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Cambridge IGCSE

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

CANDIDATE NAME

CENTRE NUMBER

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*4970364461*

**CHEMISTRY** **0620/42**

Paper 4 Theory (Extended) **February/March 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 **14** printed pages and **2** blank pages.


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**1** Period 3 of the Periodic Table is shown.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| sodium | magnesium | aluminium | silicon | phosphorus | sulfur | chlorine | argon |

Answer the following questions using only these elements.
Each element may be used once, more than once or not at all.

State which element:

**(a)** is a gas at room temperature and pressure

..... [1]

**(b)** forms a basic oxide with a formula of the form $X_2O$

..... [1]

**(c)** is made of atoms which have a full outer shell of electrons

..... [1]

**(d)** forms an oxide which causes acid rain

..... [1]

**(e)** is extracted from bauxite

..... [1]

**(f)** forms an oxide which has a macromolecular structure

..... [1]

**(g)** consists of diatomic molecules.

..... [1]

[Total: 7]

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**2** **(a)** The table gives information about some atoms or ions, **A**, **B** and **C**.

Complete the table.

| | number of protons | number of electrons | electronic structure | charge |
|---|---|---|---|---|
| **A** | 11 | 10 | 2,8 | |
| **B** | | 18 | | 0 |
| **C** | | 10 | 2,8 | –1 |

[4]

**(b)** **(i)** Carbon is an element.

Define the term *element*.

.....

..... [1]

**(ii)** $^{12}_{6}C$, $^{13}_{6}C$ and $^{14}_{6}C$ are isotopes of carbon.

Complete the table.

| | number of protons | number of neutrons |
|---|---|---|
| $^{12}_{6}C$ | | |
| $^{13}_{6}C$ | | |
| $^{14}_{6}C$ | | |

[2]

[Total: 7]

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**[Turn over**

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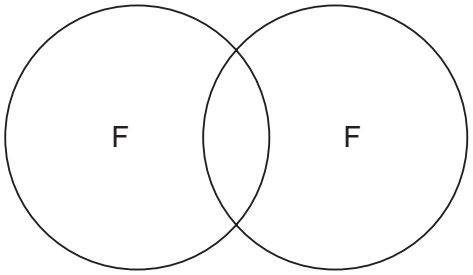
**3** Fluorine is a Group VII element. Fluorine forms compounds with metals and non-metals.

**(a)** Predict the physical state of fluorine at room temperature and pressure.

..... [1]

**(b)** Fluorine exists as diatomic molecules.

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




[2]

**(c)** Write a chemical equation for the reaction between sodium and fluorine.

..... [2]

**(d)** Explain why chlorine does **not** react with aqueous sodium fluoride.

.....

..... [1]

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**(e)** Tetrafluoromethane and lead(II) fluoride are fluorides of Group IV elements. Some properties of tetrafluoromethane and lead(II) fluoride are shown in the table.

| property | tetrafluoromethane | lead(II) fluoride |
|---|---|---|
| formula | $CF_4$ | |
| melting point / °C | –184 | 855 |
| boiling point / °C | –127 | 1290 |
| conduction of electricity when solid | non-conductor | non-conductor |
| conduction of electricity when molten | non-conductor | good conductor |

**(i)** What is the formula of lead(II) fluoride?

..... [1]

**(ii)** What type of bonding is present between the atoms in tetrafluoromethane?

..... [1]

**(iii)** What type of structure does solid lead(II) fluoride have?

..... [1]

**(iv)** Explain, in terms of attractive forces between particles, why lead(II) fluoride has a much higher melting point than tetrafluoromethane.

In your answer refer to the types of attractive forces between particles and their relative strengths.

.....

.....

.....

..... [3]

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**[Turn over**

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**(f)** Tetrafluoroethene is an unsaturated compound with the formula $C_2F_4$.
Tetrafluoroethene is the monomer used to make the polymer poly(tetrafluoroethene).

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

.....

