



Cambridge Assessment International Education
Cambridge International General Certificate of Secondary Education (9–1)

CANDIDATE
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CHEMISTRY

0971/41

Paper 4 Theory (Extended)

May/June 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 document consists of **13** printed pages and **3** blank pages.



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1 This question is about the structures of atoms and ions.

(a) Define the term *proton number*.

.....
 [2]

(b) (i) Complete the table to show the number of protons, neutrons and electrons present in atoms of ${}^{24}_{12}\text{Mg}$ and ${}^{26}_{12}\text{Mg}$.

	number of protons	number of neutrons	number of electrons
${}^{24}_{12}\text{Mg}$			
${}^{26}_{12}\text{Mg}$			

[2]

(ii) What term is used to describe atoms of the same element, such as ${}^{24}_{12}\text{Mg}$ and ${}^{26}_{12}\text{Mg}$?

..... [1]

(iii) Explain why the chemical properties of ${}^{24}_{12}\text{Mg}$ and ${}^{26}_{12}\text{Mg}$ are the same.

.....
 [2]

(c) Complete the table to identify the atoms and ions which have the following numbers of protons, neutrons and electrons.

	number of protons	number of neutrons	number of electrons
${}^{23}_{11}\text{Na}^+$	11	12	10
	4	5	4
	17	20	18

[4]

(d) State the electronic structure of the following atom and ion.

