



**Cambridge Assessment International Education**  
Cambridge International General Certificate of Secondary Education

CANDIDATE  
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**CHEMISTRY**

**0620/42**

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 syllabus is regulated for use in England, Wales and Northern Ireland as a Cambridge International Level 1/Level 2 Certificate.

This document consists of **13** printed pages and **3** blank pages.

1 The names of eight substances are given.

aluminium oxide

calcium oxide

ethanol

nitrogen

iron(III) oxide

methane

oxygen

silicon(IV) oxide

Answer the following questions about these substances.

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

State which substance is:

(a) the main constituent of natural gas

..... [1]

(b) a reactant in respiration

..... [1]

(c) the main constituent of bauxite

..... [1]

(d) a product of photosynthesis

..... [1]

(e) a greenhouse gas

..... [1]

(f) a macromolecular solid.

..... [1]

[Total: 6]

2 (a)  $^{22}_{11}\text{Na}$ ,  $^{23}_{11}\text{Na}$  and  $^{24}_{11}\text{Na}$  are isotopes of sodium.

(i) Describe how these sodium isotopes are the same and how they are different in terms of the total number of protons, neutrons and electrons in each.

same .....

.....

different .....

.....

[3]

(ii) Why do all **three** isotopes have an overall charge of zero?

.....

..... [1]

(iii) Why do all **three** isotopes have the same chemical properties?

.....

..... [2]

(iv) Why do sodium ions have a charge of +1?

.....

..... [1]

(b) Carbon is an element which exists in different forms.

(i) Name **two** forms of the element carbon that have giant covalent structures.

..... and ..... [1]

(ii) Name the oxide of carbon that is a toxic gas.

..... [1]

[Total: 9]

3 This question is about phosphorus and compounds of phosphorus.

(a) Phosphorus has the formula  $P_4$ . Some properties of  $P_4$  are shown.

melting point/ $^{\circ}C$	45
boiling point/ $^{\circ}C$	280
electrical conductivity	non-conductor
solubility in water	insoluble

(i) Name the type of bonding that exists between the atoms in a  $P_4$  molecule.

..... [1]

(ii) Explain, in terms of attractive forces between particles, why  $P_4$  has a low melting point.

.....  
 ..... [1]

(iii) Explain why phosphorus is a non-conductor of electricity.

.....  
 ..... [1]

(b) Phosphorus,  $P_4$ , reacts with air to produce phosphorus(V) oxide,  $P_4O_{10}$ .

(i) Write a chemical equation for this reaction.

..... [2]

(ii) What type of chemical reaction is this?

..... [1]

(c) Phosphorus(V) oxide,  $P_4O_{10}$ , is an acidic oxide.

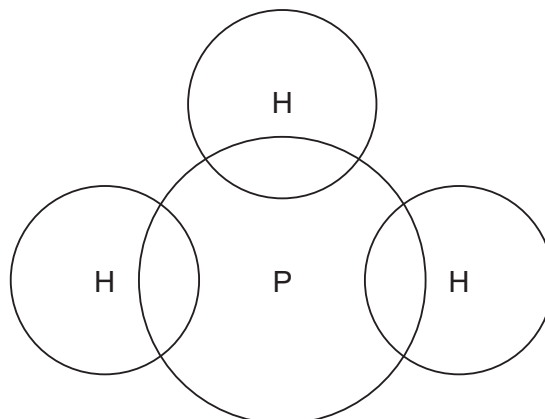
Phosphorus(V) oxide,  $P_4O_{10}$ , reacts with aqueous sodium hydroxide to form a salt containing the phosphate ion,  $PO_4^{3-}$ . Water is the only other product.

Write a chemical equation for the reaction between phosphorus(V) oxide and aqueous sodium hydroxide.

..... [2]

(d) Phosphine has the formula  $\text{PH}_3$ .

Complete the dot-and-cross diagram to show the electron arrangement in a molecule of phosphine. Show outer shell electrons only.



[2]

(e) Phosphine,  $\text{PH}_3$ , has a similar chemical structure to ammonia,  $\text{NH}_3$ .

Ammonia acts as a base when it reacts with sulfuric acid.

