

CANDIDATE  
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CENTRE  
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**CHEMISTRY**

Paper 2 Theory

**5070/21**

**May/June 2016**

**1 hour 30 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.**

**Section A**

Answer **all** questions.

Write your answers in the spaces provided in the Question Paper.

**Section B**

Answer any **three** questions.

Write your answers in the spaces provided in the Question Paper.

Electronic calculators may be used.

You may lose marks if you do not show your working or if you do not use appropriate units.

A copy of the Periodic Table is printed on page 20.

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.

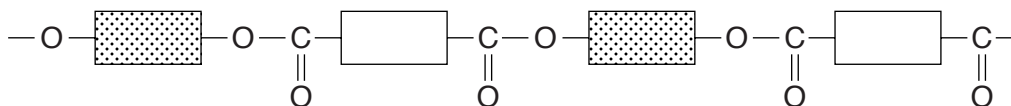
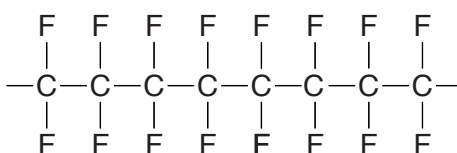
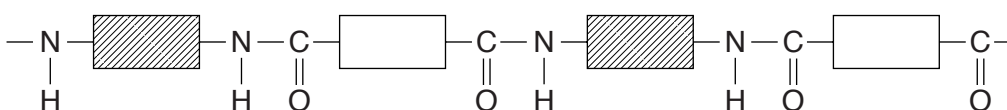
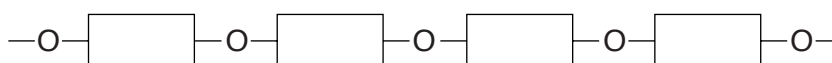
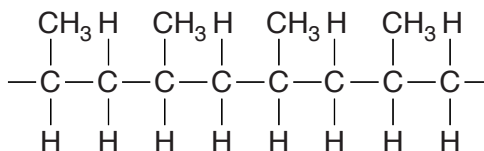
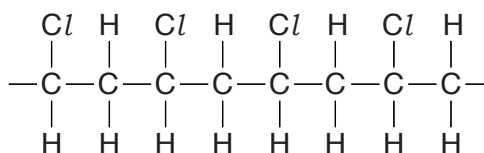
This document consists of **19** printed pages and **1** blank page.

## Section A

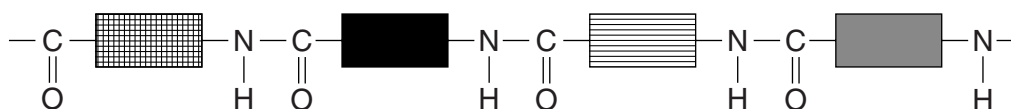
Answer **all** the questions in this section in the spaces provided.

The total mark for this section is 45.

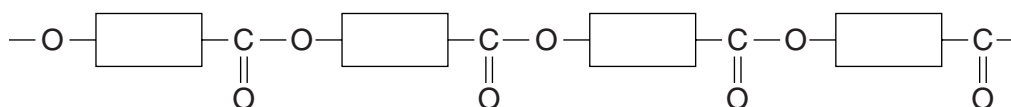
**A1** Choose from the following polymers to answer the questions.

**Terylene****PTFE****nylon****starch****poly(propene)****PVC**

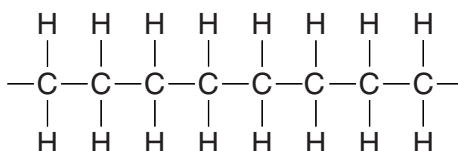
## protein



## polyester



## poly(ethene)



Each polymer can be used once, more than once or not at all.

Which is a polymer that

(a) is made from propene,

..... [1]

(b) will form hydrogen chloride when combusted,

..... [1]

(c) can be hydrolysed to form amino acids,

..... [1]

(d) can be hydrolysed to make simple sugars,

..... [1]

(e) contains the same linkage as that present in a fat?

..... [1]

[Total: 5]

**A2** Hydrogen sulfide, H<sub>2</sub>S, has a simple molecular structure. It is soluble in water.

**(a)** Suggest **one** other physical property of hydrogen sulfide.

..... [1]

**(b)** Aqueous hydrogen sulfide is a weak acid.

**(i)** Write an equation to show the dissociation of hydrogen sulfide.

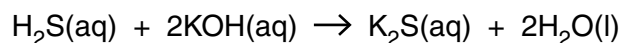
..... [1]

**(ii)** Why is aqueous hydrogen sulfide described as a weak acid?

.....

..... [1]

**(c)** Aqueous hydrogen sulfide reacts with aqueous potassium hydroxide.



What is the minimum volume, in cm<sup>3</sup>, of 0.150 mol/dm<sup>3</sup> KOH required to completely react with a solution containing 0.170 g of H<sub>2</sub>S?

volume of KOH(aq) = ..... cm<sup>3</sup> [3]

(d) Magnesium reacts with sulfur to make the ionic compound magnesium sulfide.

