Cambridge Assessment International Education

# Cambridge O Level

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*5841930783*

**CHEMISTRY** **5070/21**

Paper 2 Theory **May/June 2022**

**1 hour 30 minutes**

You must answer on the question paper.

No additional materials are needed.

**INSTRUCTIONS**

- Section A: answer **all** questions.
- Section B: answer **three** 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 75.
- 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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## Section A

Answer **all** the questions in this section in the spaces provided.

The total mark for this section is 45.

**1** Choose from the following compounds to answer the questions.

**$NH_4Cl$**

**$BaSO_4$**

**KI**

**$K_2SO_3$**

**$Mg(NO_3)_2$**

**$NaOCOCH_3$**

**$Na_2CO_3$**

**$Na_3PO_4$**

**$ZnSO_4$**

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

State which compound:

**(a)** reacts with dilute nitric acid to form a gas that turns limewater milky

..... [1]

**(b)** reacts with warm aqueous sodium hydroxide to form a gas that turns damp red litmus paper blue

..... [1]

**(c)** reacts with dilute hydrochloric acid to give a gas that decolourises acidified potassium manganate(VII)

..... [1]

**(d)** is prepared using a precipitation reaction

..... [1]

**(e)** contains an anion with a charge of –3

..... [1]

**(f)** is used to test for an oxidising agent.

..... [1]

[Total: 6]

**2** The table shows some information about elements in Group V.

| element | electronic configuration | melting point / °C | boiling point / °C |
|---|---|---|---|
| nitrogen | 2, 5 | –210 | –196 |
| phosphorus | | 44 | 280 |
| arsenic | 2, 8, 18, 5 | 817 | 613 |
| antimony | 2, 8, 18, 18, 5 | 630 | 1380 |
| bismuth | 2, 8, 18, 32, 18, 5 | | |

**(a)** State the electronic configuration for phosphorus.

..... [1]

**(b)** Explain why it is easier to predict the boiling point of bismuth than to predict its melting point.

.....

.....

..... [1]

**(c)** Use information from the table to explain why antimony is a liquid at 1000 °C.

.....

.....

..... [1]

**(d)** Nitrogen exists as a diatomic molecule, $N_2$.

**(i)** Draw the dot-and-cross diagram to show the bonding in $N_2$.

Show only the outer shell electrons.

[1]

**(ii)** Explain, in terms of structure and bonding, why nitrogen has a low melting point.

.....

..... [1]

**(e)** Bismuth is a metal.

Predict **two** physical properties of bismuth.

1 .....

2 .....
[2]

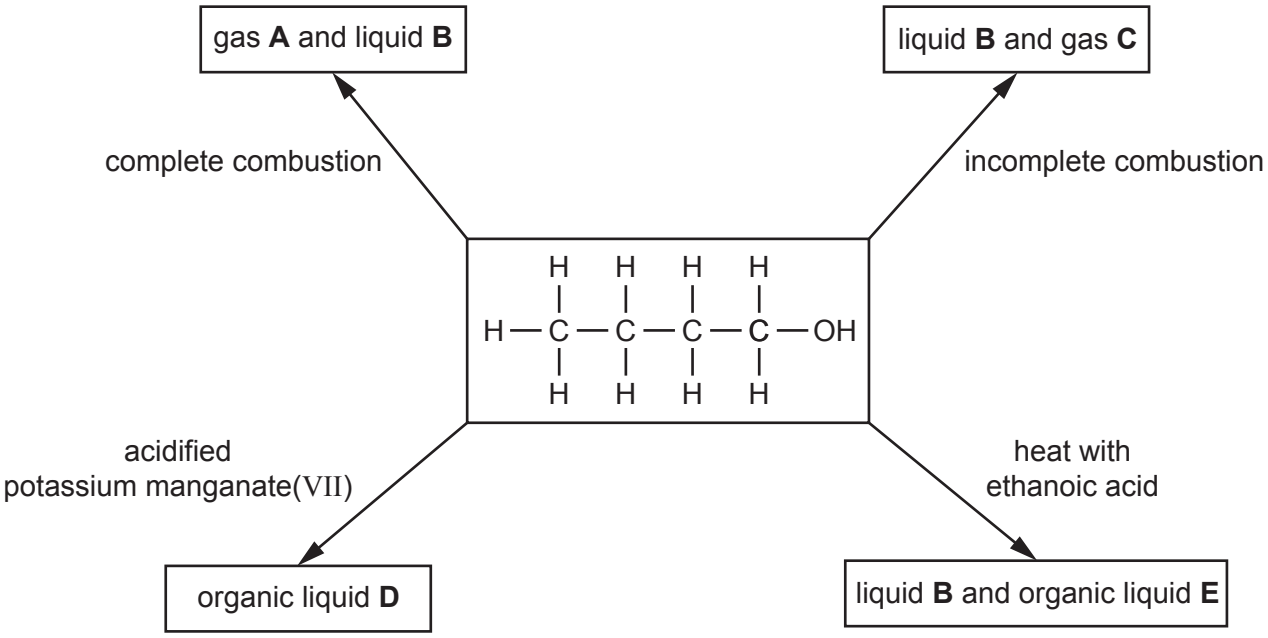
**(f)** Calculate the volume, in $dm^3$, of 19.2 g of nitrogen at room temperature and pressure.

