

Cambridge IGCSE[™]

| CANDIDATE NAME | | | | | |
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CHEMISTRY
Paper 3 Theory (Core)

0620/32

February/March 2022

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 20 pages. Any blank pages are indicated.

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[Turn over

1 (a) The electronic structures of five atoms, A, B, C, D and E, are shown.

| Α | В | С | D | E |
|---|---|---|---|---|
| | | | | |

Answer the following questions about these electronic structures. Each electronic structure may be used once, more than once or not at all.

State which electronic structure, A, B, C, D or E, represents:

| (i) an atom in Group V of the Periodic Table | |
|--|--|
|--|--|

| 111 |
|-----|
| 171 |

(ii) an atom which contains only two shells of electrons

| [1 |
|----|
| |

(iii) an atom that forms a stable ion with a charge of 2–

| [1] |
|-----|
|-----|

(iv) an atom of an element that exists as a monoatomic gas

| [1] |
|-----|
|-----|

(v) an atom of the metal that is extracted from bauxite.

| [1] |
|-----|
| [1] |

(b) Complete the table to show the number of electrons, neutrons and protons in the uranium atom and rubidium ion shown.

| | number of electrons | number of neutrons | number of protons |
|---|---------------------|--------------------|-------------------|
| ²³⁵ ₉₂ U | 92 | | |
| ⁸⁷ ₃₇ Rb ⁺ | | 50 | |

[3]

[Total: 8]

2 (a) Biogas is a mixture of gases produced when agricultural waste is broken down in the absence of oxygen.

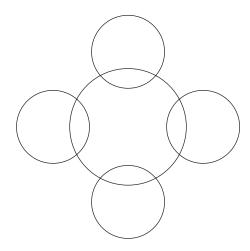
The table compares the percentage by mass of the gases present in two samples of biogas, **X** and **Y**.

| gas | biogas X /% by mass | biogas Y /% by mass |
|------------------|-------------------------------|-------------------------------|
| carbon dioxide | 26 | 32 |
| hydrogen | 1 | 1 |
| hydrogen sulfide | 0.5 | 0.5 |
| methane | 67 | 56 |
| nitrogen | 4 | 9.5 |
| oxygen | 0.5 | 0.5 |
| other gases | | 0.5 |

Answer these questions using only the information in the table.

| Deduce the percentage by mass of the other gases in biogas X . | |
|--|--|
| | [1] |
| Describe two major differences in the compositions of biogas X and biogas Y . | |
| 1 | |
| 2 | [2] |
| | Describe two major differences in the compositions of biogas X and biogas Y . |

(b) Complete the diagram to show the electronic structure in a methane molecule. Show only the outer shell electrons.



[1]

- (c) Hydrogen sulfide burns in air to produce sulfur dioxide and water.
 - (i) Complete the chemical equation for this reaction.

| $H_2S +O_2 \rightarrow 2H_2O + 2SO_2$ |
|---------------------------------------|
|---------------------------------------|

| (ii) | Explain how this equation shows that hydrogen sulfide is oxidised. |
|------|--|
| | |
| | |

.....[1]

[Total: 7]

| This q | uestion is about metals. | |
|--------------|--|-----|
| (a) St | tate three general physical properties common to most metals. | |
| 1 | | |
| 2 | | |
| 3 | | |
| | | [3] |
| (b) M | etals are often used in the form of alloys. | |
| (i) | State the meaning of the term <i>alloy</i> . | |
| | | |
| | | [1] |
| (ii) | Explain in terms of their properties why alloys are used instead of pure metals. | |
| | | [1] |
| (iii) | Stainless steel is an alloy. | |
| | Give one use of stainless steel. | |
| | | [1] |
| | | |
| (c) PI | ace these metals in order of their reactivity with oxygen. | |
| | copper | |
| | magnesium potassium | |
| | zinc | |
| Pu | ut the least reactive metal first. | |
| le | east reactive — most reactive | |
| | | |
| | | [2] |
| | | _ |