(i) Predict **two** physical properties of magnesium sulfide.

1. ....

2. ....

[2]

(ii) Explain, in terms of electrons, how a magnesium atom reacts with a sulfur atom to make a magnesium ion and a sulfide ion.

.....

.....

.....

..... [2]

[Total: 10]

**A3** Esters, such as propyl ethanoate, are often used as solvents.

**(a)** Give **one** other use for esters such as propyl ethanoate.

..... [1]

**(b)** Draw the structure of propyl ethanoate, showing all of the atoms and all of the bonds.

[1]

**(c)** A bottle of propyl ethanoate is opened in a room. Some of the propyl ethanoate evaporates and then diffuses into the room.

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

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

**(ii)** What happens to the rate of diffusion of propyl ethanoate as the temperature of the room increases?

Explain your answer in terms of the kinetic particle theory.

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

(iii) The table shows some information about different esters.

| name              | structure                             | relative molecular mass ( $M_r$ ) |
|-------------------|---------------------------------------|-----------------------------------|
| methyl methanoate | $\text{HCO}_2\text{CH}_3$             | 60                                |
| ethyl methanoate  | $\text{HCO}_2\text{C}_2\text{H}_5$    | 74                                |
| propyl methanoate | $\text{HCO}_2\text{C}_3\text{H}_7$    | 88                                |
| butyl methanoate  | $\text{HCO}_2\text{C}_4\text{H}_9$    | 102                               |
| pentyl methanoate | $\text{HCO}_2\text{C}_5\text{H}_{11}$ | 116                               |

Which ester has the **greatest** rate of diffusion at room temperature and pressure?

.....

Explain your answer.

.....

.....

[2]

[Total: 7]

**A4** Ammonia is manufactured by the reaction between hydrogen and nitrogen in the Haber process.

**(a)** State the conditions used in the Haber process.

temperature .....

pressure .....

catalyst ..... [2]

**(b)** Describe and explain the effect of increasing the pressure on the **rate** of this reaction.

.....

.....

.....

..... [2]

**(c)** Explain how a catalyst speeds up the rate of a chemical reaction.

.....

..... [1]

**(d)** Ammonia is used to make fertilisers.

The table gives some information about two fertilisers made from ammonia.

| fertiliser       | formula                    | relative formula mass ( $M_r$ ) |
|------------------|----------------------------|---------------------------------|
| ammonium nitrate | $\text{NH}_4\text{NO}_3$   | 80                              |
| urea             | $(\text{NH}_2)_2\text{CO}$ | 60                              |

Use the data in the table to show that urea contains a greater percentage by mass of nitrogen than ammonium nitrate.

[2]

[Total: 7]



**A5** The statements give some of the chemical properties of metal *X* and its compounds.

- *X* does not react with cold water.
- *X* fizzes slowly with dilute hydrochloric acid.
- *X* does not react with aqueous sodium chloride.
- *X* reacts with aqueous lead(II) nitrate.
- *X* reacts with aqueous silver nitrate.
- *XO* reacts with magnesium to form *X*.

**(a)** Use the information to help arrange the following metals in order of reactivity.

lead, magnesium, silver, sodium and *X*

most reactive .....

.....

.....

.....

least reactive ..... [2]

**(b)** Suggest a possible identity for *X*.

..... [1]

**(c)** Construct the equation for the reaction between the oxide, *XO*, and magnesium.

..... [1]

**(d)** Construct the ionic equation for the reaction between *X* and aqueous lead(II) nitrate,  $\text{Pb}(\text{NO}_3)_2(\text{aq})$ .

..... [1]

**(e)** Metal *X* is a good electrical conductor and has a high melting point.

Explain why *X*

- conducts electricity, .....
- .....
- .....
- has a high melting point. ....
- .....
- .....

[3]

[Total: 8]

**A6** The atmosphere contains a large number of gases including oxygen, nitrogen, carbon dioxide, sulfur dioxide, oxides of nitrogen, methane and chlorofluorocarbons (CFCs).

**(a)** Carbon dioxide, methane and CFCs are greenhouse gases.

**(i)** State **one** effect of an increase in the atmospheric concentration of carbon dioxide and methane.

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

**(ii)** State **one** source of methane gas.

..... [1]

**(iii)** State one **other** environmental effect of the presence of CFCs in the atmosphere.

..... [1]

**(b)** The formula of one chlorofluorocarbon is  $\text{CFCl}_3$ .

Draw the 'dot-and-cross' diagram to show the bonding in a molecule of  $\text{CFCl}_3$ . Only draw the outer-shell electrons.

[1]

(c) Oxides of nitrogen are produced during the combustion of petrol (gasoline) in a car engine.