Give your answer to **two** significant figures.

volume ..... $dm^3$ [3]

[Total: 10]

**3** The diagram shows some reactions of butanol.




**(a)** **A**, **B** and **C** are different compounds.

Identify by name **A**, **B** and **C**.

**A** .....

**B** .....

**C** .....

[3]

**(b)** Name and draw the structure of **D**.

name .....

structure

[2]

**(c)** Name and draw the structure of **E**.

name .....

structure

[2]

[Total: 7]

**4** The table shows information about some particles.

| particle | proton number | nucleon number |
|---|---|---|
| $^{35}_{17}Cl$ | 17 | 35 |
| $^{35}_{17}Cl^{-}$ | 17 | 35 |
| $^{39}_{19}K$ | 19 | 39 |
| $^{39}_{19}K^{+}$ | 19 | 39 |

**(a)** State the number of neutrons in $^{35}_{17}Cl$.

..... [1]

**(b)** State the number of electrons in $^{35}_{17}Cl^{-}$.

..... [1]

**(c)** $^{39}_{19}K$ is the full symbol for one isotope of potassium.

Suggest the full symbol for one **other** isotope of potassium.

..... [1]

**(d)** Describe how a potassium ion, $K^{+}$, is formed from a potassium atom, K.

.....

..... [1]

**(e)** Potassium chloride is an ionic compound.

Potassium chloride has a high melting point and a high boiling point.

**(i)** Explain why potassium chloride has a high melting point.

.....

.....

..... [2]

**(ii)** Predict two **other** physical properties of potassium chloride.

1 .....

2 .....
[2]

[Total: 8]

**5** Iron reacts with steam and with dilute sulfuric acid.

**(a)** The reaction between iron and steam is reversible.

The forward reaction is exothermic.

$$3Fe(s) + 4H_2O(g) \rightleftharpoons Fe_3O_4(s) + 4H_2(g)$$

An equilibrium mixture is formed when the reversible reaction happens in a closed system.

**(i)** Predict what happens to the amount of hydrogen in the equilibrium mixture if the temperature is increased and the pressure remains constant.

Explain your answer.

prediction .....

explanation .....

.....

.....
[2]

**(ii)** Predict what happens to the amount of hydrogen in the equilibrium mixture if the pressure is increased and the temperature remains constant.

Explain your answer.

prediction .....

explanation .....

.....

.....
[2]

**(b)** Iron reacts with dilute sulfuric acid to make aqueous iron(II) sulfate, $FeSO_4$.

**(i)** Construct the ionic equation, with state symbols, for this reaction.

..... [2]

**(ii)** Describe a chemical test to confirm that iron(II) sulfate is formed instead of iron(III) sulfate.

.....

.....

.....

