Cambridge IGCSE

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

| | |
|---|---|
| CANDIDATE NAME | |
| CENTRE NUMBER | |
| CANDIDATE NUMBER | |

*3497163988*

**CHEMISTRY** **0620/33**

Paper 3 Theory (Core) **May/June 2018**

**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 20.
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.

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

This document consists of **17** printed pages and **3** blank pages.




CAMBRIDGE International Examinations

**1** The names of seven gases are given.

**ammonia**
**ethene**
**helium**
**hydrogen**
**hydrogen chloride**
**methane**
**nitrogen**

**(a)** Answer the following questions about these gases.
Each gas may be used once, more than once or not at all.
State which gas:

**(i)** forms an acidic solution in water

..... [1]

**(ii)** is monatomic

..... [1]

**(iii)** forms 78% of clean dry air

..... [1]

**(iv)** is the main constituent of natural gas

..... [1]

**(v)** has molecules which each contain 14 protons.

..... [1]

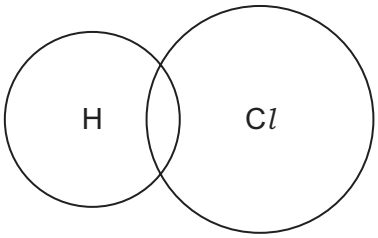
**(b) (i)** Give the names of **two** elements in the list.

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

**(ii)** What is meant by the term *element*?

..... [1]

**(c)** Complete the dot-and-cross diagram to show the electron arrangement in a molecule of hydrogen chloride. Show outer electrons only.




[2]

[Total: 9]

**2** **(a)** The table shows the percentage by volume of each of the gases present in the exhaust gases from a petrol engine and a diesel engine.

| name | percentage by volume from a petrol engine | percentage by volume from a diesel engine |
|---|---|---|
| nitrogen | 72.00 | 67.00 |
| carbon dioxide | 14.00 | |
| water vapour | 12.00 | 11.00 |
| carbon monoxide | 1.50 | 0.05 |
| oxides of nitrogen | 0.25 | 0.70 |
| hydrocarbons | 0.24 | 0.22 |
| sulfur dioxide | 0.01 | 0.03 |
| oxygen | 0.00 | 9.00 |
| | total 100.00 | total 100.00 |

**(i)** In the diesel engine, nitrogen, carbon dioxide and water vapour account for 90.00% of the exhaust gases by volume.

Calculate the percentage by volume of carbon dioxide in the exhaust gases from the diesel engine.

.....% [1]

**(ii)** Describe **three** ways in which the composition of the exhaust gases from the petrol engine differ from the composition of the exhaust gases from the diesel engine.

1 .....

2 .....

3 .....

[3]

**(iii)** Give **one** adverse effect of sulfur dioxide on health.

..... [1]

**(b)** Complete the sentences about the separation of petroleum into fractions using words from the list.

**boiling crystallisation density distillation kerosene poly(ethene)**

Fractional ..... of petroleum produces fractions such as gasoline, diesel oil and ..... . Within each fraction, the molecules have a particular range of ..... points.

[3]

**(c)** Balance the chemical equation for the complete combustion of propane.

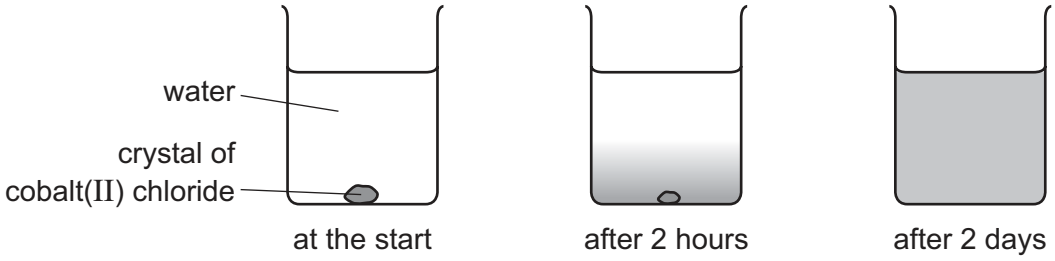
$$C_3H_8 + 5O_2 \rightarrow .....CO_2 + .....H_2O$$

[2]

[Total: 10]

**3** This question is about cobalt and its compounds.

**(a)** A coloured crystal of cobalt(II) chloride was placed at the bottom of a beaker containing water. After 2 days, the colour had spread throughout the water.