(i) Describe the chemical reaction that takes place within a car engine to form nitric oxide, NO.

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

(ii) Most of the nitric oxide and other pollutants present in the exhaust gases of a car are removed in a catalytic converter.

Describe the redox reactions that happen within a catalytic converter.

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

(d) Nitrogen dioxide is one of the causes of acid rain.

Two moles of nitrogen dioxide react with one mole of water to make an aqueous solution of two acids only.

One of these acids is nitric acid.

Deduce the formula of the other acid.

..... [1]

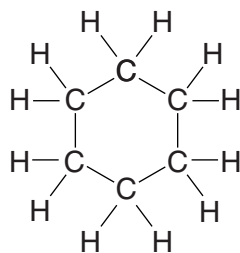
[Total: 8]





**B8** Cyclohexane,  $C_6H_{12}$ , is a cycloalkane.

Cycloalkanes react in a similar way to alkanes.



cyclohexane

**(a)** Cyclohexane is a saturated hydrocarbon.

**(i)** What is the meaning of the term *saturated*?

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

**(ii)** What is the meaning of the term *hydrocarbon*?

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

**(b)** Construct the equation for the complete combustion of cyclohexane.

..... [1]

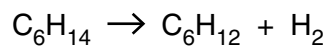
**(c)** Cyclohexane reacts with chlorine in the presence of ultraviolet light.

This is a substitution reaction.

Write the molecular formulae of **two** products of this reaction.

..... [2]

- (d) Cyclohexane can be manufactured from hexane as shown in the equation.



Calculate the mass of cyclohexane that can be made from 258 g of hexane.  
[ $M_r$  of cyclohexane = 84]

mass of cyclohexane = ..... g [2]

- (e) Another cycloalkane has the following percentage composition by mass.

C, 85.7%; H, 14.3%

- (i) Use the percentage composition by mass to show that the empirical formula of the cycloalkane is  $\text{CH}_2$ .

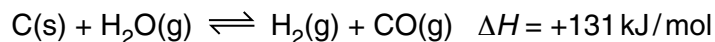
[2]

- (ii) Draw the structure of the cycloalkane with an  $M_r$  of 56, showing all of the atoms and all of the bonds.

[1]

[Total:10]

**B9** Carbon reacts with steam in a reversible reaction.



The reaction reaches an equilibrium if carried out in a closed container.

**(a)** Explain, in terms of bond breaking and bond forming, why this reaction is endothermic.

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

**(b)** When one mole of hydrogen,  $\text{H}_2$ , is formed, 131 kJ of energy is absorbed.

Calculate the amount of energy absorbed when  $240 \text{ dm}^3$  of hydrogen, measured at room temperature and pressure, is formed.

energy absorbed = ..... kJ [2]

**(c)** Predict, with a reason, how the **position of equilibrium** of this reaction changes as the

**(i)** pressure is increased at constant temperature,

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

**(ii)** temperature is increased at constant pressure.

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



(d) The reaction between carbon and steam is a possible source of hydrogen.

(i) Suggest one disadvantage of using this reaction as a source of hydrogen.

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

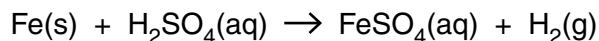
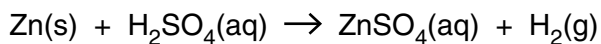
(ii) Another source of hydrogen is the cracking of hydrocarbons from crude oil.

Give one advantage of manufacturing hydrogen from the reaction of carbon with steam rather than from crude oil.

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

[Total: 10]

**B10** Both zinc and iron react with dilute sulfuric acid.



**(a)** A 0.65 g sample of zinc is reacted with excess sulfuric acid.

**(i)** Calculate the volume of hydrogen, measured at room temperature and pressure, formed in this reaction.

volume of hydrogen = ..... dm<sup>3</sup> [2]

**(ii)** Explain why a different volume of hydrogen, measured at room temperature and pressure, is formed when 0.65 g of iron is reacted with excess sulfuric acid.

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

**(b)** A mixture of iron powder and zinc powder is added to excess sulfuric acid.

When the reaction stops, aqueous sodium hydroxide is added drop by drop to the reaction mixture until it is in excess.

Describe what you would observe during the addition of aqueous sodium hydroxide and explain the reactions taking place.

observations

.....  
 .....

explanations

.....  
 .....  
 .....  
 .....

[4]

(c) The products of heating iron(II) sulfate are iron(III) oxide, sulfur dioxide and sulfur trioxide.

(i) Explain how you can tell that the reaction involves an oxidation.

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

(ii) Describe the chemical test for sulfur dioxide.

test .....

.....

observation .....

..... [2]

[Total: 10]

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## The Periodic Table of Elements

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

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

The volume of one mole of any gas is 24 dm<sup>3</sup> at room temperature and pressure (r.t.p.)