3

| (d) | When 4.8 g of magnesium reacts with excess oxygen, 8.0 g of magnesium oxide is formed. |
|-----|--|
| | Calculate the minimum mass of magnesium needed to produce 24.0 g of magnesium oxide. |

minimum mass = g [1]

[Total: 9]

| 1 | This qu | estic | n is a | about acids, ba | ases a | ind salts. | | | | | |
|---|--------------------|-------|----------------|----------------------|------------------------|----------------------|----------|---------------------|--------|----------------|-----|
| | (a) So | dium | hydr | oxide is a base | e. | | | | | | |
| | (i) | Na | me th | ne products for | med w | when sodium hydi | oxide | reacts with dilute | nitric | acid. | |
| | | | | | | | | | | | |
| | | | | | | | | | | [2 | [.] |
| | (ii) | De | scribe | e the effect of s | sodiur | n hydroxide on a | name | d indicator. | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | [2 | .] |
| | (iii) | Co | mplet | te the word equ | uation | for the reaction of | sodiu | ım hydroxide with a | ammo | nium chloride | :_ |
| | sodium hydroxid | | + | ammonium chloride | $\Bigg] \rightarrow $ | | + | | + | water | |
| | | | | | | | | | | [2 | .] |
| | | | e hov fate. | w to prepare p | ure, d | ry crystals of the s | salt zii | nc sulfate from an | aque | ous solution o | f |
| | | | | | | | | | | | |
| | | | | | | | | | | [2 | [] |

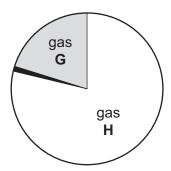
(c) The rate of reaction of zinc powder with dilute sulfuric acid is found by measuring the increase

| in volume of hydrogen gas produced as time increases. |
|---|
| Describe the effect, if any, of each of the following on the rate of this reaction. |
| The reaction is carried out with large pieces of zinc instead of zinc powder. |
| All other conditions stay the same. |
| |
| The reaction is carried out using a catalyst. |
| All other conditions stay the same. |
| |
| The reaction is carried out with dilute sulfuric acid of a lower concentration. |
| All other conditions stay the same. |
| |

[3]

[Total: 11]

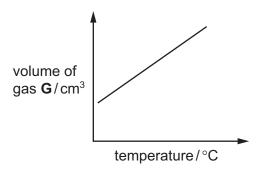
- 5 This question is about air.
 - (a) The pie chart shows the proportions of the main gases in clean, dry air.



(i) Name the gases **G** and **H**.

| gas G | |
|--------------|-------------|
| gas H | [2] |

(ii) The graph shows how the volume of a sample of gas **G** changes as temperature increases. The pressure is kept constant.



Describe how the volume of gas **G** changes as temperature increases.

| [4 | | |
|----|-------|--|
| | F 4 7 | |
| | 111 | |
| | | |

(iii) There is a small percentage of noble gases in the air. The noble gases are unreactive.

Explain why the noble gases are unreactive in terms of their electronic structure.

(iv) Describe the arrangement and separation of the particles in a gas.

arrangement

separation[2]

| (b) | Two | o of the pollutants in air are oxides of nitrogen and lead compounds. | |
|-----|------|---|-----|
| | (i) | Give one effect of each of these pollutants on health. | |
| | | oxides of nitrogen | |
| | | lead compounds | |
| | | | [2] |
| | (ii) | Name two other pollutants present in air. | |
| | | State the source of each of these pollutants. | |
| | | pollutant 1 | |
| | | source of pollutant 1 | |
| | | pollutant 2 | |
| | | source of pollutant 2 | |
| | | | [4] |
| | | [Total: | 12] |