Explain these observations using the kinetic particle model.

.....

.....

.....

.....

..... [3]

**(b)** Cobalt(II) chloride can be used to test for the presence of water.

$$\underset{\substack{\text{anhydrous}\\\text{cobalt(II) chloride}}}{CoCl_2} + 6H_2O \rightleftharpoons \underset{\substack{\text{hydrated}\\\text{cobalt(II) chloride}}}{CoCl_2.6H_2O}$$

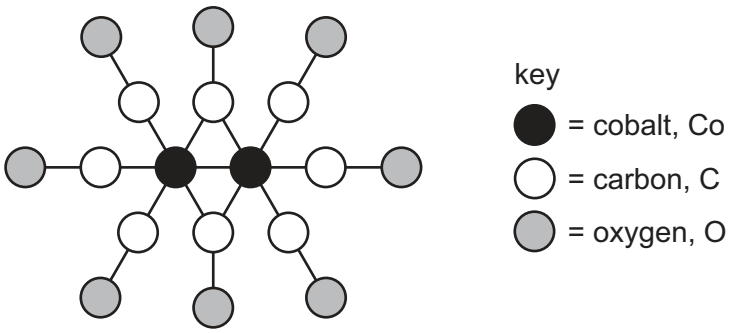
**(i)** What is meant by the symbol $\rightleftharpoons$?

..... [1]

**(ii)** Describe how the colour of anhydrous cobalt(II) chloride changes when water is added to it.

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

**(c)** A compound of cobalt can be represented by the structure shown.




Deduce the molecular formula of this compound showing the number of cobalt, carbon and oxygen atoms.

..... [1]

**(d)** The table compares the reactivity of cobalt with that of three other metals.

| metal | reactivity with cold water | reactivity with steam |
|---|---|---|
| barium | reacts rapidly | |
| cobalt | no reaction | reacts slowly when heated |
| magnesium | reacts very slowly | reacts rapidly |
| zinc | no reaction | reacts easily when heated |

Use this information to put the metals in order of their reactivity. Put the least reactive metal first.

least reactive ⟶ most reactive

[2]

**(e)** Cobalt is a transition element. Lithium is an element in Group I of the Periodic Table.

Describe **three** ways in which the properties of cobalt differ from those of lithium.

1 .....

2 .....

3 .....

[2]

**(f)** When cobalt(II) oxide, CoO, is heated in air, an oxide with the formula $Co_3O_4$ is formed.

Balance the chemical equation for this reaction.

$$.....CoO + O_2 \rightarrow 2Co_3O_4$$

[1]

**(g)** When $Co_3O_4$ is heated with hydrogen, cobalt metal can be formed.

$$Co_3O_4 + 4H_2 \rightarrow 3Co + 4H_2O$$

How does this equation show that $Co_3O_4$ is reduced?

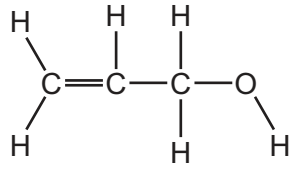
.....

..... [1]

[Total: 13]

**4** This question is about alcohols.

**(a)** The structure of compound **P** is shown.



**(i)** What feature of the structure of compound **P** shows that it is unsaturated?

..... [1]

**(ii)** Describe how the colour of aqueous bromine changes when an excess of compound **P** is added to it.

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

**(iii)** The melting point of compound **P** is –129 °C.
The boiling point of compound **P** is 97 °C.

What is the physical state of compound **P** at –120 °C?
Explain your answer.

.....

..... [2]

**(b)** Ethanol is an alcohol with two carbon atoms.

**(i)** Draw the structure of ethanol showing all of the atoms and all of the bonds.

[1]

**(ii)** Ethanol can be manufactured by fermentation.

Complete the sentences about fermentation using words from the list.

| | | | |
|---|---|---|---|
| **30 °C** | **300 °C** | **distillation** | **electrolysis** |
| **elements** | **enzymes** | **salt** | **sugar** |

A flask containing ..... solution and yeast is heated to ..... .