..... [1]

**(ii)** Describe a test to show that tetrafluoroethene is unsaturated.

test.....

observations .....
[2]

**(iii)** Draw the structure of a molecule of tetrafluoroethene. Show all of the atoms and all of the bonds.

[1]

**(iv)** Tetrafluoroethene can be polymerised to form poly(tetrafluoroethene).

Draw **one** repeat unit of poly(tetrafluoroethene). Show all of the atoms and all of the bonds.

[2]

**(v)** Deduce the empirical formula of:

tetrafluoroethene .....

poly(tetrafluoroethene). .....
[2]

[Total: 20]

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**4** This question is about ethanoic acid, $CH_3COOH$.

**(a)** Ethanoic acid is manufactured from methanol and carbon monoxide.

$$CH_3OH(g) + CO(g) \rightleftharpoons CH_3COOH(g)$$

The process is done at 200 °C and 30 atmospheres pressure.
The forward reaction is exothermic.

Complete the table using only the words *increases*, *decreases* or *no change*.

| | effect on the rate of the forward reaction | effect on the equilibrium yield of $CH_3COOH(g)$ |
|---|---|---|
| adding a catalyst | | no change |
| increasing the temperature | | |
| decreasing the pressure | decreases | |

[4]

**(b)** How would you show that an aqueous solution of ethanoic acid is an acid **without** using an indicator or measuring the pH?

State the reagent you would use and give the expected observations. Write a chemical equation for the reaction that you describe.

- reagent

.....

- expected observations

.....

.....

- chemical equation

.....

[3]

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**(c)** Ethanoic acid is a weak acid.

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

.....

..... [1]

**(ii)** Why is ethanoic acid described as *weak*?

.....

..... [1]

**(d)** Ethanoic acid reacts with methanol to form an ester.

**(i)** State **two** conditions required for this reaction.

1 .....

2 .....
[2]

**(ii)** Draw the structure of the ester formed when ethanoic acid reacts with methanol. Show all of the atoms and all of the bonds. Name the ester.

structure

name .....
[3]

**(iii)** Name an ester which is a structural isomer of the ester in **(d)(ii)**.

..... [1]

[Total: 15]

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**5** Titanium is extracted from an ore called rutile. Rutile is an impure form of titanium(IV) oxide, $TiO_2$.

**(a)** Rutile is mixed with coke and heated in a furnace through which chlorine gas is passed. The product is gaseous titanium(IV) chloride, $TiCl_4$.

$$TiO_2(s) + 2C(s) + 2Cl_2(g) \rightarrow TiCl_4(g) + 2CO(g)$$

The gaseous titanium(IV) chloride produced is condensed into the liquid state. The titanium(IV) chloride is then separated from liquid impurities.

**(i)** Suggest the name of the process by which liquid titanium(IV) chloride could be separated from the liquid impurities.

..... [1]

**(ii)** Carbon monoxide, CO(g), is also produced in the reaction.

Why should carbon monoxide **not** be released into the atmosphere?

..... [1]

**(b)** Calculate the volume of chlorine gas, $Cl_2(g)$, at room temperature and pressure, that reacts completely with 400 g of $TiO_2(s)$ using the following steps.

$$TiO_2(s) + 2Cl_2(g) + 2C(s) \rightarrow TiCl_4(g) + 2CO(g)$$

- Calculate the relative formula mass, $M_r$, of $TiO_2$.

$M_r$ of $TiO_2$ = .....

- Calculate the number of moles in 400 g of $TiO_2$.

..... mol

- Determine the number of moles of $Cl_2$ that react with 400 g of $TiO_2$.

moles of $Cl_2$ = ..... mol

- Calculate the volume of $Cl_2$ that reacts with 400 g of $TiO_2$.

volume of $Cl_2$ = ..... $dm^3$
[4]

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**(c)** Titanium(IV) chloride, $TiCl_4$, is heated with an excess of magnesium, in an atmosphere of argon.

