Cambridge Assessment International Education

Cambridge O Level

CANDIDATE NAME									
CENTRE NUMBER						CANDIDATE NUMBER				

0123456789

CHEMISTRY **5070/02**

Paper 2 Theory **For examination from 2023**

SPECIMEN PAPER **1 hour 45 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. Any blank pages are indicated.

1 Choose from the list of oxides to answer the questions.

calcium oxide

carbon dioxide

copper(II) oxide

silicon(IV) oxide

sodium oxide

sulfur dioxide

sulfur trioxide

zinc oxide

Each oxide can be used once, more than once or not at all.

Identify which oxide:

(a) has a giant covalent structure

..... [1]

(b) reacts with acids and with alkalis

..... [1]

(c) is used in flue gas desulfurisation

..... [1]

(d) contains a cation with a charge of +1.

..... [1]

[Total: 4]

2 Atoms and ions contain protons, neutrons and electrons.

(a) Complete Table 2.1.

Table 2.1

	relative charge	relative mass
proton	+1	
neutron		1
electron		

[3]

(b) Table 2.2 shows some information about six particles.

Table 2.2

particle	number of protons	number of neutrons	number of electrons
A	37	48	37
B	53	74	54
C	92	143	92
D	92	143	89
E	92	146	92
F	94	150	92

(i) Deduce the nucleon number for particle **A**.

..... [1]

(ii) Explain why particle **B** is a negative ion.

.....

..... [1]

(iii) Identify two **atoms** that are isotopes of the same element.

..... and .....

Explain your answer.

.....

.....

[2]

[Total: 7]

3 Salts can be prepared by the reaction of acids with bases or alkalis and also by precipitation reactions.

(a) State the ionic equation for the reaction between an acid and an alkali.

..... [1]

(b) Sodium sulfate is a soluble salt prepared by a titration method using an acid and an alkali.

Identify the acid and the alkali used to prepare sodium sulfate.

acid .....

alkali .....
[1]

(c) Aqueous sodium sulfate is used to prepare barium sulfate in a precipitation reaction.

$$Ba^{2+}(aq) + SO_4^{2-}(aq) \rightarrow BaSO_4(s)$$

In an experiment 20.0 cm^3 of 0.550 mol / dm^3 of barium nitrate is added to an excess of sodium sulfate.

(i) State the colour of the precipitate formed in the reaction.

..... [1]

(ii) Calculate the maximum mass of barium sulfate that could be made.

[M_r: $BaSO_4$, 233]

Show your working.

maximum mass of barium sulfate = ... g [2]

(iii) A mass of 1.92 g of dry barium sulfate is obtained.

Calculate the percentage yield of barium sulfate.

percentage yield of barium sulfate = ...% [1]

[Total: 6]

4 Calcium chloride, $CaCl_2$, is an ionic compound.

(a) Deduce the electronic configuration for each of the ions in calcium chloride.

calcium ion .....

chloride ion .....
[2]

(b) When **molten** calcium chloride is electrolysed with inert electrodes, calcium and chlorine are formed.

Construct ionic half-equations for the two electrode reactions.

reaction at the negative electrode

.....

reaction at the positive electrode

.....
[2]

(c) The electrolysis of concentrated aqueous calcium chloride with inert electrodes is similar to that of concentrated aqueous sodium chloride.

Predict the products of the electrolysis of concentrated **aqueous** calcium chloride with inert electrodes.

..... [1]

(d) Calcium chloride has a high melting point.

Explain why calcium chloride has a high melting point. Use ideas about structure and bonding.

.....

.....

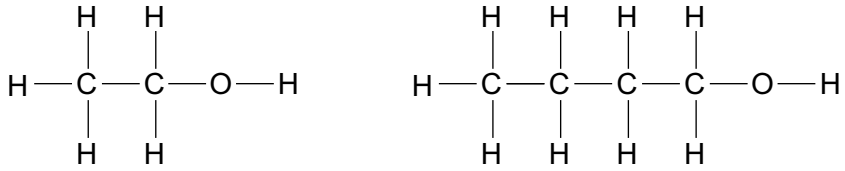
.....