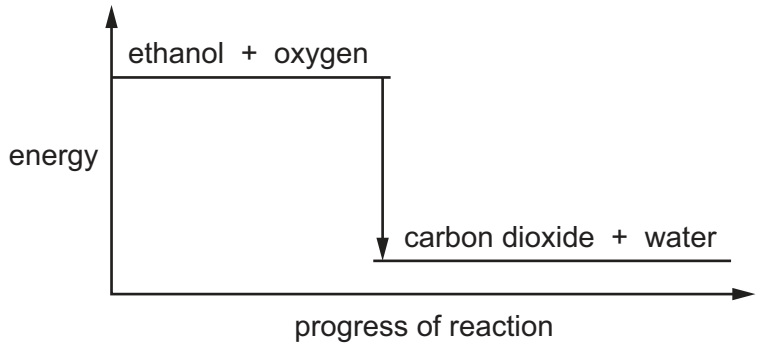
The yeast contains ..... which catalyse the reaction. The ethanol is separated by ..... . [4]

**(iii)** Ethanol can be used as a fuel.

Give **one** other use of ethanol in industry.

..... [1]

**(iv)** The energy level diagram for the complete combustion of ethanol is shown.




Explain how this diagram shows that the reaction is exothermic.

.....

..... [1]

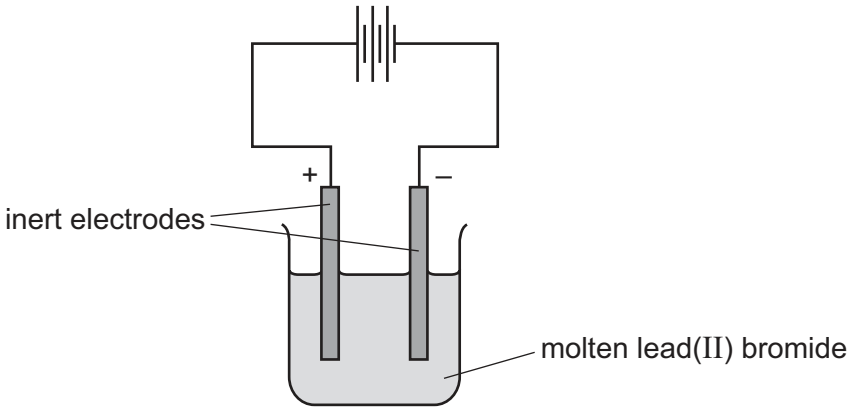
**(v)** Carbon dioxide and water can be formed when ethanol burns in a limited supply of air.

State the name of **two** other products which can be formed when ethanol burns in a limited supply of air.

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

[Total: 14]

**5** **(a)** Molten lead(II) bromide can be electrolysed using the apparatus shown.




The negative electrode is called the cathode.

State the name of the positive electrode.

..... [1]

**(b)** Predict the products of the electrolysis of molten lead(II) bromide at:

the negative electrode .....

the positive electrode. .....
[2]

**(c)** Lead(II) bromide is insoluble in cold water.
Sodium bromide is soluble in cold water.

Describe how you could obtain crystals of sodium bromide from a mixture of solid lead(II) bromide and solid sodium bromide.

.....

.....

.....

..... [3]

**(d)** When chlorine is bubbled through a colourless aqueous solution of sodium bromide, the solution turns orange-brown.

Name the orange-brown substance. Suggest, using ideas about reactivity of the halogens, why the reaction occurs.

orange-brown substance .....

why the reaction occurs .....

.....
[2]

**(e)** What is the colour of the precipitate formed when aqueous silver nitrate is added to aqueous sodium bromide?

..... [1]

**(f)** Complete the sentence about the formation of a chloride ion from a chlorine atom.

A chloride ion is formed when a chlorine atom gains one ..... . [1]

[Total: 10]

**6** This question is about isotopes.

**(a)** An atom of an isotope of oxygen is represented by the symbol shown.

$^{17}_{8}O$

Describe the structure of an atom of this isotope of oxygen.
In your answer, include:

- the position of the protons, neutrons and electrons in the atom
- the number of protons, neutrons and electrons present in the atom.

.....

.....

.....

.....

.....

.....