Al

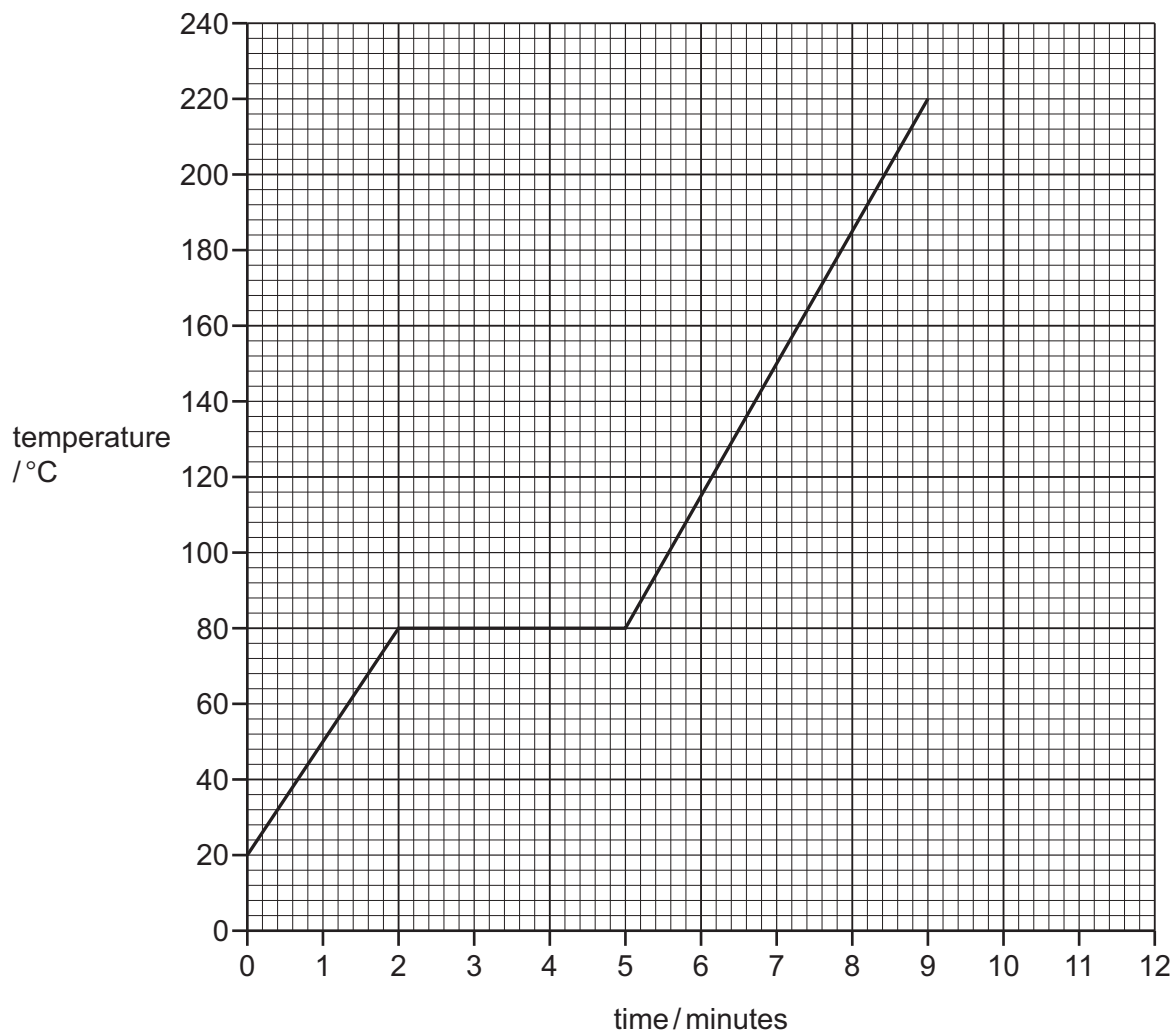
S^{2-}

[2]

[Total: 13]

- 2 **Z** is a covalent substance. In an experiment, a sample of pure solid **Z** was continually heated for 11 minutes.

The graph shows how the temperature of the sample of pure **Z** changed during the first 9 minutes.



- (a) What is the melting point of pure **Z**?

..... °C [1]

- (b) The sample of pure **Z** began to boil at 9 minutes. It was boiled for 2 minutes.

Use this information to sketch on the grid how the temperature of the sample of pure **Z** changed between 9 minutes and 11 minutes. [1]

- (c) The sample of pure **Z** was continually heated between 2 minutes and 5 minutes.

Explain, in terms of attractive forces, why there was no increase in the temperature of the sample of pure **Z** between 2 minutes and 5 minutes.

.....

 [2]

- (d) Describe how the motion of particles of pure **Z** changed from 0 minutes to 2 minutes.

.....
 [2]

- (e) The experiment was repeated using a solid sample of **impure Z**.

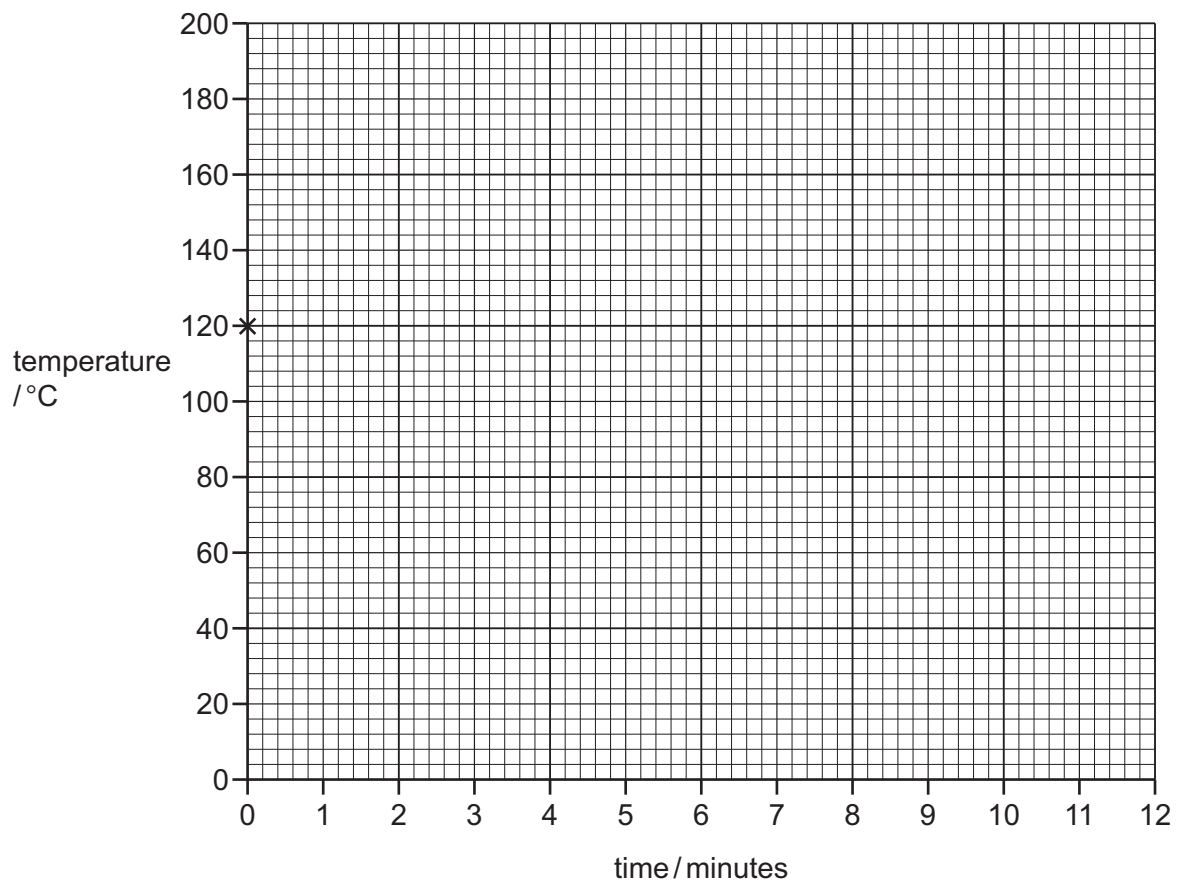
Suggest the differences, if any, in the melting point and boiling point of the sample of impure **Z** compared to the sample of pure **Z**.