..... [2]

**(iii)** The aqueous iron(II) sulfate formed is crystallised to make hydrated iron(II) sulfate, $FeSO_4 \cdot 7H_2O$.

Calculate the relative formula mass of hydrated iron(II) sulfate.

relative formula mass = ..... [1]

**(iv)** A student uses 2.80 g of iron to make 12.5 g of hydrated iron(II) sulfate crystals.

This is a 90% yield.

Calculate the mass of hydrated iron(II) sulfate crystals made from 2.80 g of iron if the yield is 100%.

mass = ..... g [1]

**(c)** Aqueous iron(II) sulfate is electrolysed using graphite electrodes.

Predict the products of this electrolysis.

product at cathode .....

product at anode .....
[1]

**(d)** Iron is extracted from iron ore in a blast furnace.

Describe the essential reactions involved in the extraction of iron.

.....

.....

.....

.....

.....

.....

..... [3]

[Total: 14]

## Section B

Answer **three** questions from this section in the spaces provided.

The total mark for this section is 30.

**6** Carbon monoxide and nitrogen monoxide are pollutants formed in a car engine.

**(a)** Describe how nitrogen monoxide is formed in a car engine.

.....

..... [1]

**(b)** Carbon monoxide reacts with nitrogen monoxide as shown in the equation.

$$2CO + 2NO \rightarrow 2CO_2 + N_2$$

This reaction is extremely slow at room temperature but is much faster in the presence of a catalyst in a catalytic converter.

**(i)** Explain why this reaction involves **both** oxidation and reduction.

.....

.....

..... [2]

**(ii)** The reaction between carbon monoxide and nitrogen monoxide is exothermic.

Explain, using ideas about bond breaking and bond forming, why the reaction is exothermic.

.....

.....

.....

..... [2]

**(iii)** Explain, using ideas about particles, why increasing the temperature increases the rate of the reaction between carbon monoxide and nitrogen monoxide.

.....

.....

.....

..... [2]

**(iv)** Explain why a catalyst increases the rate of the reaction between carbon monoxide and nitrogen monoxide.

.....

..... [1]

**(v)** Explain, using ideas about particles, why the catalyst in a catalytic converter needs to have a large surface area.

.....

.....

..... [2]

[Total: 10]

**7** Aluminium is an element in Group III of the Periodic Table.

**(a)** Aluminium is used to make containers for food because it does not react with water.

State and explain, in terms of its properties, one other large-scale use of aluminium.

large-scale use .....

explanation .....

.....
[1]

**(b)** Explain why aluminium does not react with cold water.

.....

.....

.....

..... [2]

**(c)** Describe, with the aid of a labelled diagram, the metallic bonding in solid aluminium.

.....

.....

.....
[2]

**(d)** Aluminium is manufactured by the electrolysis of aluminium oxide dissolved in molten cryolite.

Write the ionic equations for the reactions at the cathode and at the anode.

cathode .....

anode .....
[2]

**(e)** A sample of 2.34 g of aluminium is reacted with 50.0 $cm^3$ of 2.00 mol / $dm^3$ sulfuric acid.

$$2Al(s) + 3H_2SO_4(aq) \longrightarrow Al_2(SO_4)_3(aq) + 3H_2(g)$$

Show by calculation that the aluminium is in excess in this reaction.

[3]

[Total: 10]

**8** Alkenes are a homologous series of unsaturated hydrocarbons.

**(a)** Name the alkene which has only three carbon atoms in its molecule.

..... [1]

**(b)** Draw the structure of an unbranched and of a branched alkene.

Show all of the atoms and all of the bonds in each structure.

unbranched alkene

branched alkene

[2]

**(c)** Describe a chemical test that distinguishes an alkene from an alkane.

chemical test .....

result with alkene .....

result with alkane .....

[2]

**(d)** Alkenes are manufactured by the cracking of long chain hydrocarbons.

The equation for the cracking of $C_{14}H_{30}$ is shown.

$$C_{14}H_{30} \rightarrow 2\mathbf{X} + C_8H_{18}$$

**(i)** Give **two** reasons why the cracking of long chain hydrocarbons is important.

.....