..... [5]

**(b)** Which **two** statements about isotopes are correct?
Tick **two** boxes.

| | |
|---|---|
| Isotopes of the same element have different numbers of protons. | ☐ |
| Isotopes of the same element have different numbers of neutrons. | ☐ |
| Isotopes are always radioactive. | ☐ |
| The isotope $^{235}_{92}U$ is a source of energy. | ☐ |
| $^{14}_{6}C$ and $^{14}_{7}N$ are isotopes of each other. | ☐ |

[2]

**(c)** What is meant by the term *nucleon number*?

.....

..... [1]

[Total: 8]

**7** This question is about Group I elements and their compounds.

**(a)** The properties of some Group I elements are shown in the table.

| element | melting point / °C | relative hardness | observations when it reacts with cold water |
|---|---|---|---|
| lithium | 181 | 23 | |
| sodium | 98 | 3 | rapid bubbling but does **not** burst into flame |
| potassium | 63 | | very rapid bubbling and bursts into flame |
| rubidium | | 1 | bursts into flame and explodes |

**(i)** Complete the table to estimate:
- the relative hardness of potassium
- the melting point of rubidium.

[2]

**(ii)** Use the information in the table to predict what you would observe when lithium reacts with cold water.

..... [1]

**(b)** Write the electronic structure of a sodium atom.

..... [1]

**(c)** When sodium reacts with water, an alkaline solution is formed.

$$2Na + 2H_2O \rightarrow 2NaOH + H_2$$

**(i)** Use the information in the equation to explain why the solution formed is alkaline.

..... [1]

**(ii)** Describe how you could use a named indicator solution to show that the solution is alkaline.

.....

..... [2]



**[Turn over**

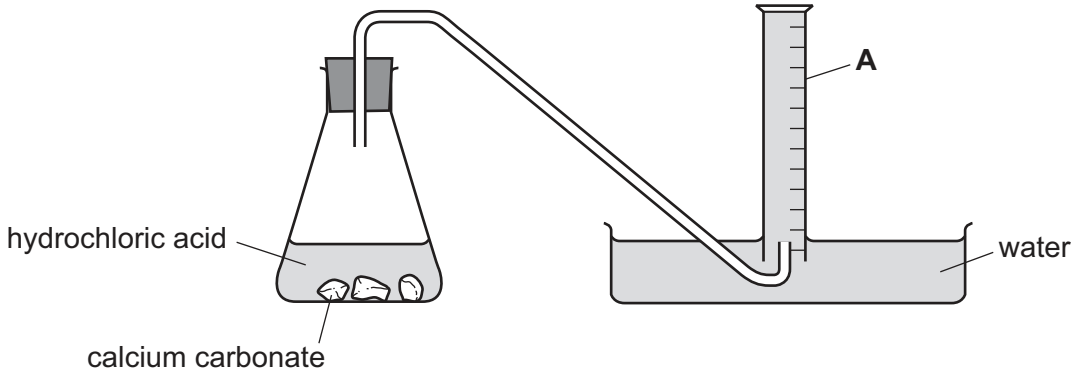
**(d)** Sodium tetrahydridoborate, $NaBH_4$, is an ionic compound.

Calculate the relative formula mass of $NaBH_4$.
Show all your working.
Use your Periodic Table to help you.

relative formula mass = ..... [2]

[Total: 9]

**8** The apparatus shown is used to investigate the rate of reaction between calcium carbonate and hydrochloric acid at 30 °C.




**(a)** Name the piece of apparatus labelled **A** in the diagram.

..... [1]

**(b)** Describe how this apparatus can be used to find the rate of reaction.

.....

.....

..... [2]

**(c)** The experiment is repeated at 20 °C. All other conditions are kept the same.

How does the decrease in temperature affect the rate of reaction?

..... [1]

**(d)** The experiment is repeated using the same mass of different size pieces of calcium carbonate. All other conditions are kept the same.

The sizes of the pieces of calcium carbonate are:
- large pieces
- small pieces
- powder

Complete the table by writing the sizes of the pieces in the first column.

| size of the pieces of calcium carbonate | initial rate of reaction in $cm^3$ gas / s |
|---|---|
| | 5 |
| | 2 |
| | 12 |

[1]

**(e)** Give the names of the **three** products formed when calcium carbonate reacts with hydrochloric acid.

1 .....

2 .....

3 .....
[2]

[Total: 7]

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## The Periodic Table of Elements

| Group I | Group II | | | | | | | | | | | Group III | Group IV | Group V | Group VI | Group VII | Group 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.).