melting point

boiling point [2]

- (f) A sample of pure **Z** was allowed to cool from 120 °C to 20 °C. The total time taken was 8 minutes.

Starting from point **x**, sketch on the grid how the temperature of the sample of pure **Z** changed between 0 minutes and 8 minutes.



[2]

[Total: 10]

3 Zinc and copper are elements next to each other in the Periodic Table.

(a) Zinc is obtained from zinc blende in a two-step process.

- In **step 1**, zinc blende is converted into zinc oxide.
- In **step 2**, zinc oxide is converted into zinc in a blast furnace.

Outline how each of these steps are done.

In your answer:

- give **one** chemical equation for each step
- describe how zinc is removed from the blast furnace in **step 2**.

step 1

.....

chemical equation

step 2

.....

chemical equation

removal of zinc in **step 2**

.....

[5]

(b) Name the alloy formed when zinc is mixed with copper.

..... [1]

(c) Copper is a transition element. It can have variable oxidation states.

State **two** other chemical properties of transition elements which make them different from Group I elements.

1

2

[2]

(d) A compound of copper can be used to test for water.

(i) State the full name of this compound of copper.

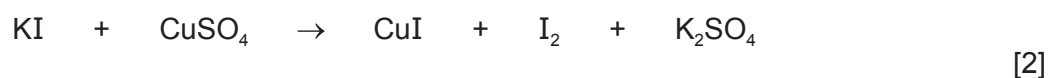
..... [1]

(ii) State the colour change that occurs when water is added to this compound of copper.

from to [2]

(e) Aqueous potassium iodide reacts with aqueous copper(II) sulfate to produce iodine.

(i) Balance the chemical equation for this reaction.



(ii) Deduce the charge on the copper ion in CuI.

..... [1]

(iii) In terms of electron transfer, explain why copper is reduced in this reaction.

..... [1]

(iv) Identify the reducing agent.

..... [1]

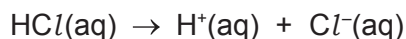
[Total: 16]

- 4 Ethanoic acid is a weak acid and hydrochloric acid is a strong acid.
Both ethanoic acid and hydrochloric acid dissociate in aqueous solution.

(a) (i) Define the term *acid*.

..... [1]

- (ii) The chemical equation shows the changes which occur when the **strong** acid, hydrochloric acid, is added to water.



Complete the chemical equation to show the changes which occur when the **weak** acid, ethanoic acid, is added to water.