6 The table shows some properties of four Group I elements.

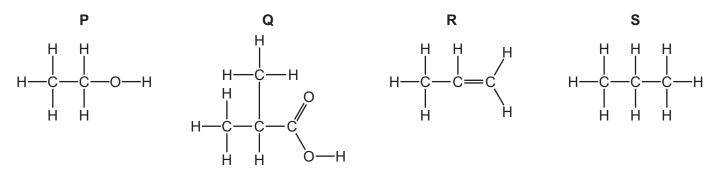
| element | melting point /°C | boiling point /°C | relative hardness |
|-----------|----------------------|----------------------|-------------------|
| lithium | 181 | 1342 | |
| sodium | 98 | | 0.70 |
| potassium | 63 | 760 | 0.36 |
| rubidium | 39 | 686 | 0.22 |

| (a) | (i) | Complete the table by estimating: the boiling point of sodium the relative hardness of lithium. | [2] |
|-----|------|---|-----|
| | (ii) | Predict the physical state of lithium at 200 °C. | |
| | | Give a reason for your answer. | |
| | | | |
| | | | [2] |
| (b) | Pot | assium reacts with water. | |
| | | $2K + 2H_2O \rightarrow 2KOH + H_2$ | |
| | Des | scribe two observations when potassium reacts with water. | |
| | | | |

[2]

| (C) | Litr | num is extracted by the electrolysis of molten lithium chloride. |
|-----|-------|---|
| | (i) | Name a non-metal used to make the electrodes. |
| | | [1] |
| | (ii) | Give one property, other than the conduction of electricity, that makes this substance suitable for use as an electrode. |
| | | [1] |
| (| (iii) | State the products of the electrolysis of molten lithium chloride at: |
| | | the negative electrode (cathode) |
| | | the positive electrode (anode). |
| | | i-j |
| (d) | Lith | ium chloride conducts electricity when molten and when in aqueous solution. |
| | Giv | e two other physical properties of lithium chloride that show it is an ionic compound. |
| | 1 | |
| | 2 | |
| | | [2] |
| | | [Total: 12] |

7 (a) The structures of four organic compounds, P, Q, R and S, are shown.



Answer the following questions about these structures.

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

| (i) | State which structure, P , Q , R or S , has a carboxylic acid functional group. | |
|-------|---|-----|
| | | [1] |
| (ii) | State which structure, P , Q , R or S , is in the same homologous series as ethane. | |
| | | [1] |
| (iii) | State which structure, P , Q , R or S , decolourises aqueous bromine. | |
| | | [1] |
| (iv) | Deduce the molecular formula of structure Q to show the number of carbon, hydrogen a oxygen atoms. | and |
| | | [1] |
| | | |

- **(b)** Structure **S** is produced by cracking petroleum fractions.
 - (i) Complete the sentence using a word from the list.

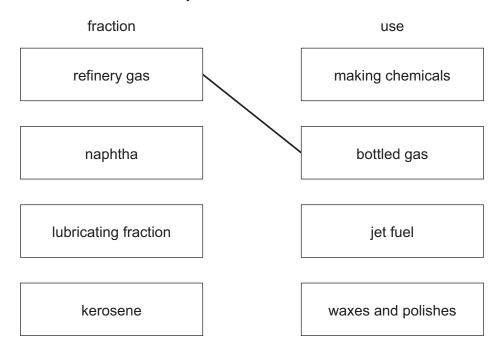
(ii) Cracking is an example of thermal decomposition.

State the meaning of the term thermal decomposition.

.....[2]

(c) Link each petroleum fraction on the left to its use on the right.

The first one has been done for you.



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[2]

[Total: 9]

