{10}.
Show all of the atoms and all of the bonds.

[2]

(iii) All structural isomers of C_4H_{10} are flammable.

Write a chemical equation for the **incomplete** combustion of C_4H_{10}.

..... [2]

[Total: 10]

6 Dilute hydrochloric acid, $HCl(aq)$, reacts with aqueous sodium carbonate, $Na_2CO_3(aq)$.

The chemical equation for the reaction is shown.

$$2HCl + Na_2CO_3 \rightarrow 2NaCl + CO_2 + H_2O$$

(a) A 25.0 cm^3 portion of $Na_2CO_3(aq)$ was placed in a conical flask with a few drops of a suitable indicator. It was titrated against $HCl(aq)$ of concentration 0.180 mol / dm^3.

20.0 cm^3 of $HCl(aq)$ was required to reach the end-point.

Calculate the concentration of the $Na_2CO_3(aq)$, in mol / dm^3, using the following steps.

- Calculate the number of moles of HCl used in the titration.

..... mol

- Calculate the number of moles of Na_2CO_3 contained in the 25.0 cm^3 portion of $Na_2CO_3(aq)$.

..... mol

- Calculate the concentration of the $Na_2CO_3(aq)$ in mol / dm^3.

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

(b) In another experiment, the volume of carbon dioxide, CO_2, produced was 48.0 cm^3, measured at room temperature and pressure.

How many moles of CO_2 is this?

moles of CO_2 = ... mol [1]

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(c) A sample of concentrated hydrobromic acid, HBr(aq), was electrolysed using platinum electrodes.
The concentration of the hydrobromic acid was 8.89 mol / dm^3.

(i) Calculate the concentration of the HBr(aq) in g / dm^3.

concentration of HBr(aq) = ... g / dm^3 [1]

(ii) Explain why concentrated HBr(aq) can conduct electricity.

.....

.....

..... [2]

(iii) Magnesium is **not** a suitable material from which to make the electrodes.

Explain why.

.....

..... [1]

(iv) Predict the product formed at the anode when concentrated HBr(aq) is electrolysed.

..... [1]

(v) Write the ionic half-equation for the reaction occurring at the cathode.

..... [2]

[Total: 11]

7 This question is about ethanol.

(a) Ethanol that is suitable for use as a fuel can be manufactured from sugars such as glucose, $C_6H_{12}O_6$, by a two-step process.

Describe how this can be done. In your answer, include:

- an equation for the reaction in which ethanol is formed
- the essential conditions for the reaction in which ethanol is formed
- the name of the process used to obtain ethanol that is pure enough to use as a fuel from the reaction mixture.

.....

.....

.....

.....

.....

.....

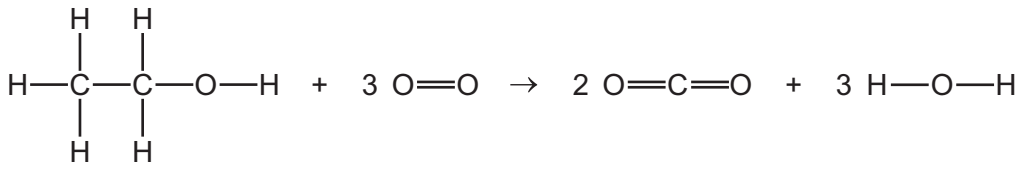
.....

.....

.....

..... [5]

(b) The equation for the complete combustion of ethanol is shown.



Use the bond energies in the table to calculate the energy change, in kJ / mol, for the complete combustion of ethanol.

bond	bond energy in kJ / mol
C–C	347
C–H	413
C–O	358
C=O	805
O–H	464
O=O	498

- Energy needed to break bonds.

..... kJ

- Energy released when bonds are formed.

..... kJ

- Energy change for the complete combustion of ethanol.

energy change = ... kJ / mol
[3]

(c) Ethanol can be oxidised by hydrogen peroxide to form ethanal, CH_3CHO. A catalyst for this reaction is Fe^{3+}.

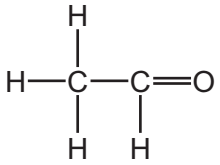
(i) What is meant by the term *catalyst*?

.....

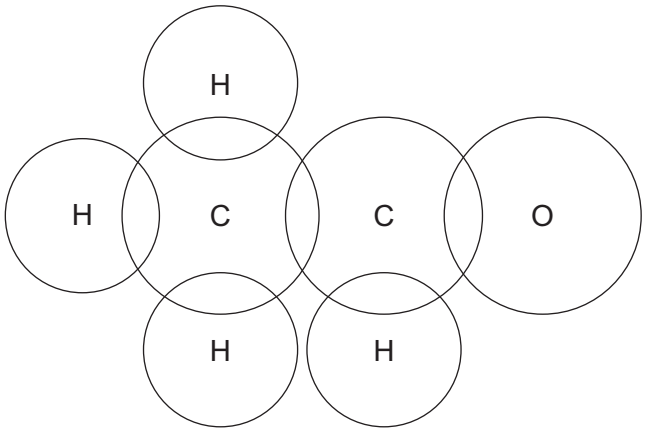
.....

..... [2]

(ii) The structure of ethanal is shown.



Complete the dot-and-cross diagram to show the electron arrangement in a molecule of ethanal. Show outer shell electrons only.



[3]

(iii) The table gives the boiling points of ethanal and ethanol.

substance	boiling point / °C
ethanal	20
ethanol	78

In terms of attractive forces between particles, suggest why ethanal has a lower boiling point than ethanol.

.....

..... [1]

(d) Ethene gas reacts with steam to form gaseous ethanol.

$$C_2H_4(g) + H_2O(g) \rightleftharpoons CH_3CH_2OH(g)$$

The reaction can reach a position of equilibrium. The forward reaction is exothermic.

(i) State and explain the effect of increasing the pressure on the **position of equilibrium**. All other conditions are unchanged.

.....

.....

..... [2]

(ii) Increasing the pressure of a gas increases its concentration.

State and explain the effect of increasing the pressure on the **rate** of the reaction. All other conditions are unchanged.

.....

.....

..... [2]

(iii) State and explain the effect of increasing the temperature on the **position of equilibrium**. All other conditions are unchanged.

.....

.....

..... [2]

[Total: 20]

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The Periodic Table of Elements

Key

atomic number
atomic symbol
name
relative atomic mass

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 –		

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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