Cambridge Assessment International Education

Cambridge O Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

CHEMISTRY **5070/22**

Paper 2 Theory **May/June 2021**

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. Any blank pages are indicated.

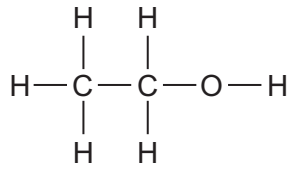
[Turn over

Section A

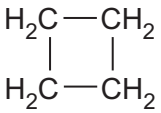
Answer **all** the questions in this section in the spaces provided.

The total mark for this section is 45.

1 Choose from the following compounds to answer the questions.



A



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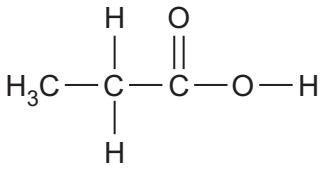

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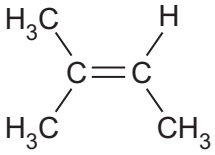

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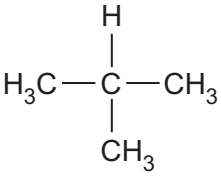

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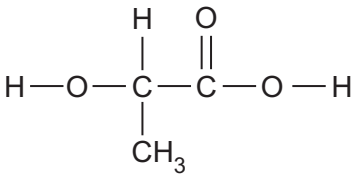

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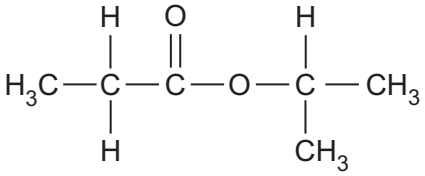

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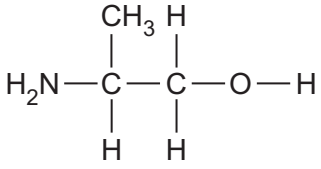


H

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

(a) State which compound:

(i) has a molecule with only 11 atoms

..... [1]

(ii) is oxidised to form ethanoic acid

..... [1]

(iii) is an isomer of butene

..... [1]

(iv) reacts with hydrogen in the presence of a catalyst to make an alkane

..... [1]

(v) contains four different elements chemically combined.

..... [1]

(b) Identify two compounds that have a pH of less than 7 in aqueous solution.

..... [1]

[Total: 6]

2 Oxygen, sulfur, selenium, tellurium and polonium are in Group VI.

(a) State the percentage composition by volume of oxygen in dry air.

..... [1]

(b) State one large-scale use for oxygen.

..... [1]

(c) Two isotopes of polonium are shown.

$^{209}_{84}Po$ $^{210}_{84}Po$

(i) Explain why both isotopes have the same chemical properties.

..... [1]

(ii) Give one difference in the atomic structure of these two isotopes.

..... [1]

(d) Selenium forms a compound that contains only selenium, oxygen and chlorine.

The compound contains 9.6% oxygen by mass and 42.8% chlorine by mass.

Calculate the empirical formula of this compound.

empirical formula ..... [3]

(e) A sample of oxygen has a volume of 11.5 dm^3 at room temperature and pressure.

(i) The temperature of the sample is decreased.

The pressure remains constant.

Describe and explain, using kinetic particle theory, what happens to the volume of the sample.

.....

..... [1]

(ii) The pressure of the sample is decreased.

The temperature remains constant.

Describe and explain, using kinetic particle theory, what happens to the volume of the sample.

.....

..... [1]

(iii) Calculate the mass of oxygen in the 11.5 dm^3 sample at room temperature and pressure.

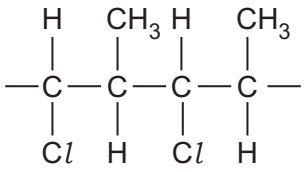
Give your answer to **two** significant figures.

mass ..... g [2]

[Total: 11]

3 There is concern about the disposal of plastics made from non-biodegradable polymers.

(a) The partial structure of a non-biodegradable polymer is shown.



(i) Name the type of polymer shown.

..... [1]

(ii) Draw the structure of the monomer used to make this polymer.

[1]

(iii) This polymer is often disposed of by combustion.

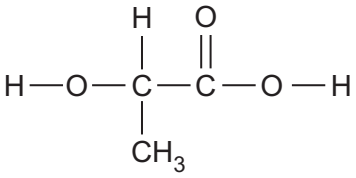
Suggest one problem associated with this method of disposal.

.....

..... [1]

(b) Lactic acid is used to make poly(lactic acid), a biodegradable polymer.

The structure of lactic acid is shown.



(i) Suggest what is meant by the term *biodegradable*.