| This q | uestion is about chlorine and compounds of chlorine. | |
|----------------|--|---------|
| (a) C | hlorine is an element in Group VII of the Periodic Table. | |
| S | tate the meaning of the term <i>element</i> . | |
| ••• | | |
| ••• | | [1] |
| (b) S | tate one use of chlorine. | |
| (b) O | | [1] |
| ••• | | ני. |
| (c) C | hlorine reacts with phosphorus to produce phosphorus (V) chloride. | |
| (i) | Balance the equation for this reaction. | |
| | P + $Cl_2 \rightarrow 2PCl_5$ | [2] |
| (ii) | This reaction is exothermic. | |
| | State the meaning of the term exothermic. | |
| | | [1] |
| (d) C | hlorine reacts with aqueous sodium bromide. | |
| (u) (i) | | |
| (·/ | , complete the word equation for the reaction. | |
| | chlorine + sodium \rightarrow + | |
| | bioinide | |
| | | [2] |
| (ii) | Describe a test for bromide ions. | |
| | test | |
| | observations | [0] |
| /:::: | | [2] |
| (iii) | | |
| | Suggest in terms of chemical reactivity why there is no reaction. | [1] |
| | | |

8

(e) A compound of chlorine has the formula $C_3H_6Cl_2$.

Complete the table to calculate the relative molecular mass of $C_3H_6C\mathit{l}_2$.

| atom | number of atoms | relative atomic mass | |
|----------|-----------------|-------------------------|-------------|
| carbon | 3 | 12 | 3 × 12 = 36 |
| hydrogen | | 1 | |
| chlorine | | 35.5 | |

relative molecular mass = [2]

[Total: 12]

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The Periodic Table of Elements

