Cambridge Assessment International Education

# Cambridge IGCSE™

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

Paper 4 Theory (Extended) **February/March 2021**

**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. Any blank pages are indicated.




**[Turn over**

**1** The table shows the numbers of protons, neutrons and electrons in particles **A** to **I**.

| particle | protons | neutrons | electrons |
|---|---|---|---|
| **A** | 1 | 0 | 0 |
| **B** | 6 | 6 | 6 |
| **C** | 6 | 8 | 6 |
| **D** | 10 | 10 | 10 |
| **E** | 16 | 16 | 18 |
| **F** | 17 | 18 | 17 |
| **G** | 18 | 22 | 18 |
| **H** | 19 | 20 | 19 |
| **I** | 20 | 20 | 18 |

Answer the following questions about particles **A** to **I**. Each letter may be used once, more than once or not at all.

**(a)** State which of the particles **A** to **I**:

**(i)** is an anion ..... [1]

**(ii)** are cations ..... and ..... [2]

**(iii)** are noble gas atoms ..... and ..... [2]

**(iv)** is a halogen atom ..... [1]

**(v)** is a Group I atom ..... [1]

**(vi)** have the same nucleon number ..... and ..... [1]

**(vii)** causes acidity in aqueous solutions ..... [1]

**(viii)** is used to define the relative atomic mass of elements. ..... [1]

**(b)** Explain why **B** and **C** are isotopes of the same element.

.....

..... [2]

[Total: 12]

**2** The elements shown are gases at room temperature and pressure.

**hydrogen**
**nitrogen**
**oxygen**
**chlorine**

**(a)** State which **one** of these gases is green.

..... [1]

**(b)** The gases shown exist as diatomic molecules.

State the name of **another** element which has diatomic molecules and is a gas at room temperature and pressure.

..... [1]

**(c)** When separate samples of each of these gases are placed in a container they will diffuse.

**(i)** Describe why these gases diffuse.

..... [1]

**(ii)** State which of these four gases has the highest rate of diffusion.

Explain your answer.

gas .....

explanation .....

.....
[2]

**(d)** Nitrogen, oxygen and other substances are found in clean, dry air.

**(i)** State the percentage of nitrogen in clean, dry air.

..... [1]

**(ii)** Other than nitrogen and oxygen, identify another element found in clean, dry air.

..... [1]

**(iii)** Identify a compound found in clean, dry air.

..... [1]

**(iv)** Nitrogen and oxygen can be separated from liquid air.

State the name of this process.

..... [2]

[Total: 10]

**3** This question is about ammonia.

**(a)** Nitrogen reacts with hydrogen to form ammonia in an industrial process.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

**(i)** Name this industrial process.

..... [1]

**(ii)** State the meaning of the symbol $\rightleftharpoons$.

..... [1]

**(iii)** State the conditions used in this industrial process. Include units.

temperature .....

pressure .....

[2]

**(iv)** Name the catalyst used in this industrial process.

..... [1]

**(v)** If the pressure is increased, the yield of ammonia increases.

Explain why, in terms of equilibrium.

.....

.....

..... [2]

**(vi)** If the temperature is increased, the rate of reaction increases.

Explain why, in terms of particles.

.....

.....

.....

.....

..... [3]

**(b)** Ammonia reacts with sulfuric acid to make a compound which is used as a fertiliser.

Write the chemical equation for the reaction between ammonia and sulfuric acid.

..... [2]

[Total: 12]

**4** A student wanted to make some zinc chloride crystals.

The student followed the procedure shown.

**step 1** Add excess zinc powder to dilute hydrochloric acid to form aqueous zinc chloride.

**step 2** Remove unreacted zinc powder from the aqueous zinc chloride.

**step 3** Heat the solution until it is saturated.

**step 4** Allow the saturated solution to cool and remove the crystals that form.

**(a)** Write the equation for the reaction in **step 1**. Include state symbols.

..... [3]

**(b)** Explain why **excess** zinc powder is added in **step 1**.

..... [1]

**(c)** Suggest how unreacted zinc powder is removed in **step 2**.

..... [1]

**(d)** A saturated solution is formed in **step 3**.

Suggest what is meant by the term *saturated solution*.

.....

..... [2]

**(e)** Explain why crystals form as the solution cools in **step 4**.

..... [1]

**(f)** Name **two** zinc compounds which react with dilute hydrochloric acid to form zinc chloride.

.....

