



# Cambridge IGCSE™ (9–1)

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## 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.

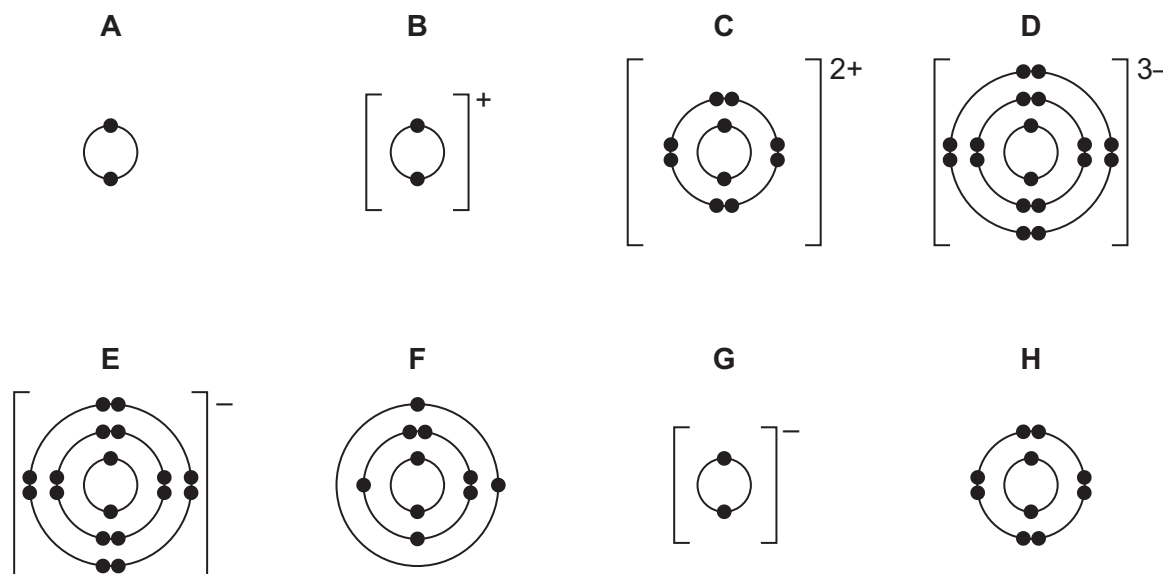
### INFORMATION

- 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,  $\text{FeSO}_4 \cdot x\text{H}_2\text{O}$ , 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]

- (c) On analysing the crystals, the student found that one mole of the hydrated iron(II) sulfate crystals,  $\text{FeSO}_4 \cdot x\text{H}_2\text{O}$ , had a mass of 278 g.

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

- calculate the mass of one mole of  $\text{FeSO}_4$

mass = ..... g

- calculate the mass of  $\text{H}_2\text{O}$  present in one mole of  $\text{FeSO}_4 \cdot x\text{H}_2\text{O}$

mass of  $\text{H}_2\text{O}$  = ..... 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]

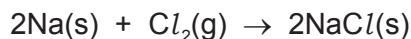
- (iii) Write the ionic equation for the reaction between aqueous silver nitrate and aqueous potassium bromide.

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.



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

The reaction takes place at room temperature and pressure.

volume of chlorine gas = .....  $\text{cm}^3$  [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]

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]

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

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

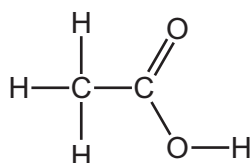
(i) State the other condition needed for this reaction to take place.

..... [1]

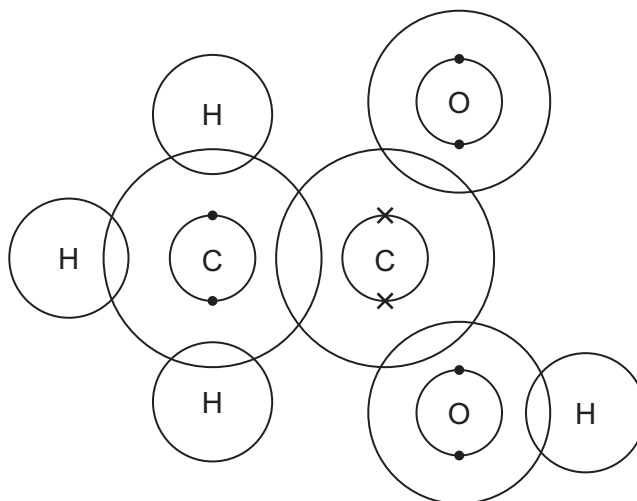
(ii) State the type of chemical change that happens to the ethanol during this reaction.