.....

..... [2]

**(ii)** Compound **X** contains 85.7% carbon by mass and 14.3% hydrogen by mass.

Calculate, using the percentage composition data, the empirical formula of **X**.

Show your working.

State the molecular formula of **X**.

empirical formula .....

molecular formula .....
[3]

[Total: 10]

**9** Ammonia, $NH_3$, is used to make nitrogenous fertilisers.

**(a)** Ammonia is manufactured using the reversible reaction between nitrogen and hydrogen.

Construct the equation for this reversible reaction.

..... [2]

**(b)** Ammonia is used to make the soluble salt ammonium nitrate, $NH_4NO_3$.

**(i)** Name the acid that reacts with ammonia to make ammonium nitrate.

..... [1]

**(ii)** Calculate the percentage by mass of nitrogen in ammonium nitrate.

percentage by mass = ..... [2]

**(c)** Nitrogenous fertilisers such as ammonium nitrate leach from farmland and cause water pollution problems in rivers and lakes.

**(i)** Name the process caused by this type of water pollution.

..... [1]

**(ii)** Explain why this type of water pollution problem is increased when nitrate fertilisers are used instead of other fertilisers.

.....

..... [1]

**(d)** A farmer adds ammonium nitrate, $NH_4NO_3$, to soil. The farmer then adds calcium hydroxide, $Ca(OH)_2$, to the same soil.

**(i)** State the purpose of adding calcium hydroxide to soil.

..... [1]

**(ii)** Construct the equation for the reaction between ammonium nitrate and calcium hydroxide.

Using your equation, explain why the ammonium nitrate fertiliser is less effective after calcium hydroxide is added.

.....

.....

.....

..... [2]

[Total: 10]

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## The Periodic Table of Elements