..... [2]

**(g)** If excess calcium metal is used instead of excess zinc powder in **step 1**, pure calcium chloride crystals do **not** form.

Explain why.

.....

..... [1]

**(h)** Some salts can be made by titration.

In a titration experiment, 20.0 $cm^3$ of aqueous sodium hydroxide reacts exactly with 25.0 $cm^3$ of 0.100 $mol/dm^3$ dilute sulfuric acid to make sodium sulfate.

$$2NaOH(aq) + H_2SO_4(aq) \rightarrow Na_2SO_4(aq) + 2H_2O(l)$$

**(i)** Circle the name of the type of reaction that takes place.

**decomposition** **neutralisation** **precipitation** **reduction**

[1]

**(ii)** Calculate the concentration of the aqueous sodium hydroxide in $g/dm^3$ using the following steps.

- Calculate the number of moles of dilute sulfuric acid used.

..... mol

- Determine the number of moles of sodium hydroxide which react with the dilute sulfuric acid.

..... mol

- Calculate the concentration of the aqueous sodium hydroxide in $mol/dm^3$.

..... $mol/dm^3$

- Calculate the concentration of the aqueous sodium hydroxide in $g/dm^3$.

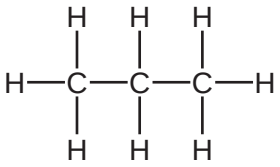
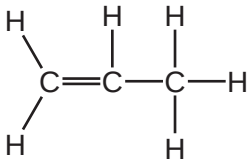
..... $g/dm^3$

[5]

[Total: 17]

**QUESTION 5 STARTS ON THE NEXT PAGE.**

**5** The table shows the names or structures of organic compounds **P** to **U**.

| **P** | **Q** | **R** |
|---|---|---|
|  | propanoic acid | but-1-ene |
| **S** | **T** | **U** |
| propan-1-ol | methyl butanoate |  |

**(a)** Give the letters of the organic compounds, **P** to **U**, that are unsaturated hydrocarbons.

..... [2]

**(b)** Describe the test for an unsaturated hydrocarbon.

test .....

observations .....
[2]

**(c)** But-1-ene is an unbranched molecule.

**(i)** Name the unbranched isomer of but-1-ene.

..... [1]

**(ii)** Draw the structure of a branched isomer of but-1-ene. Show all of the atoms and all of the bonds.

[1]

**(d)** Dodecane is an alkane with 12 carbon atoms. Dodecane can be cracked.

**(i)** Write the formula of dodecane.

..... [1]

**(ii)** Give the letters of all the organic compounds, **P** to **U**, that can be formed when dodecane is cracked.

..... [2]

**(e)** Name the reagent and suggest the conditions needed to convert organic compound **U** into organic compound **S**.

reagent .....

conditions .....

[3]

**(f)** Organic compound **S** can be converted to organic compound **Q** by reaction with an acidified reagent.

**(i)** Name the type of chemical change that happens to organic compound **S**.

..... [1]

**(ii)** Name the acidified reagent added to organic compound **S**.

..... [1]

**(g)** Organic compound **T** is made by reacting two compounds together.

**(i)** Name the homologous series that organic compound **T** belongs to.

..... [1]

**(ii)** Name the **two** compounds which react together to make organic compound **T**.

Draw the structures of each compound you have named. Show all of the atoms and all of the bonds.

name .....

structure

name .....

structure

[4]

**(iii)** Deduce the molecular formula of organic compound **T**.

..... [1]

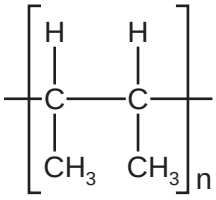
[Total: 20]

**6** Polymers are large molecules built up from small molecules.

**(a)** State the name given to the small molecules from which polymers are made.

..... [1]

**(b)** The formula of a polymer is shown.




**(i)** Draw the structure of the small molecule from which this polymer is made. Show all of the atoms and all of the bonds.

[2]

**(ii)** State the type of polymerisation used to make this polymer.

..... [1]

**(c)** Three amino acids are shown. They combine to form part of a natural polymer.


**(i)** Name the type of natural polymer formed when amino acids combine.

..... [1]

**(ii)** Complete the diagram to show part of the structure of the natural polymer that forms when these three amino acids combine. Show all of the bonds in the linkages.

[3]

**(iii)** Name the type of chemical reaction that takes place when this natural polymer is converted back to amino acids.

..... [1]

[Total: 9]

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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.).