..... [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]



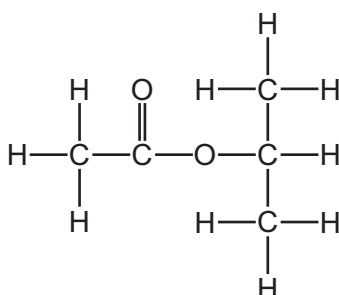
- (b) Ethanoic acid is a weak acid and hydrochloric acid is a strong acid.

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.



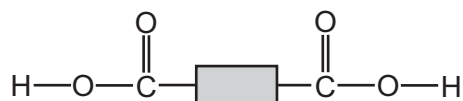
- (i) Name the **other** product formed when ethanoic acid reacts with an alcohol to make this ester.  
 ..... [1]
- (ii) Give **one** condition needed when ethanoic acid reacts with the alcohol to make this ester.  
 ..... [1]
- (iii) Draw the structure of the alcohol which was added to ethanoic acid 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.

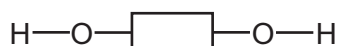
Hexanedioic acid has the structure:  $\text{HOOC}-\text{CH}_2-\text{CH}_2-\text{CH}_2-\text{CH}_2-\text{COOH}$ .

This structure can be simplified as shown.



Ethanediol has the structure:  $\text{HO}-\text{CH}_2-\text{CH}_2-\text{OH}$ .

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	2	3	4	5	6	7	8	9	10
H hydrogen 1	He helium 4	B boron 11	C carbon 12	N nitrogen 14	O oxygen 16	F fluorine 19	Ne neon 20		
<b>Key</b>									
atomic number atomic symbol name relative atomic mass									
3	4	5	6	7	8	9	10	11	12
Li lithium 7	Be beryllium 9	B boron 11	C carbon 12	N nitrogen 14	O oxygen 16	F fluorine 19	Ne neon 20	Na sodium 23	Mg magnesium 24
11	12	13	14	15	16	17	18	19	20
Na sodium 23	Mg magnesium 24	Al aluminium 27	Si silicon 28	P phosphorus 31	S sulfur 32	Cl chlorine 35.5	Ar argon 40	K potassium 39	Ca calcium 40
19	20	21	22	23	24	25	26	27	28
K potassium 39	Ca calcium 40	Sc scandium 45	Ti titanium 48	V vanadium 51	Cr chromium 52	Mn manganese 55	Fe iron 56	Co cobalt 59	Ni nickel 59
37	38	39	40	41	42	43	44	45	46
Rb rubidium 85	Sr strontium 88	Y yttrium 89	Zr zirconium 91	Nb niobium 93	Mo molybdenum 96	Tc technetium —	Ru ruthenium 101	Rh rhodium 103	Pd palladium 106
55	56	57–71	72	73	74	75	76	77	78
Cs caesium 133	Ba barium 137	lanthanoids	Hf hafnium 178	Ta tantalum 181	W tungsten 184	Re rhenium 186	Os osmium 190	Ir iridium 192	Pt platinum 195
87	88	89–103	104	105	106	107	108	109	110
Fr francium —	Ra radium —	actinoids	Rf rutherfordium —	Db dubnium —	Sg seaborgium —	Bh bohrium —	Hs hassium —	Mt meitnerium —	Ds darmstadtium —
81	82	83	84	85	86	87	88	89	90
Tl thallium 204	Pb lead 207	Bi bismuth 209	Po polonium —	At astatine —	Rn radon —	Ac actinium —	Th thorium 232	Pa protactinium 231	U uranium 238
91	92	93	94	95	96	97	98	99	100
Th thorium 232	Pa protactinium 231	Np neptunium —	Pu plutonium —	Am americium —	Cm curium —	Bk berkelium —	Cf californium —	Es einsteinium —	Fm fermium —
101	102	103	104	105	106	107	108	109	110
Md mendelevium —	No nobelium —	Lr lawrencium —	103	104	105	106	107	108	109
109	110	111	112	113	114	115	116	117	118
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