Cambridge Assessment International Education

Cambridge IGCSE™ (9–1)

CANDIDATE NAME									
CENTRE NUMBER						CANDIDATE NUMBER				

7479384252

CHEMISTRY **0971/42**

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

1 hour 15 minutes

You must answer on the question paper.

No additional materials are needed.

INSTRUCTIONS

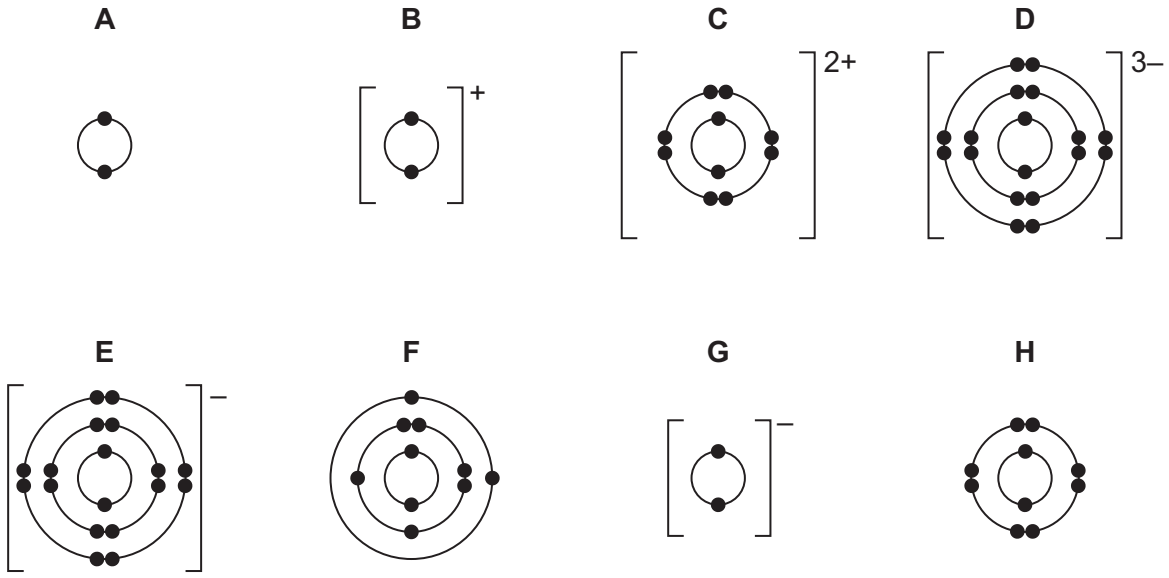
- Answer **all** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen or correction 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 **12** pages. Blank pages are indicated.

1 The electronic structures of some atoms and ions are shown.



(a) Write the letters, **A**, **B**, **C**, **D**, **E**, **F**, **G** or **H**, of the electronic structures which show:

(i) atoms of two different noble gases ..... and ..... [2]

(ii) an ion of a Group I element ..... [1]

(iii) an ion of a Group V element ..... [1]

(iv) a pair of ions that could form a compound with the formula XY_2. ..... and ..... [1]

(b) State which electronic structure, **A**, **B**, **C**, **D**, **E**, **F**, **G** or **H**, is incorrect.

Explain why.

incorrect electronic structure .....

explanation .....

..... [2]

(c) State how many protons are found in the nucleus of ion **C**. ..... [1]

(d) Use the Periodic Table to deduce:

(i) the chemical symbol for ion **G** ..... [1]

(ii) the element which forms an ion with a 3+ charge and the same electronic structure as **H**.

..... [1]

[Total: 10]

2 Soluble salts can be made by adding a metal carbonate to a dilute acid.

(a) Give the formula of the dilute acid which reacts with a metal carbonate to form a nitrate salt.

..... [1]

(b) A student wanted to make hydrated iron(II) sulfate crystals, $FeSO_4 \cdot xH_2O$, by adding excess iron(II) carbonate to dilute sulfuric acid. The student followed the procedure shown.

step 1 Add dilute sulfuric acid to a beaker.

step 2 Add small amounts of iron(II) carbonate to the dilute sulfuric acid in the beaker until the iron(II) carbonate is in excess.

step 3 Filter the mixture formed in **step 2**.

step 4 Heat the filtrate until it is a saturated solution. Allow to cool.

step 5 Once cold, pour away the remaining solution. Dry the crystals between filter papers.