(i) What is meant by the term *base*?

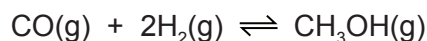
..... [1]

(ii) Write a chemical equation for the reaction between ammonia and sulfuric acid.

..... [2]

[Total: 13]

- 4 Methanol is made industrially by reacting carbon monoxide with hydrogen. The gases react at a temperature of 250 °C and a pressure of 75 atmospheres.



The forward reaction is exothermic.

- (a) Suggest a source of hydrogen for this industrial process.

..... [1]

- (b) Complete the table using only the words *increases*, *decreases* or *no change*.

	effect on the rate of the reverse reaction	effect on the equilibrium yield of CH <sub>3</sub> OH(g)
adding a catalyst		no change
increasing the temperature	increases	
decreasing the pressure		

[4]

- (c) Methanol is a member of the homologous series of alcohols.

- (i) State **two** general characteristics of a homologous series.

1 .....

2 .....

[2]

- (ii) Draw the structures of **two** different alcohols, each containing **three** carbon atoms. Show all of the atoms and all of the bonds.

Name these **two** alcohols.

name .....
------------

name .....
------------

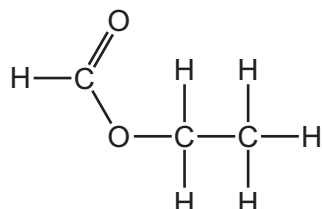
[4]

- (iii) What term is used to describe compounds with the same molecular formula but different structural formulae?

..... [1]

- (d) Alcohols react with carboxylic acids to produce esters.

- (i) The structure of ester **X** is shown.



Name ester **X**.

..... [1]

- (ii) Give the name of the carboxylic acid and the alcohol that react together to produce ester **X**.

carboxylic acid .....

alcohol .....

[2]

- (iii) Ester **Y** is different from ester **X** but also has the formula  $C_3H_6O_2$ .

Draw the structure of ester **Y**. Show all of the atoms and all of the bonds.

..... [2]

[Total: 17]

5 Copper(II) sulfate crystals,  $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ , are hydrated.

Copper(II) sulfate crystals are made by reacting copper(II) carbonate with dilute sulfuric acid.

The equation for the overall process is shown.



**step 1** Powdered solid copper(II) carbonate is added to  $50.0 \text{ cm}^3$  of  $0.05 \text{ mol/dm}^3$  sulfuric acid until the copper(II) carbonate is in excess.

**step 2** The excess of copper(II) carbonate is separated from the aqueous copper(II) sulfate.

**step 3** The aqueous copper(II) sulfate is heated until the solution is saturated.

**step 4** The solution is allowed to cool and crystallise.

**step 5** The crystals are removed and dried.

(a) Calculate the maximum mass of the copper(II) sulfate crystals,  $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ , that can form using the following steps.

- Calculate the number of moles of  $\text{H}_2\text{SO}_4$  in  $50.0 \text{ cm}^3$  of  $0.05 \text{ mol/dm}^3$   $\text{H}_2\text{SO}_4$ .

..... mol

- Determine the number of moles of  $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$  that can form.

..... mol

- The  $M_r$  of  $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$  is 250.

Calculate the maximum mass of  $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$  that can form.

..... g  
[3]



- (b) **Steps 1–5** were done correctly but the mass of crystals obtained was less than the maximum mass.

Explain why.

..... [1]

- (c) State **two** observations that would indicate that the copper(II) carbonate is in excess in **step 1**.

1 .....

2 ..... [2]

- (d) When the reaction in **step 1** is done using lumps of copper(II) carbonate instead of powder, the rate of reaction decreases. All other conditions are kept the same.

Give a reason for this. Explain your answer in terms of particles.

.....  
 .....  
 ..... [2]

- (e) Name a different substance, other than copper(II) carbonate, that could be added to dilute sulfuric acid to produce copper(II) sulfate in **step 1**.

..... [1]

- (f) Name the process used to separate the aqueous copper(II) sulfate from the excess of copper(II) carbonate in **step 2**.

..... [1]

- (g) The solution of aqueous copper(II) sulfate was heated until it was saturated in **step 3**.