.....

..... [1]

(ii) Draw the partial structure of poly(lactic acid).

Show at least two repeat units.

[2]

(iii) A factory uses 500 tonnes of lactic acid to make poly(lactic acid).

The percentage yield is 100% but the mass of poly(lactic acid) made is less than 500 tonnes.

Explain why the mass of poly(lactic acid) made is less than 500 tonnes.

.....

..... [1]

(iv) Aqueous lactic acid reacts with acidified potassium manganate(VII).

There is a colour change from purple to colourless.

Suggest what happens to the lactic acid in this reaction.

..... [1]

(v) Aqueous lactic acid is neutralised by aqueous sodium hydroxide.

Write the ionic equation for this neutralisation.

..... [1]

(vi) Aqueous lactic acid reacts with magnesium.

Name the gas made in this reaction.

..... [1]

[Total: 10]

4 Zinc bromide and zinc carbonate are both ionic compounds.

(a) Predict two physical properties, other than electrical conductivity, of zinc bromide.

1. .....

2. .....
[2]

(b) Zinc reacts with bromine to make zinc bromide.

$$Zn + Br_2 \longrightarrow ZnBr_2$$

Zinc bromide contains Zn^{2+} and Br^- ions.

Explain, in terms of the movement of electrons, how $ZnBr_2$ is formed from zinc atoms and bromine molecules.

.....

.....

..... [2]

(c) Aqueous zinc bromide reacts with magnesium as shown.

$$Zn^{2+} + Mg \longrightarrow Mg^{2+} + Zn$$

(i) Use the equation to explain that oxidation takes place.

.....

..... [1]

(ii) Use the equation to explain that reduction takes place.

.....

..... [1]

(d) Zinc carbonate is insoluble in water.

(i) Zinc carbonate can be prepared by reacting aqueous zinc bromide with CO_3^{2-}(aq) ions in a precipitation reaction.

Name a suitable aqueous solution that can provide CO_3^{2-}(aq) ions.

..... [1]

(ii) A sample of zinc carbonate is heated strongly.

Name the products of this reaction.

..... [1]

[Total: 8]

5 Petroleum (crude oil) provides the raw materials for making ethanol and ammonia.

(a) Describe how petroleum (crude oil) is separated to make fractions such as naphtha and petrol (gasoline).

.....

.....

..... [2]

(b) Compounds such as $C_{11}H_{24}$ in the naphtha fraction are cracked to make hydrogen, alkenes and smaller alkanes.

(i) Explain how the molecular formula $C_{11}H_{24}$ shows the compound is an alkane.

.....

..... [1]

(ii) Construct an equation to show the cracking of $C_{11}H_{24}$ to make ethene and an alkane only.

..... [1]

(c) Describe how hydrogen is converted into ammonia in the Haber process.

Include the conditions used in the Haber process.

.....

.....

.....

.....

..... [3]

(d) State one **other** use for hydrogen.

..... [1]

(e) Ethene reacts with a compound to make ethanol.

(i) Name the compound.

..... [1]

(ii) State one condition for this reaction.

..... [1]

[Total: 10]

Section B

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

The total mark for this section is 30.

6 Sulfur dioxide and oxides of nitrogen are pollutants found in air.

(a) State one environmental problem caused by the presence of sulfur dioxide in the air.

..... [1]

(b) Coal-fired power stations produce sulfur dioxide as a pollutant.

The sulfur dioxide produced is prevented from entering the air by a process called flue gas desulfurisation, FGD.

Name the compound used in FGD that reacts with the sulfur dioxide.

..... [1]

(c) Coal-fired power stations also produce oxides of nitrogen such as NO.

NO is produced when nitrogen, N_2, reacts with oxygen.

(i) Construct the equation for this reaction.

..... [1]

(ii) Draw a dot-and-cross diagram to show the bonding in a molecule of nitrogen.

Only include the outer shell electrons.

[1]

(iii) Explain why the rate of reaction between nitrogen and oxygen increases as the temperature increases.

.....

.....

..... [2]

(d) Nitrogen dioxide, NO_2, reacts with water to form a mixture of dilute nitric acid, HNO_3, and dilute nitrous acid, HNO_2.

$$2NO_2 + H_2O \longrightarrow HNO_2 + HNO_3$$

(i) Nitrogen dioxide reacts with aqueous sodium hydroxide to form two different salts and water.

Construct the equation for this reaction.

..... [2]

(ii) Nitric acid is a strong acid.

Nitrous acid is a weak acid.

Describe the difference between a weak acid and a strong acid.

.....

.....