..... [2]

[Total: 7]

BLANK PAGE

5 Fig. 5.1 shows the alcohols ethanol and butan-1-ol.



ethanol **butan-1-ol**

Fig. 5.1

(a) Describe the manufacture of ethanol from ethene.

.....

.....

..... [2]

(b) Ethanol is used as a fuel.

(i) State one **other** use of ethanol.

..... [1]

(ii) Construct a symbol equation to show the **incomplete** combustion of ethanol.

..... [2]

(c) Ethanol is oxidised to form ethanoic acid.

State the name of a reagent that is used for this oxidation.

..... [1]

(d) Draw the displayed formula of a **different** alcohol that is an isomer of butan-1-ol.

[1]

(e) Butan-1-ol is heated with concentrated sulfuric acid which acts as a catalyst.

But-1-ene and one other compound are formed.

(i) Draw the structural formula of but-1-ene.

[1]

(ii) Deduce the **other** compound formed in the reaction.

..... [1]

(f) But-2-ene, $CH_3CH=CHCH_3$, is polymerised to give poly(but-2-ene).

(i) State the type of polymerisation that occurs.

..... [1]

(ii) Draw the structure of poly(but-2-ene) showing at least one repeat unit.

[2]

[Total: 12]

6 A mixture of ethanoic acid, ethene and oxygen is passed over a catalyst at 200 °C to manufacture ethenyl ethanoate, $CH_3COOCH=CH_2$.

$$CH_3COOH + CH_2=CH_2 + ½O_2 \rightarrow CH_3COOCH=CH_2 + H_2O$$

The reaction is exothermic.

(a) Draw a reaction pathway diagram for this reaction on Fig. 6.1.

On your diagram label:
- the axes
- the reactants and products
- the enthalpy change of the reaction, ΔH
- the activation energy, E_a.

Fig. 6.1 [4]

(b) Explain why the enthalpy change of the reaction is exothermic.

Use ideas about bond breaking and bond making.

.....

.....

.....

..... [2]

[Total: 6]

7 Peroxodisulfate ions, $S_2O_8^{2-}$, react with iodide ions in aqueous solution.

$$S_2O_8^{2-}(aq) + 2I^-(aq) \rightarrow 2SO_4^{2-}(aq) + I_2(aq)$$

(a) Iodide ions are oxidised in this reaction.

State how the equation shows this.

.....

..... [1]

(b) Table 7.1 shows how the relative rate of this reaction changes when different concentrations of peroxodisulfate ions and iodide ions are used.

Table 7.1

experiment	concentration of $S_2O_8^{2-}$ in mol / dm^3	concentration of I^- in mol / dm^3	relative rate of reaction
1	0.008	0.02	1.7
2	0.016	0.02	3.3
3	0.032	0.02	6.8
4	0.008	0.04	3.4
5	0.008	0.08	6.9

Using the information in Table 7.1, describe how **increasing** the concentration of each of these ions affects the relative rate of reaction.

peroxodisulfate ions

.....

.....

iodide ions

.....

.....
[2]

(c) Iron(III) ions, Fe^{3+}, catalyse this reaction.

Explain how catalysts increase the rate of a reaction.

.....

.....

..... [2]
[Total: 5]

8 Copper reacts with concentrated nitric acid to form copper(II) nitrate.

$$Cu(s) + 4HNO_3(aq) \rightarrow Cu(NO_3)_2(aq) + 2NO_2(g) + 2H_2O(l)$$

(a) State the meaning of (aq).

.....

..... [1]

(b) An excess of copper is added to 25.0 cm^3 of 16.0 mol / dm^3 HNO_3.

Use this information, together with the equation, to calculate the volume of NO_2 formed. The gas volume is measured at room temperature and pressure.

Show your working and state the units.

volume of NO_2 = ... [3]

(c) When heated, $Cu(NO_3)_2$ decomposes to form CuO, NO_2 and O_2.

Construct the symbol equation for this reaction.

..... [1]

(d) To a small sample of $Cu(NO_3)_2(aq)$, a student adds aqueous ammonia drop by drop until it is in excess.

(i) Describe what is observed.

.....

.....

.....

..... [2]

(ii) The student repeats the experiment but adds aqueous sodium hydroxide instead of aqueous ammonia.