- (i) Suggest what is meant by the term *saturated solution*.

.....  
 .....  
 ..... [2]

- (ii) What evidence would show that the solution was saturated in **step 3**?

..... [1]

- (iii) Why should the aqueous copper(II) sulfate **not** be heated to dryness in **step 3**?

..... [1]

[Total: 14]

6 The halogens are the elements in Group VII of the Periodic Table.

(a) Predict the physical state and colour of astatine at room temperature and pressure.

physical state .....

colour .....

[2]

(b) When chlorine reacts with aqueous potassium bromide a displacement reaction occurs.

(i) Describe the colour change of the solution.

from ..... to .....

[2]

(ii) Write a chemical equation for this reaction.

..... [2]

(c) Reactions occur when some aqueous solutions of halogens are added to aqueous solutions of halides.

Use the key to complete the table to show the results of adding halogens to halides.

key

✓ = reaction

x = no reaction

		halides		
		KCl(aq)	KBr(aq)	KI(aq)
halogens	Cl <sub>2</sub> (aq)		✓	
	Br <sub>2</sub> (aq)			
	I <sub>2</sub> (aq)			

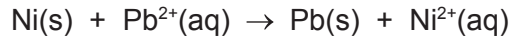
[2]

[Total: 8]

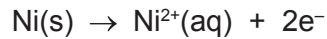
- 7 (a) Displacement reactions occur between metals and metal ions.

Displacement reactions can be used to determine the order of reactivity of metals such as lead (Pb), nickel (Ni), and silver (Ag).

The ionic equation for a displacement reaction is shown.



The ionic half-equations for this reaction are shown.



The ionic half-equations show that electrons are donated by nickel atoms and accepted by lead ions.

- (i) Identify the reducing agent in the displacement reaction. Give a reason for your answer.

reducing agent.....

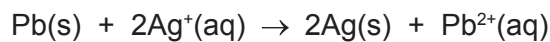
reason.....

[2]

- (ii) What is the general term given to the type of reaction in which electrons are transferred from one species to another?

..... [1]

- (b) The ionic equation for another displacement reaction is shown.



Write the **two** ionic half-equations for this reaction.

1 .....

2 .....

[2]

- (c) Use the information in (a) and (b) to put the **three** metals lead, nickel and silver in order of reactivity.

	most reactive
	↑
	least reactive

[1]

(d) Nickel is a transition element. Nickel is stronger than sodium.

Describe **two** other differences in the physical properties of nickel and sodium.

- 1 .....
- 2 .....

[2]

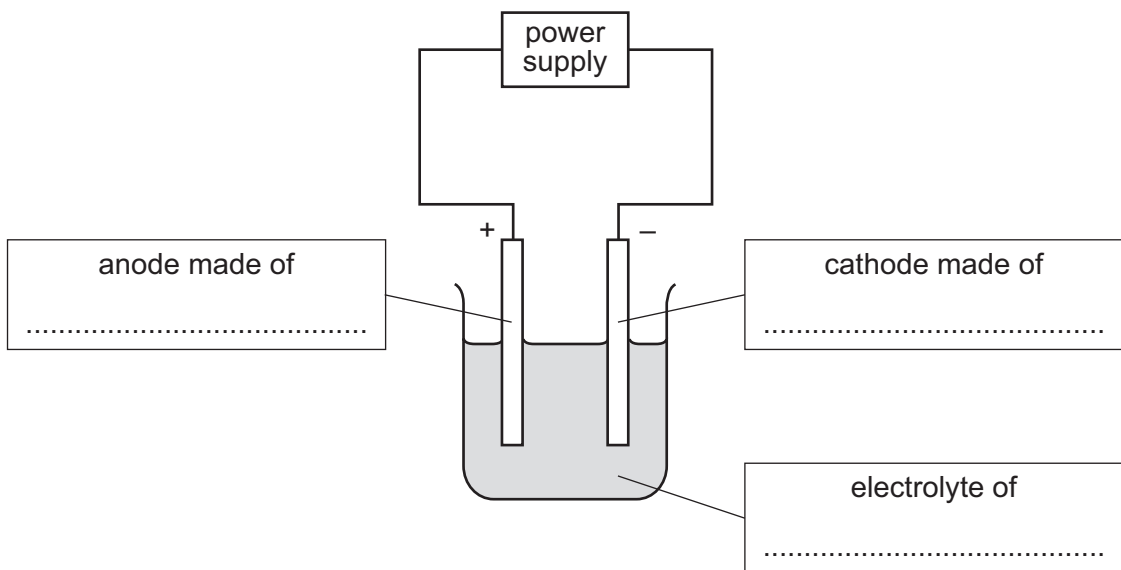
(e) Predict **one** difference in the appearance of aqueous solutions of nickel compounds compared to aqueous solutions of sodium compounds.