..... [2]

[Total: 10]

7 Sulfamic acid, NH_2SO_3H, is a white crystalline solid.

It reacts with aqueous sodium nitrite to make nitrogen gas, as shown in the equation.

$$NH_2SO_3H(s) + NaNO_2(aq) \longrightarrow N_2(g) + H_2O(l) + NaHSO_4(aq)$$

(a) An excess of sulfamic acid reacts with a 20.0 cm^3 sample of 0.150 mol / dm^3 $NaNO_2(aq)$.

Calculate the maximum volume, in dm^3, of nitrogen formed, measured at room temperature and pressure.

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

(b) The rate of this reaction can be determined by measuring the volume of nitrogen formed every second.

Draw a labelled diagram of the assembled apparatus that can be used to make, collect and measure the volume of nitrogen formed in this reaction.

[2]

(c) The concentration of $NaNO_2(aq)$ is increased.

The temperature of the reaction remains constant.

State and explain how the rate of reaction changes.

.....

.....

.....

.....

..... [3]

(d) Sulfamic acid forms salts called sulfamates that contain the anion $NH_2SO_3^-$.

Magnesium carbonate, $MgCO_3$, is added to a sample of $NH_2SO_3H(aq)$.

Magnesium sulfamate, water and a gas are formed. The gas turns limewater milky.

Construct the equation for this reaction.

..... [3]

[Total: 10]

8 Lead is a metal with proton number 82.

(a) (i) Use the Periodic Table to state the number of occupied electron shells in an atom of lead.

..... [1]

(ii) Use the Periodic Table to state the number of electrons in the outer shell of an atom of lead.

..... [1]

(b) Describe, with the aid of a labelled diagram, the metallic bonding in lead.

.....

.....

.....

..... [3]

(c) Give two physical properties of lead that are characteristic of all metals.

1. .....

2. .....
[1]

(d) Lead(II) ethanoate is a white crystalline soluble salt.

Name a suitable combination of an acid and an insoluble base which is used to prepare lead(II) ethanoate.

acid .....

base .....
[1]

(e) Aqueous lead(II) ethanoate reacts with aqueous sodium iodide.

A yellow precipitate of lead(II) iodide, PbI_2, is formed.

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

..... [2]

(f) Explain why solid lead(II) iodide cannot be electrolysed.

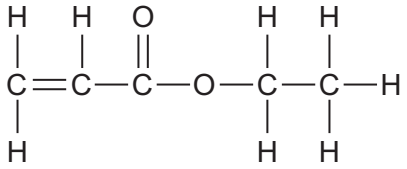
.....

.....

..... [1]

[Total: 10]

9 The structure of ethyl propenoate is shown.



(a) Circle the atoms in the structure that show that ethyl propenoate is an ester. [1]

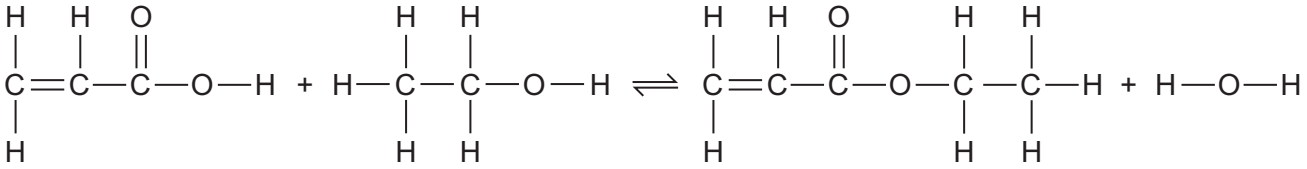
(b) Aqueous bromine is shaken with a sample of ethyl propenoate.

Explain, in terms of the structure of ethyl propenoate, why the aqueous bromine turns colourless.

.....

..... [1]

(c) Ethyl propenoate is prepared by the reversible reaction between a carboxylic acid and an alcohol, as shown.



A mixture of the carboxylic acid and the alcohol is allowed to reach equilibrium.

(i) Name the alcohol used in the reaction.

..... [1]

(ii) The reaction uses an acid catalyst.

State the effect of this catalyst on the position of equilibrium.

..... [1]

(iii) The concentration of the alcohol is increased.

Describe and explain what happens to the position of equilibrium.

.....

.....

..... [2]

(d) In an experiment 10.8 g of the carboxylic acid is reacted with an excess of the alcohol. The experimental yield of ethyl propenoate is 9.45 g.

[The relative formula mass of the carboxylic acid is 72.]

(i) Show that the maximum possible yield of ethyl propenoate is 15.0 g.

[3]

(ii) Calculate the percentage yield of ethyl propenoate in this experiment.

% yield ..... [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.).