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

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

Paper 4 Theory (Extended) **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 12.
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 **11** printed pages and **1** blank page.


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**1** Give the name of the process that is used:

**(a)** to obtain water from aqueous sodium chloride

..... [1]

**(b)** to produce lead from molten lead(II) bromide

..... [1]

**(c)** to separate an insoluble solid from a liquid

..... [1]

**(d)** to separate the components of petroleum

..... [1]

**(e)** to separate a mixture of coloured dyes.

..... [1]

[Total: 5]

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**2** This question is about the elements in Period 3 of the Periodic Table.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Na | Mg | A*l* | Si | P | S | C*l* | Ar |

For each of the following, identify a Period 3 element which matches the description. Each element may be used once, more than once or not at all.

State which Period 3 element:

**(a)** forms an oxide with a macromolecular structure

..... [1]

**(b)** is extracted from the ore bauxite

..... [1]

**(c)** is soft, metallic and stored in oil

..... [1]

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

..... [1]

**(e)** provides an inert atmosphere in lamps

..... [1]

**(f)** forms **two** different oxides during the Contact process

..... [1]

**(g)** is non-metallic and an important component of fertilisers.

..... [1]

[Total: 7]

**3** Complete the following table.

| particle | number of protons | number of electrons | number of neutrons | number of nucleons |
|---|---|---|---|---|
| $^{23}_{11}$Na | 11 | 11 | ..... | 23 |
| $^{37}_{17}$C*l*$^{-}$ | ..... | ..... | 20 | ..... |
| $^{56}_{26}$..... | 26 | 24 | 30 | 56 |

[6]

[Total: 6]

**4** Potassium reacts with bromine at room temperature to form potassium bromide.

**(a)** Write a chemical equation for this reaction. Include state symbols.

..... [3]

**(b)** Potassium bromide exists as an ionic lattice.
Potassium bromide does **not** conduct electricity when solid but does conduct electricity when molten.

**(i)** What is meant by the term *ionic lattice*?

.....

..... [2]

**(ii)** Explain why potassium bromide does **not** conduct electricity when solid but does conduct electricity when molten.

.....

.....

..... [2]

**(c)** Concentrated aqueous potassium bromide is an electrolyte.

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

.....

..... [2]

**(ii)** Describe the electrolysis of concentrated aqueous potassium bromide.

Include:
- an ionic half-equation for the reaction at the cathode
- the name of the product at the anode
- the name of the potassium compound formed.

.....

.....

.....

..... [4]

**(iii)** When molten potassium bromide is electrolysed, the product at the cathode is different.

Name the product at the cathode when molten potassium bromide is electrolysed.

..... [1]

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**(d)** Iodine reacts with chlorine to form iodine monochloride, $ICl$, as the only product.

**(i)** Write a chemical equation for this reaction.

..... [2]

**(ii)** Draw a dot-and-cross diagram to show the electron arrangement in a molecule of iodine monochloride. Show outer shell electrons only.

[2]

**(e)** Potassium bromide has a melting point of 734 °C.
Iodine monochloride has a melting point of 27 °C.

In terms of attractive forces, explain why there is a large difference between these melting points.

.....

.....

.....

.....

..... [3]

**(f)** When chlorine gas is passed through aqueous potassium bromide, a redox reaction occurs. The ionic equation is shown.

$$Cl_2 + 2Br^- \rightarrow 2Cl^- + Br_2$$

**(i)** Write an ionic half-equation showing what happens to the chlorine molecules, $Cl_2$, in this reaction.

..... [1]

**(ii)** Explain why the bromide ions, $Br^-$, act as reducing agents in this reaction.

..... [1]

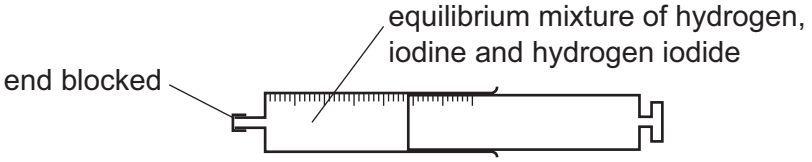
[Total: 23]

**5** Hydrogen and iodine react together in a reversible reaction. Hydrogen iodide is formed.

$$\underset{\text{colourless gas}}{H_2(g)} + \underset{\text{purple gas}}{I_2(g)} \rightleftharpoons \underset{\text{colourless gas}}{2HI(g)}$$

The forward reaction is exothermic.

A gas syringe containing an equilibrium mixture of hydrogen, iodine and hydrogen iodide gases was sealed and heated to 250 °C. The equilibrium mixture was a pale purple colour.