**Key**

| atomic number |
|---|
| **atomic symbol** |
| name |
| relative atomic mass |

| Group I | Group II | | | | | | | | | | | Group III | Group IV | Group V | Group VI | Group VII | Group VIII |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | 1<br>H<br>hydrogen<br>1 | | | | | | | | | | 2<br>He<br>helium<br>4 |
| 3<br>Li<br>lithium<br>7 | 4<br>Be<br>beryllium<br>9 | | | | | | | | | | | 5<br>B<br>boron<br>11 | 6<br>C<br>carbon<br>12 | 7<br>N<br>nitrogen<br>14 | 8<br>O<br>oxygen<br>16 | 9<br>F<br>fluorine<br>19 | 10<br>Ne<br>neon<br>20 |
| 11<br>Na<br>sodium<br>23 | 12<br>Mg<br>magnesium<br>24 | | | | | | | | | | | 13<br>Al<br>aluminium<br>27 | 14<br>Si<br>silicon<br>28 | 15<br>P<br>phosphorus<br>31 | 16<br>S<br>sulfur<br>32 | 17<br>Cl<br>chlorine<br>35.5 | 18<br>Ar<br>argon<br>40 |
| 19<br>K<br>potassium<br>39 | 20<br>Ca<br>calcium<br>40 | 21<br>Sc<br>scandium<br>45 | 22<br>Ti<br>titanium<br>48 | 23<br>V<br>vanadium<br>51 | 24<br>Cr<br>chromium<br>52 | 25<br>Mn<br>manganese<br>55 | 26<br>Fe<br>iron<br>56 | 27<br>Co<br>cobalt<br>59 | 28<br>Ni<br>nickel<br>59 | 29<br>Cu<br>copper<br>64 | 30<br>Zn<br>zinc<br>65 | 31<br>Ga<br>gallium<br>70 | 32<br>Ge<br>germanium<br>73 | 33<br>As<br>arsenic<br>75 | 34<br>Se<br>selenium<br>79 | 35<br>Br<br>bromine<br>80 | 36<br>Kr<br>krypton<br>84 |
| 37<br>Rb<br>rubidium<br>85 | 38<br>Sr<br>strontium<br>88 | 39<br>Y<br>yttrium<br>89 | 40<br>Zr<br>zirconium<br>91 | 41<br>Nb<br>niobium<br>93 | 42<br>Mo<br>molybdenum<br>96 | 43<br>Tc<br>technetium<br>– | 44<br>Ru<br>ruthenium<br>101 | 45<br>Rh<br>rhodium<br>103 | 46<br>Pd<br>palladium<br>106 | 47<br>Ag<br>silver<br>108 | 48<br>Cd<br>cadmium<br>112 | 49<br>In<br>indium<br>115 | 50<br>Sn<br>tin<br>119 | 51<br>Sb<br>antimony<br>122 | 52<br>Te<br>tellurium<br>128 | 53<br>I<br>iodine<br>127 | 54<br>Xe<br>xenon<br>131 |
| 55<br>Cs<br>caesium<br>133 | 56<br>Ba<br>barium<br>137 | 57–71<br>lanthanoids | 72<br>Hf<br>hafnium<br>178 | 73<br>Ta<br>tantalum<br>181 | 74<br>W<br>tungsten<br>184 | 75<br>Re<br>rhenium<br>186 | 76<br>Os<br>osmium<br>190 | 77<br>Ir<br>iridium<br>192 | 78<br>Pt<br>platinum<br>195 | 79<br>Au<br>gold<br>197 | 80<br>Hg<br>mercury<br>201 | 81<br>Tl<br>thallium<br>204 | 82<br>Pb<br>lead<br>207 | 83<br>Bi<br>bismuth<br>209 | 84<br>Po<br>polonium<br>– | 85<br>At<br>astatine<br>– | 86<br>Rn<br>radon<br>– |
| 87<br>Fr<br>francium<br>– | 88<br>Ra<br>radium<br>– | 89–103<br>actinoids | 104<br>Rf<br>rutherfordium<br>– | 105<br>Db<br>dubnium<br>– | 106<br>Sg<br>seaborgium<br>– | 107<br>Bh<br>bohrium<br>– | 108<br>Hs<br>hassium<br>– | 109<br>Mt<br>meitnerium<br>– | 110<br>Ds<br>darmstadtium<br>– | 111<br>Rg<br>roentgenium<br>– | 112<br>Cn<br>copernicium<br>– | | 114<br>Fl<br>flerovium<br>– | | 116<br>Lv<br>livermorium<br>– | | |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| lanthanoids | 57<br>La<br>lanthanum<br>139 | 58<br>Ce<br>cerium<br>140 | 59<br>Pr<br>praseodymium<br>141 | 60<br>Nd<br>neodymium<br>144 | 61<br>Pm<br>promethium<br>– | 62<br>Sm<br>samarium<br>150 | 63<br>Eu<br>europium<br>152 | 64<br>Gd<br>gadolinium<br>157 | 65<br>Tb<br>terbium<br>159 | 66<br>Dy<br>dysprosium<br>163 | 67<br>Ho<br>holmium<br>165 | 68<br>Er<br>erbium<br>167 | 69<br>Tm<br>thulium<br>169 | 70<br>Yb<br>ytterbium<br>173 | 71<br>Lu<br>lutetium<br>175 |
| actinoids | 89<br>Ac<br>actinium<br>– | 90<br>Th<br>thorium<br>232 | 91<br>Pa<br>protactinium<br>231 | 92<br>U<br>uranium<br>238 | 93<br>Np<br>neptunium<br>– | 94<br>Pu<br>plutonium<br>– | 95<br>Am<br>americium<br>– | 96<br>Cm<br>curium<br>– | 97<br>Bk<br>berkelium<br>– | 98<br>Cf<br>californium<br>– | 99<br>Es<br>einsteinium<br>– | 100<br>Fm<br>fermium<br>– | 101<br>Md<br>mendelevium<br>– | 102<br>No<br>nobelium<br>– | 103<br>Lr<br>lawrencium<br>– |

The volume of one mole of any gas is 24 $dm^3$ at room temperature and pressure (r.t.p.).

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