| 1 | | | | | | | | | Gro | Group | | | | | | | | |
|--|---|--|------------------------------|--------------------------|-----|-----------------|---|------------------|-----------------|------------------|------------------|----------------|-----------------|-----------------|------------------|------------------|------------------|---------------|
| 1 | = | | | | | | | | | | | | = | ≥ | > | > | = | = |
| hydrogen line 5 6 7 8 9 B C N O F 11 12 14 15 16 17 26 27 28 30 31 32 33 34 35 Fe CO Ni Copper 27 28 33 34 35 Fe CO Ni Copper 27 28 33 34 35 1 cond 27 28 29 30 31 32 33 34 35 1 cond 20 Ni Copper 20 30 31 32 33 34 35 CI 1 cond 20 Ni Copper 2nc 70 73 36 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 80 | | | | | | | | - I | | | | | | | | | | F 2 |
| 26 6 7 8 9 B C N O F Bonn Carbon Introgen Oxygen fluorine 26 27 28 29 30 31 32 35.5 Fe CO Ni Cu Zn Ga Ge As Se CI 101 27 28 29 30 31 32 33 34 35.5 101 27 28 29 30 31 32 33 34 35.5 101 20 Ni Zn Ga Ge As Se CI 101 44 45 46 47 48 49 50 51 70 70 101 103 106 47 48 49 50 51 72 73 72 102 103 106 106 112 112 1 | Key | Key | Key | Key | | | | hydrogen 1 | | | | | | | | | | helium 4 |
| Parish P | 4 atomic number | atomic number | atomic number | tomic number | | | ı | | | | | | 5 | 9 | 7 | 8 | 6 | 10 |
| Parish P | Be atomic symbol | atomic symbol | atomic symbol | mic symbol | loc | | | | | | | | Ω | ပ | z | 0 | ட | Ne |
| 13 14 15 16 17 17 18 18 14 15 16 17 19 19 19 19 19 19 19 | beryllium name 9 relative atomic mass | name relative atomic mass | name relative atomic mass | name tive atomic mass | SS | | | | | | | | boron 11 | carbon 12 | nitrogen 14 | oxygen 16 | fluorine 19 | neon 20 |
| Alia | 12 | | | | | | | | | | | | 13 | 14 | 15 | 16 | 17 | 18 |
| 26 27 28 29 30 31 32 35.5 Fe Co Ni Cu Zn Ga Ge As Se Br fo Cobalt nickel copper zinc gallum germanium arsenic selenium bronine fo 44 45 64 65 70 73 75 79 80 Ru Ab Ad Af Cd In Sh 77 78 80 Ru Tod Ad Ad Ad Ad Ad Ad Ad osmium indium tindium ti | Mg | | | | | | | | | | | | Αſ | S | ۵ | ഗ | Cl | Ā |
| 26 27 28 30 31 32 33 34 35 Fe Co Ni Cu Zn Ga Ge As Se Br iron cobalt nickel copper zinc gallium germanium arsenic Selenium bronnine 44 45 46 47 48 49 50 51 52 53 Ru Ah AG Cd In Sh Te 52 53 80 nuthenium rhodium palledrum silver cadmium indium tin AT Te 17 Br 101 102 108 Cd In Sh Te 17 Br At At At At At At At Br | magnesium 24 | | | | | | | | | | | | aluminium 27 | silicon 28 | phosphorus 31 | sulfur 32 | chlorine 35.5 | argon 40 |
| Fe Co Ni Cu Zn Ga Ge As Se Br iron cobalt iron cobalt nickel copper zinc gallium germanium assenic selenium bronnine 444 45 46 47 48 49 50 51 52 53 Ru Rh 46 47 48 49 50 51 52 53 Ru Rh AG Cd In Sh Te 1 52 53 53 53 53 53 53 53 53 54 1 | 21 22 23 24 | 22 23 24 | 23 24 | 24 | | 25 | | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 |
| ion cobalt nickel copper zinc gallium germanium asseniu selenium bromine 44 45 46 47 48 49 50 51 52 53 Ru Rb 46 47 48 49 50 51 52 53 Ru Rb Ag Cd In Sh 76 In 55 53 53 101 77 78 79 80 81 82 84 85 127 Osmium inidium 110 Hg TI Pb Bi Po 71 Osmium inidium 140 17 Pb Bi Po 127 Osmium inidium 140 17 204 207 209 At 108 110 111 112 114 116 116 116 Hsssium meinterium meinterium copr | Sc | , C | ပ် > | ပ် | | Mn | | Fe | ပိ | Z | C | Zu | Ga | Ge | As | Se | ğ | 궃 |
| A4 45 46 47 48 49 50 51 52 53 Ru Rh Pd Ag Cd In Sn Sp Te I 101 103 106 108 112 119 122 128 1 76 77 78 79 80 81 82 83 84 85 Ossmum 192 Pt Au Hg 77 Pb Bi Po At 190 192 195 197 201 207 209 - - 190 110 111 112 114 116 116 - - - Hs Mt Ds Rg Cn F1 Lv - - - | calcium scandium titanium vanadium chromium manganese 40 45 48 51 52 55 | titanium vanadium chromium r 48 51 52 | vanadium chromium r 51 52 | chromium r | | manganese 55 | | iron 56 | cobalt 59 | nickel 59 | copper 64 | zinc 65 | gallium 70 | germanium 73 | arsenic 75 | selenium 79 | bromine 80 | krypton 84 |