**(i)** Balance the chemical equation for the reaction.

$$TiCl_4 + \text{.....} Mg \rightarrow Ti + \text{.....} MgCl_2$$

[1]

**(ii)** Titanium(IV) chloride can be reacted with sodium instead of magnesium.

The reaction between titanium(IV) chloride and sodium is similar to the reaction between titanium(IV) chloride and magnesium.

Write a chemical equation for the reaction between titanium(IV) chloride and sodium.

..... [1]

**(iii)** Suggest why the reaction between titanium(IV) chloride and magnesium is done in an atmosphere of argon and **not** in air.

.....

..... [1]

**(d)** After titanium(IV) chloride is heated with magnesium, the unreacted magnesium is removed by adding an excess of dilute hydrochloric acid to the mixture.

The dilute hydrochloric acid also dissolves the magnesium chloride.
The dilute hydrochloric acid does **not** react with the titanium or dissolve it.

**(i)** Give **two** observations and write a chemical equation for the reaction that occurs when dilute hydrochloric acid reacts with magnesium.

1 .....

2 .....

chemical equation .....

[3]

**(ii)** Name the process that is used to separate the titanium from the mixture after all the magnesium has been removed.

..... [1]

**(iii)** Titanium does not react with the dilute hydrochloric acid or dissolve in it.

Suggest why titanium does **not** react with dilute hydrochloric acid.

..... [1]

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**(e)** Magnesium cannot be produced by electrolysis of aqueous magnesium chloride using inert electrodes.

**(i)** Name the product formed at the negative electrode (cathode) during the electrolysis of aqueous magnesium chloride.

..... [1]

**(ii)** Suggest how magnesium can be produced from magnesium chloride by electrolysis.

..... [1]

[Total: 16]

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**[Turn over**

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**6** This question is about transition elements.

**(a)** Transition elements are harder and stronger than Group I elements.

Describe **two** other differences in **physical** properties between transition elements and Group I elements.

1 .....

2 .....
[2]

**(b)** State **one** physical property of transition elements that is similar to Group I elements.

..... [1]

**(c)** State **two** chemical properties of transition elements.

1 .....

2 .....
[2]

**(d)** Cobalt is a transition element. Anhydrous cobalt(II) chloride is used to test for water.

State the colour change that occurs when water is added to anhydrous cobalt(II) chloride.

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

**(e)** Iron is a transition element.

**(i)** Which **two** substances react with iron to form rust?

1 .....

2 .....
[2]

**(ii)** Which metal is used to galvanise iron?

..... [1]

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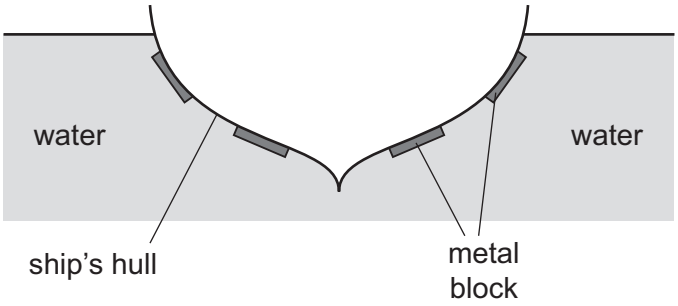
**(f)** The hull of a ship is made from steel (mainly iron). Metal blocks are placed on the ship's hull to prevent rusting.




Use your knowledge of the reactivity series to explain why:

- magnesium is suitable to use as the metal blocks
- copper is **not** suitable to use as the metal blocks.

.....

.....

..... [2]

**(g)** Rust contains iron(III) oxide.

Phosphoric acid, $H_3PO_4$, can be used to remove rust from an iron object and prevent further rusting.

**(i)** Write a chemical equation for the reaction between iron(III) oxide and phosphoric acid to form iron(III) phosphate and water.

..... [2]

**(ii)** Iron(III) phosphate is an insoluble salt.

Suggest how the formation of iron(III) phosphate prevents further rusting.

.....

..... [1]

[Total: 15]

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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.).



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