$\text{CH}_3\text{COOH(aq)}$ [2]

- (b) A student does experiments to show that hydrochloric acid is a strong acid and ethanoic acid is a weak acid. The student adds an excess of hydrochloric acid and an excess of ethanoic acid to separate samples of lumps of calcium carbonate.

Only the identity of the acid is changed between the experiments. All other conditions are kept the same.

- (i) State **two** observations which would show that hydrochloric acid is a stronger acid than ethanoic acid.

1

2 [2]

- (ii) The student uses the same size container and checks that the pressure is the same for each experiment.

State **three** other conditions which must be kept the same to ensure fair testing.

1

2

3 [3]

(c) Hydrochloric acid produces salts called chlorides.

Magnesium carbonate reacts with hydrochloric acid to produce magnesium chloride.



A student used 50.00 cm^3 of 2.00 mol/dm^3 hydrochloric acid in an experiment to produce magnesium chloride.

Calculate the mass, in g, of magnesium carbonate needed to react exactly with 50.00 cm^3 of 2.00 mol/dm^3 hydrochloric acid using the following steps.

- Calculate the number of moles of HCl present in 50.00 cm^3 of 2.00 mol/dm^3 HCl .

..... mol

- Determine the number of moles of MgCO_3 which would react with 50.00 cm^3 of 2.00 mol/dm^3 HCl .

..... mol

- Calculate the relative formula mass, M_r , of MgCO_3 .

M_r of $\text{MgCO}_3 =$

- Calculate the mass of MgCO_3 needed to react exactly with 50.00 cm^3 of 2.00 mol/dm^3 HCl .

mass = g
[4]

- (d) A student prepares crystals of magnesium chloride by adding an excess of magnesium carbonate to 50.00 cm³ of 2.00 mol/dm³ hydrochloric acid.

The student filters the mixture and rinses the residue.

- (i) Why does the student add an **excess** of magnesium carbonate?

..... [1]

- (ii) Why does the student rinse the residue?

..... [1]

- (iii) Describe how the student would obtain pure crystals of magnesium chloride from the filtrate.

.....

 [3]

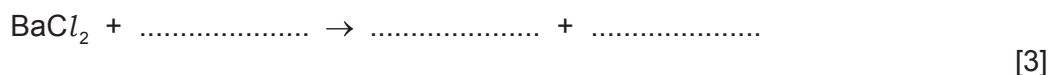
- (e) Silver chloride, AgCl, is insoluble. It can be made by a precipitation reaction between aqueous barium chloride and a suitable aqueous silver salt.

- (i) What is meant by the term *precipitate*?

.....
 [2]

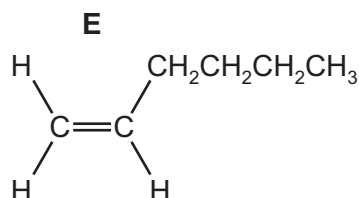
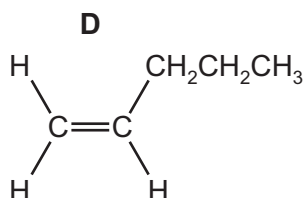
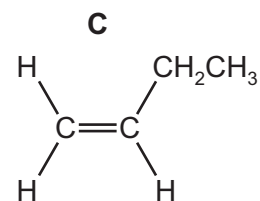
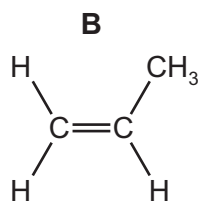
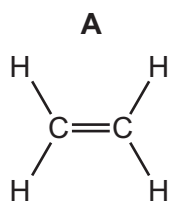
- (ii) Name a suitable silver salt to use to prepare silver chloride.
 Complete the chemical equation to show the formation of insoluble silver chloride from aqueous barium chloride and the silver salt you have named.

name of a suitable silver salt



[Total: 22]

5 The structures of five alkenes, **A**, **B**, **C**, **D** and **E**, are shown.



(a) What is the general formula of alkenes?

..... [1]

(b) What is the molecular formula of alkene **D**?