- .....
- ..... [1]

(f) Copper is refined (purified) by electrolysis. Nickel can be refined using a similar method.

(i) The diagram shows the refining of nickel by electrolysis.

Complete the labels in the boxes.



[3]

(ii) Indicate, by writing **N** on the diagram, where nickel is produced.

[1]

[Total: 13]





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## The Periodic Table of Elements

Group									
I	II	III	IV	V	VI	VII	VIII		
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		
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		
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		
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 Fl flerovium —	115 Mc moscovium —	116 Lv livermorium —	117 Ts tennessium —	118 Og oganeson —		
			119 Uue unbinetium —	120 Uub unbiunium —	121 Uut unbinium —	122 Uuq unquadium —	123 Uuq unquadium —		
			124 Uuq unquadium —	125 Uuq unquadium —	126 Uuq unquadium —	127 Uuq unquadium —	128 Uuq unquadium —		
			129 Uuq unquadium —	130 Uuq unquadium —	131 Uuq unquadium —	132 Uuq unquadium —	133 Uuq unquadium —		
			134 Uuq unquadium —	135 Uuq unquadium —	136 Uuq unquadium —	137 Uuq unquadium —	138 Uuq unquadium —		
			139 Uuq unquadium —	140 Uuq unquadium —	141 Uuq unquadium —	142 Uuq unquadium —	143 Uuq unquadium —		
			144 Uuq unquadium —	145 Uuq unquadium —	146 Uuq unquadium —	147 Uuq unquadium —	148 Uuq unquadium —		
			149 Uuq unquadium —	150 Uuq unquadium —	151 Uuq unquadium —	152 Uuq unquadium —	153 Uuq unquadium —		
			154 Uuq unquadium —	155 Uuq unquadium —	156 Uuq unquadium —	157 Uuq unquadium —	158 Uuq unquadium —		
			159 Uuq unquadium —	160 Uuq unquadium —	161 Uuq unquadium —	162 Uuq unquadium —	163 Uuq unquadium —		
			164 Uuq unquadium —	165 Uuq unquadium —	166 Uuq unquadium —	167 Uuq unquadium —	168 Uuq unquadium —		
			169 Uuq unquadium —	170 Uuq unquadium —	171 Uuq unquadium —	172 Uuq unquadium —	173 Uuq unquadium —		
			174 Uuq unquadium —	175 Uuq unquadium —	176 Uuq unquadium —	177 Uuq unquadium —	178 Uuq unquadium —		
			179 Uuq unquadium —	180 Uuq unquadium —	181 Uuq unquadium —	182 Uuq unquadium —	183 Uuq unquadium —		
			184 Uuq unquadium —	185 Uuq unquadium —	186 Uuq unquadium —	187 Uuq unquadium —	188 Uuq unquadium —		
			189 Uuq unquadium —	190 Uuq unquadium —	191 Uuq unquadium —	192 Uuq unquadium —	193 Uuq unquadium —		
			194 Uuq unquadium —	195 Uuq unquadium —	196 Uuq unquadium —	197 Uuq unquadium —	198 Uuq unquadium —		
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			299 Uuq unquadium —	300 Uuq unquadium —	301 Uuq unquadium —	302 Uuq unquadium —	303 Uuq unquadium —		

Group

1

H hydrogen 1
--------------------

Key

atomic number
atomic symbol
name
relative atomic mass

2	He helium 4
---	-------------------

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<sup>3</sup> at room temperature and pressure (r.t.p.).