**(a)** What is meant by the term *equilibrium*?

.....

.....

..... [2]

**(b)** The plunger of the gas syringe was pressed in while the end of the gas syringe was blocked. This increased the pressure. The position of the equilibrium did **not** change. The colour of the gaseous mixture turned darker purple.

**(i)** Give a reason why the position of the equilibrium did **not** change.

..... [1]

**(ii)** Suggest why the gaseous mixture turned darker purple, even though the position of the equilibrium did **not** change.

..... [1]

**(c)** The temperature of the gas syringe was increased to 300 °C.

**(i)** What happened to the **position** of the equilibrium when the temperature of the gas syringe was increased from 250 °C to 300 °C?

..... [1]

**(ii)** What happened to the **rate** of the forward reaction and the **rate** of the backward reaction when the temperature of the gas syringe was increased from 250 °C to 300 °C?

rate of the forward reaction .....

rate of the backward reaction .....
[2]

[Total: 7]

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**6** **(a)** All sodium salts are soluble in water. All nitrates are soluble in water. Barium carbonate is insoluble in water.

Describe how you would make a pure, dry sample of barium carbonate by precipitation.
Include:
- the names of the starting materials
- full practical details
- a chemical equation.

.....

.....

.....

.....

.....

..... [5]

**(b)** Nitrates decompose when heated.

**(i)** Write a chemical equation for the decomposition of sodium nitrate when it is heated.

..... [2]

**(ii)** The unbalanced chemical equation for the decomposition of hydrated copper(II) nitrate crystals is shown.

Balance the chemical equation for this reaction.

$2Cu(NO_3)_2.3H_2O(s) \rightarrow$ .....$CuO(s)$ + .....$NO_2(g)$ + $O_2(g)$ + .....$H_2O(g)$

[2]

**(iii)** When the hydrated copper(II) nitrate crystals are heated, steam is produced. When the steam condenses on a cool surface, it turns into a colourless liquid.

Anhydrous cobalt(II) chloride is used to show that the colourless liquid contains water.

How does the colour of the anhydrous cobalt(II) chloride change?

from ..... to .....

[2]

**(iv)** How would the student test to determine if the water produced in **(b)(iii)** is pure?

..... [1]

[Total: 12]

**7** Many organic compounds, such as alcohols, carboxylic acids and esters, contain the elements carbon, hydrogen and oxygen only.

**(a)** Compound **R** has the following composition by mass: C, 60.00%; H, 13.33%; O, 26.67%.

Calculate the empirical formula of compound **R**.

empirical formula = ..... [2]

**(b)** Compound **S** has the empirical formula $C_2H_4O$ and a relative molecular mass of 88.

Calculate the molecular formula of compound **S**.

molecular formula = ..... [2]

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**(c)** Compounds **T** and **V** both have the molecular formula $C_3H_6O_2$.

- Compound **T** produces bubbles of carbon dioxide gas when it is added to aqueous sodium carbonate.
- Compound **V** is an ester.

**(i)** What is the name given to compounds with the same molecular formula but different structures?

..... [1]

**(ii)** Draw the structures of compounds **T** and **V**. Show all of the atoms and all of the bonds.

compound **T**

compound **V**

[2]

**(iii)** All compounds with the molecular formula $C_3H_6O_2$ can undergo complete combustion in an excess of oxygen.

Complete the chemical equation for this reaction.

$C_3H_6O_2$ + ..... → ..... + .....

[2]

**(d)** Compound **W** has the molecular formula $C_2H_6O$. Compound **W** reacts when heated with ethanoic acid and a catalyst to produce a sweet-smelling liquid.

**(i)** Give the name of the homologous series to which compound **W** belongs.

..... [1]

**(ii)** Draw the structure of compound **W**. Show all of the atoms and all of the bonds.

[1]

**(e)** Alkanes and alkenes are hydrocarbons.

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

.....

..... [2]

**(ii)** State the general formula of:

alkanes .....

alkenes .....
[2]

**(f)** Ethanol can be produced from long-chain alkanes as shown.

$$\text{long-chain alkane} \xrightarrow{\textbf{step 1}} \text{ethene} \xrightarrow{\textbf{step 2}} \text{ethanol}$$

Describe the **two-stage** manufacture of ethanol from the long-chain alkane octane, $C_8H_{18}$.
Include:
- the names of the types of chemical reactions that occur
- reaction equations
- reaction conditions.

**step 1** .....

.....

.....

.....

**step 2** .....

.....

.....

..... [5]

[Total: 20]

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## The Periodic Table of Elements

**Key**

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

Group

| I | II | | | | | | | | | | | III | IV | V | VI | VII | 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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