Describe what is observed.

.....

..... [1]

[Total: 8]

9 Iodine reacts with chlorine to form iodine(I) chloride, ICl.

(a) Iodine(I) chloride reacts in a similar way to bromine.

Iodine(I) chloride reacts with ethene in an addition reaction.

Draw the displayed formula of the product of this reaction.

[1]

(b) Iodine(I) chloride reacts in a similar way to chlorine.

Iodine(I) chloride reacts with ethane in a photochemical reaction in the presence of ultraviolet light.

(i) State the type of reaction that takes place.

..... [1]

(ii) Suggest a symbol equation for the reaction between iodine(I) chloride and ethane.

..... [1]

(c) The dot-and-cross diagram for a molecule of iodine(I) chloride is similar to that for a molecule of chlorine.

Draw the dot-and-cross diagram for a molecule of iodine(I) chloride.

Show outer electrons only.

[1]

(d) Iodine(I) chloride reacts with chlorine to form iodine(III) chloride.

This reaction is investigated at 200 °C in a closed system.

The reversible reaction reaches an equilibrium.

$$ICl(g) + Cl_2(g) \rightleftharpoons ICl_3(g)$$

(i) Describe **two** features of a reversible reaction at equilibrium, in a closed system.

In your answer, refer to the rate of reaction and to the concentrations of reactants and product.

.....

.....

.....

.....

..... [2]

(ii) The pressure of the equilibrium mixture is increased.

The temperature is kept at 200 °C.

$ICl(g)$ is a dark brown gas. $ICl_3(g)$ is a yellow gas.

Predict and explain what will happen to the colour of the equilibrium mixture.

prediction .....

.....

explanation .....

.....

.....

[2]

[Total:8]

10 Air contains a mixture of gases including the noble gases neon, argon, krypton and xenon. These noble gases are monatomic elements.

(a) State what is meant by monatomic.

.....

..... [1]

(b) State why noble gases are unreactive.

.....

..... [1]

(c) State why fractional distillation can be used to separate a liquid mixture of neon, argon, krypton and xenon.

.....

..... [1]

(d) State which noble gas, neon, argon, krypton or xenon, has the fastest rate of diffusion at 20 °C.

.....

Explain your answer.

.....

.....
[2]

(e) Air also contains oxides of nitrogen that are pollutants.

(i) State **one** adverse effect of oxides of nitrogen in the air.

..... [1]

(ii) With the aid of a symbol or word equation, explain how oxides of nitrogen such as NO are formed within a car engine.

.....

.....

..... [2]

[Total: 8]

BLANK PAGE

11 Table 11.1 shows some information about the homologous series of unbranched carboxylic acids.

Table 11.1

name	structure	boiling point / °C
methanoic acid	HCOOH	101
ethanoic acid	CH_3COOH	118
propanoic acid	CH_3CH_2COOH	141
butanoic acid	$CH_3CH_2CH_2COOH$	164
pentanoic acid	$CH_3CH_2CH_2CH_2COOH$	186

(a) One of the characteristics of a homologous series is that it has a general formula.

(i) Deduce the general formula for the homologous series of unbranched carboxylic acids.

..... [1]

(ii) Describe two **other** characteristics of a homologous series.

1 .....

.....

2 .....

.....

[2]

(b) An aqueous solution of propanoic acid is a weak acid.

Define the term acid.

.....

..... [1]

(c) Butanoic acid reacts with ethanol to make an ester.

State the name of the ester made and draw the displayed formula of the ester linkage.

name .....

displayed formula

[2]

(d) Ethanoic acid is a liquid at room temperature.

Describe the changes in the arrangement and movement of the molecules of ethanoic acid when it is heated from room temperature to 120 °C.

.....

.....

.....

.....

.....

..... [3]

[Total: 9]

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		**Key** atomic number atomic symbol name relative atomic mass									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 A*l* aluminium 27	14 Si silicon 28	15 P phosphorus 31	16 S sulfur 32	17 C*l* 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 T*l* 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 –	113 Nh nihonium –	114 F*l* flerovium –	115 Mc moscovium –	116 Lv livermorium –	117 Ts tennessine –	118 Og oganesson –

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.).