(i) Why must the iron(II) carbonate be added in excess in **step 2**?

..... [1]

(ii) State **two** observations in **step 2** that would show that iron(II) carbonate was in excess.

1 .....

2 .....
[2]

(iii) Describe what should be done during **step 3** to ensure there is a maximum yield of crystals.

..... [1]

(iv) A saturated solution is formed in **step 4**.

Describe what a saturated solution is.

.....

..... [2]

(v) Name a different compound that could be used instead of iron(II) carbonate to produce hydrated iron(II) sulfate crystals from dilute sulfuric acid.

..... [1]

[Turn over

(c) On analysing the crystals, the student found that one mole of the hydrated iron(II) sulfate crystals, $FeSO_4 \bullet xH2O$, had a mass of 278 g.

Determine the value of *x* using the following steps:

- calculate the mass of one mole of $FeSO_4$

mass = ... g

- calculate the mass of H_2O present in one mole of $FeSO_4 \bullet xH_2O$

mass of H_2O = ... g

- determine the value of *x*.

x = ...
[3]

(d) Insoluble salts can be made by mixing solutions of two soluble salts.

A student followed the procedure shown to make silver bromide, an insoluble salt.

step 1 Add aqueous silver nitrate to a beaker. Then add aqueous potassium bromide and stir.

step 2 Filter the mixture formed in **step 1**.

step 3 Dry the residue.

(i) State the term used to describe this method of making salts.

..... [1]

(ii) Give the observation the student would make during **step 1**.

..... [1]

(iii) Write the ionic equation for the reaction between aqueous silver nitrate and aqueous potassium bromide.

Include state symbols.

..... [3]

(e) Sodium chloride is an ionic salt. It can be made by reacting sodium with chlorine gas.

The equation for this reaction is shown.

$$2Na(s) + Cl_2(g) \rightarrow 2NaCl(s)$$

Calculate the volume of chlorine gas, in cm^3, that reacts to form 2.34 g of $NaCl$.

The reaction takes place at room temperature and pressure.

volume of chlorine gas = ... cm^3 [3]

(f) Sodium chloride does not conduct electricity when solid, but does conduct electricity when molten.

(i) Explain why, in terms of structure and bonding.

.....

.....

.....

..... [3]

(ii) Name the product formed at the positive electrode when electricity is passed through molten sodium chloride.

..... [1]

(iii) State the type of change that occurs at the positive electrode in **(ii)**.

Explain your answer in terms of electron transfer.

type of change .....

explanation .....
[2]

(iv) Describe what else can be done to sodium chloride to allow it to conduct electricity.

..... [1]

[Total: 26]

[Turn over

3 Group I metals are very reactive. Transition elements are also metals but are less reactive than Group I metals.

(a) State **two** physical properties of Group I metals which are similar to those of transition metals.

1 .....

2 .....
[2]

(b) Describe **two** ways in which the physical properties of Group I metals are different from those of transition metals.

1 .....

.....

2 .....

.....
[2]

(c) When Group I metals are added to water they fizz and an alkaline solution forms.

(i) Name the gas given off.

..... [1]

(ii) Identify the ion present in the solution which makes the solution alkaline.

..... [1]

(iii) Write the chemical equation for the reaction between sodium and water.

..... [2]

(d) When the transition element iron is added to water the iron rusts.

When an iron object is coated with a layer of zinc, rusting is prevented.

(i) Name this process of coating iron objects with a layer of zinc.

..... [1]

(ii) Explain how completely coating an iron object with a layer of zinc prevents rusting.

..... [1]

(iii) Rusting of iron ships can be prevented by attaching zinc blocks to the hull of the ship.

Explain how this prevents rusting.

.....

..... [2]

[Total: 12]

4 Alkenes and alkanes are homologous series of compounds containing carbon and hydrogen atoms.

(a) State the name of the type of compound made from carbon and hydrogen atoms only.

..... [1]

(b) Alkenes take part in addition reactions.

(i) Describe what is meant by the term *addition reaction*.

..... [1]

(ii) Draw the structure of the product made in the addition reaction between propene and bromine. Show all of the atoms and all of the bonds.

[2]

(iii) Describe the colour change seen when propene is added to aqueous bromine.