| Rh Pd Ag Cd In Sh Sb Te I rhodum palladfum silver cadmium indium tin antimony tellutrium iodine 103 106 108 112 119 122 128 127 1r 1r 80 81 82 83 84 85 iridum platinum gold mercury 171 Pb Bi Po At iridum platinum gold mercury thallium lead bismuth polonium astatine 192 195 197 201 204 207 209 — — Mt Ds Rg Cn Fl Lv Lv Inferentium methering demstadtum ropernicium flerovium livermorium livermorium | 39 40 41 42 | 40 41 42 | 41 42 | 42 | | 43 | | 44 | 45 | 46 | 47 | 48 | 49 | 20 | 51 | 52 | 53 | 54 |
| rhodium palladium silver cadmium indium tin antimony tellurium lodine 103 106 108 112 115 119 122 127 Ir Pt Au Hg T7 Pb Bi Po At indium platinum gold mercury thallum lead bismuth polonium astatine 192 109 111 112 204 207 209 — — Mt Ds Rg Cn F1 Lv Lv menterium damstadtum ropernicum flerovium livermorium | Y Zr Nb Mo | Zr Nb Mo | Nb Mo | Mo | | ပု | | R | 格 | Pd | Ag | В | In | Sn | Sb | Те | Н | Xe |
| T7 78 79 80 81 82 83 84 85 Ir Pt Au Hg T1 Pb Bi Po At indum platinum gold mercury thallum lead bismuth polonium astatine 192 195 197 201 204 207 209 — — Mt Ds Rg Cn Fl Lv Infermutim metherinium damstadtum roepenicium flerovium livermorium | zirconium niobium molybdenum 91 93 96 | zirconium niobium molybdenum 91 93 96 | niobium molybdenum 93 96 | molybdenum 96 | | technetiu - | Ε | ruthenium 101 | rhodium 103 | palladium 106 | silver 108 | cadmium 112 | indium 115 | tin 119 | antimony 122 | tellurium 128 | iodine 127 | xenon 131 |
| Ir Pt Au Hg Tl Pb Bis Po At Polonium astatine indium 192 195 197 201 204 mercury 201 thaillum 192 lead 207 209 — | 57–71 72 73 74 | 72 73 74 | 73 74 | 74 | | 75 | | 92 | 77 | 78 | 79 | 80 | 81 | 82 | 83 | 84 | 85 | 98 |
| indium platinum gold mercury thallium lead bismuth polonium astatine 192 195 197 201 204 207 209 - - 109 110 111 112 114 116 - - MIt Ds Rg Cn F1 Lv Lv melinerium damstadtum roepenicium flerovium livermorium | lanthanoids Hf Ta W | Hf Ta W | Ta | > | | Re | | Os | 'n | 础 | Αn | 윈 | lΤ | Pp | <u>.</u> | Ъ | ¥ | R |
| 109 110 111 112 114 Mt Ds Rg Cn Fl metherium damstadtum roentgenium copernicium flerovium | tantalum 181 | tantalum tungsten 181 184 | tantalum tungsten 181 184 | tungsten 184 | | rhenium 186 | | osmium 190 | iridium 192 | platinum 195 | gold 197 | mercury 201 | thallium 204 | lead 207 | bismuth 209 | molod – | astatine - | radon |
| Mt Ds Rg Cn F1 melinerium damstadtium roentgenium copernicium flerovium | 89–103 104 105 106 | 104 105 106 | 105 106 | 106 | | 107 | | 108 | 109 | 110 | 111 | 112 | | 114 | | 116 | | |
| meitherium damstadtium roentgenium copernicium flerovium l | actinoids Rf Db Sg | Rf Db Sg | Db Sg | Sg | | ВР | | Hs | ¥ | Ds | Rg | S | | Ŀ | | ^ | | |
| | radium rutherfordium dubnium seaborgium bohrium | dubnium seaborgium | dubnium seaborgium | seaborgium | | bohrium – | | hassium | meitnerium - | damstadtium - | roentgenium - | copernicium | | flerovium - | | livermorium - | | |

| 71 Lu | lutetium 175 | 103 | ۲ | lawrencium - | |
|------------------------|---------------------|-----|-----------|---------------------|--|
| ° A | ytterbium 173 | 102 | % | nobelium – | |
| e9 Tm | thulium 169 | 101 | Md | mendelevium - | |
| ₈₈ <u>п</u> | erbium 167 | 100 | Fm | fermium - | |
| 67 Ho | holmium 165 | 66 | Es | einsteinium – | |
| © Dy | dysprosium 163 | 86 | ŭ | californium - | |
| e5 Tb | terbium 159 | 26 | Ř | berkelium - | |
| ² G | gadolinium 157 | 96 | Cm | curium | |
| es Eu | europium 152 | 92 | Am | americium _ | |
| 62 Sm | samarium 150 | 94 | Pu | plutonium | |
| e1 Pm | promethium — | 93 | dN | neptunium – | |
| 9 P N | neodymium 144 | 92 | \supset | uranium 238 | |
| 59 P | praseodymium 141 | 91 | Ра | protactinium 231 | |
| Se Ce | cerium 140 | 06 | H | thorium 232 | |
| 57 La | lanthanum 139 | 88 | Ac | actinium | |

lanthanoids

actinoids

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