..... [1]

(c) Predict which alkene, **A**, **B**, **C**, **D** or **E**, has the highest boiling point.
Explain your answer.

alkene

explanation

..... [2]

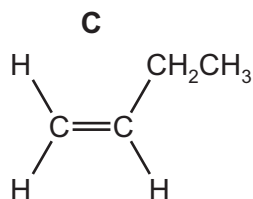
(d) Which alkene, **A**, **B**, **C**, **D** or **E**, diffuses most quickly?
Explain your answer.

alkene

explanation

..... [2]

- (e) A student added aqueous bromine to alkene **C**.



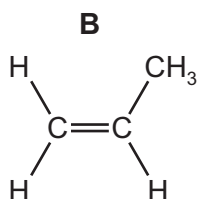
Describe the colour change seen and draw the structure of the product. Show all of the atoms and all of the bonds.

colour change from to

structure

[2]

- (f) Two different alcohols can be produced from alkene **B** by an addition reaction.



- (i) Draw the structures of the **two** alcohols. Show all of the atoms and all of the bonds.

[2]

- (ii) State the reagent and conditions needed to produce an alcohol from alkene **B**.

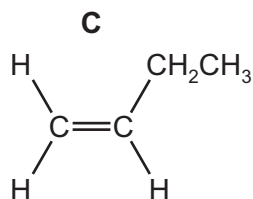
reagent

conditions

.....

[3]

(g) Alkene **C** can be converted into a polymer.



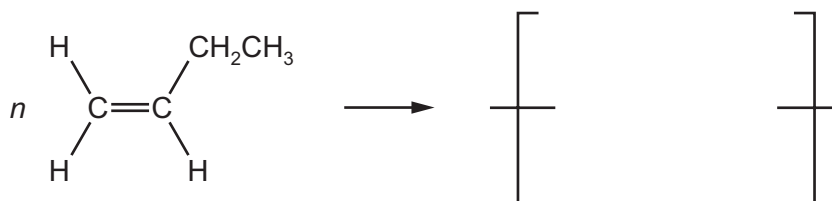
(i) What type of polymerisation occurs?

..... [1]

(ii) Suggest the name of the polymer formed.

..... [1]

(iii) Complete the chemical equation to show this polymerisation.



[3]

(iv) State the empirical formula of the polymer formed.

..... [1]

[Total: 19]

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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		
Key									
atomic number atomic symbol name relative atomic mass									
11	12	13	14	15	16	17	18		
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		
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 —
atomic number atomic symbol name relative atomic mass									
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 —	Cn copernicium —	Nh nihonium —	Dl dubnium —	Fl flerovium —
91	92	93	94	95	96	97	98	99	100
Ac actinium —	Th thorium 232	Pa protactinium 231	U uranium 238	Np neptunium —	Pu plutonium —	Am americium —	Cm curium —	Bk berkelium —	Cf californium —
101	102	103	104	105	106	107	108	109	110
Lr lawrencium —	No nobelium —	Lr lawrencium —	Lr lawrencium —	Lr lawrencium —	Lr lawrencium —	Lr lawrencium —	Lr lawrencium —	Lr lawrencium —	Lr lawrencium —

lanthanoids

actinoids

57	58	59	60	61	62	63	64	65	66	67	68	69	70	71
La lanthanum 139	Ce cerium 140	Pr praseodymium 141	Nd neodymium 144	Pm promethium —	Sm samarium 150	Eu europium 152	Gd gadolinium 157	Tb terbium 159	Dy dysprosium 163	Ho holmium 165	Er erbium 167	Tm thulium 169	Yb ytterbium 173	Lu lutetium 175
89	90	91	92	93	94	95	96	97	98	99	100	101	102	103
Ac actinium —	Th thorium 232	Pa protactinium 231	U uranium 238	Np neptunium —	Pu plutonium —	Am americium —	Cm curium —	Bk berkelium —	Cf californium —	Es einsteinium —	Fm fermium —	Md mendelevium —	No nobelium —	Lr lawrencium —

The volume of one mole of any gas is 24 dm³ at room temperature and pressure (r.t.p.).