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

(iv) Draw the structures of molecules of **two** different alkenes which both undergo an addition reaction with steam to form butan-2-ol. Show all of the atoms and all of the bonds.

[2]

(c) Propane undergoes a substitution reaction with chlorine.

Write the chemical equation for the reaction between one molecule of propane and one molecule of chlorine.

..... [2]

[Total: 10]

[Turn over

5 This question is about alcohols, carboxylic acids and esters.

(a) Ethanol will react with hot aqueous potassium manganate(VII) to form ethanoic acid.

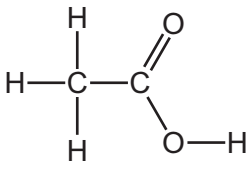
(i) State the other condition needed for this reaction to take place.

..... [1]

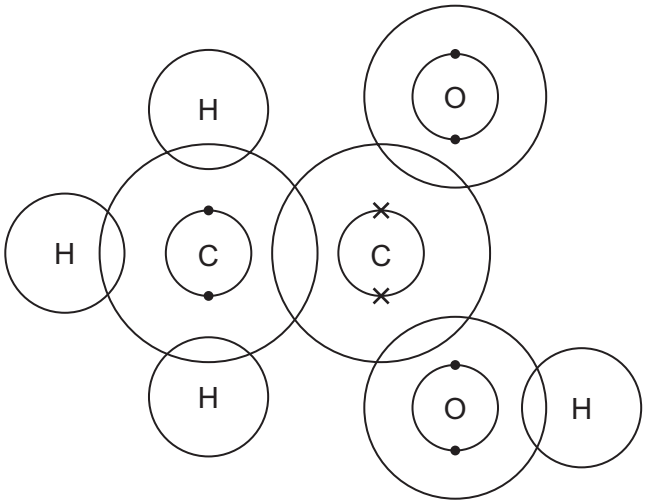
(ii) State the type of chemical change that happens to the ethanol during this reaction.

..... [1]

(iii) The structure of ethanoic acid is shown.



Complete the dot-and-cross diagram to show the electron arrangement in a molecule of ethanoic acid.



[3]

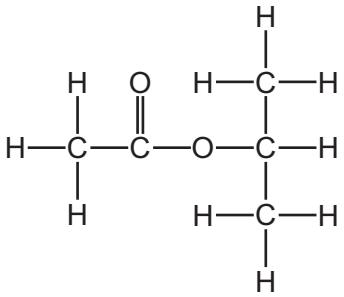
(b) Ethanoic acid is a weak acid and hydrochloric acid is a strong acid.

Complete the table to show the similarities and differences in the properties of samples of these two acids of equal concentration.

	dilute ethanoic acid	dilute hydrochloric acid
extent of dissociation		
colour after adding universal indicator solution		
observation when magnesium ribbon is added		

[6]

(c) Ethanoic acid will react with an alcohol to form the ester shown.



(i) Name the **other** product formed when ethanoic acid reacts with an alcohol to make this ester.

..... [1]

(ii) Give **one** condition needed when ethanoic acid reacts with the alcohol to make this ester.

..... [1]

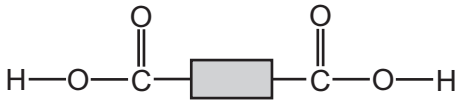
(iii) Draw the structure of the alcohol which was added to ethanoic acid to make this ester. Show all of the atoms and all of the bonds.

[2]

(d) Polyesters can be manufactured from carboxylic acids and alcohols.

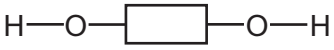
Hexanedioic acid has the structure: $HOOC–CH_2–CH_2–CH_2–CH_2–COOH$.

This structure can be simplified as shown.



Ethanediol has the structure: $HO–CH_2–CH_2–OH$.

This structure can be simplified as shown.



The functional groups are found at the end of each molecule.

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

..... [1]

(ii) Determine the empirical formula of hexanedioic acid.

..... [1]

(iii) Calculate the percentage by mass of oxygen present in ethanediol.

Give your answer to the nearest whole number.

..... % [2]

(iv) Complete the diagram to show a section of polyester manufactured from hexanedioic acid and ethanediol. Include all of the atoms and all of the bonds in the linkages.

[2]

(v) State the name of a polyester.

..... [1]

[Total: 22]

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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.).