

Cambridge International Examinations

Cambridge Ordinary Level

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



CHEMISTRY 5070/21

Paper 2 Theory

October/November 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 18 printed pages and 2 blank pages.



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 compounds to answer the questions below.

| Ba(NO ₃) ₂ |
|-----------------------------------|
| CaCO ₃ |
| CaO |
| CH ₄ |
| C_3H_8 |
| Fe_2O_3 |
| $KMnO_4$ |
| NaNO ₃ |
| NO |
| SO ₂ |
| V_2O_5 |
| Zn(NO ₃) ₂ |

Each of these compounds can be used once, more than once or not at all.

Which compound

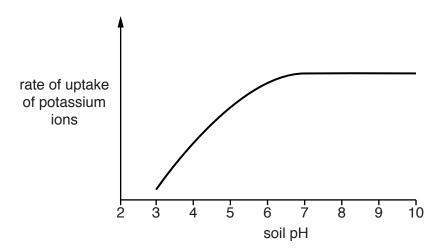
| (a) | is an atmospheric pollutant formed by lightning activity, |
|-----|---|
| | [1] |
| (b) | is the main constituent of natural gas, |
| | [1] |
| (c) | dissolves in water to form an aqueous solution which gives a white precipitate on addition of aqueous sodium sulfate, |
| | [1] |
| (d) | is a catalyst in the contact process for the manufacture of sulfuric acid, |
| | [1] |
| (e) | is a product of the thermal decomposition of limestone? |
| | [1] |
| | |

[Total: 5]

A2 Sulfuric acid is a strong acid.

| (a) | (i) | What is meant by the term strong acid? |
|-----|------|--|
| | | [1] |
| | (ii) | Describe how you could measure the pH of dilute sulfuric acid. |
| | | |
| | | [1] |
| (b) | Mar | y plants cannot grow in soils which are too acidic. |
| | Des | cribe and explain how soils which are too acidic can be treated to reduce the acidity. |
| | | |
| | | |
| | | [2] |
| | | |

(c) The graph shows the effect of soil pH on the rate of uptake of potassium ions by plant roots.



| Describe how the rate of uptake of potassium ions varies with soil pH. | |
|--|-----------|
| | |
| | [1 |
| | [Total: 5 |

| (b) Th | The table shows some information about different alcohols. | | | | | |
|--------------------------------|--|-----------------------------------|-------------------|--------------------|---------------------------------|--|
| | alcohol | formula | melting point | boiling point | density in g/cm ³ | |
| | ethanol | C ₂ H ₅ OH | -117 | 79 | 0.789 | |
| | propanol | C ₃ H ₇ OH | -126 | 98 | 0.804 | |
| | butanol | C ₄ H ₉ OH | -89 | 117 | | |
| | pentanol | C ₅ H ₁₁ OH | – 79 | 138 | 0.815 | |
| | hexanol | C ₆ H ₁₃ OH | -47 | 158 | 0.820 | |
| (iii) | What is the answer. | physical state | | | and pressure? Ex | |
| (iii) | | physical state | of pentanol at ro | oom temperature | | |
| (iii) | | physical state | of pentanol at ro | oom temperature | and pressure? Ex | |
| | answer. | | of pentanol at ro | oom temperature | and pressure? Ex | |
| (c) Ho | answerw does viscos | ity change in t | of pentanol at ro | oom temperature | and pressure? Ex | |
| (c) Ho Ex | answer. w does viscos | ity change in t | of pentanol at ro | series of alcohols | and pressure? Ex | |
| (c) Ho Ex | answer. w does viscos | wer. | of pentanol at ro | series of alcohols | and pressure? Ex | |
| (c) Ho Ex (d) Co | answer. w does viscos plain your ans | wer. | of pentanol at ro | series of alcohols | and pressure? Ex | |

(ii) Draw the structure of propanoic acid, showing all the atoms and all the bonds.

[1]

[Total: 11]

 $\bf A4~$ Peroxodisulfate ions, $\rm S_2O_8^{\ 2-},$ react with iodide ions in aqueous solution.

$$\mathrm{S_2O_8}^{2-}\mathrm{(aq)} \ + \ 2\mathrm{I^-(aq)} \ \longrightarrow \ 2\mathrm{SO_4}^{2-}\mathrm{(aq)} \ + \ \mathrm{I_2(aq)}$$

The table shows how the relative rate of this reaction changes when different concentrations of peroxodisulfate ions and iodide ions are used.

| experiment | concentration of S ₂ O ₈ ²⁻ in mol/dm ³ | concentration of I ⁻ in mol/dm ³ | relative rate of reaction |
|------------|---|---|---------------------------|
| 1 | 0.008 | 0.02 | 1.7 |
| 2 | 0.016 | 0.02 | 3.3 |
| 3 | 0.032 | 0.02 | 6.8 |
| 4 | 0.008 | 0.04 | 3.4 |
| 5 | 0.008 | 0.08 | 6.9 |

| (a) | | e the information in the table to describe how increasing the concentration of each of the saffects the relative rate of reaction. | hese |
|-----|------|--|------|
| | per | oxodisulfate ions | |
| | | | |
| | iodi | ide ions | |
| | | | [2] |
| (b) | Iror | n(III) ions, Fe ³⁺ , catalyse this reaction. | |
| | Exp | plain how catalysts increase the rate of a reaction. | |
| | | | |
| | | | [1] |
| (c) | Iron | n(III) ions react with iodide ions. | |
| | | $2I^{-}(aq) + 2Fe^{3+}(aq) \rightarrow I_{2}(aq) + 2Fe^{2+}(aq)$ | |
| | (i) | Explain how iron(III) ions are acting as an oxidising agent in this reaction. | |
| | | | |
| | | | [1] |
| | (ii) | What colour change is observed when this reaction happens? | |
| | | | |

| | (iii) | Describe a test for iron(III) ions. |
|-----|-------|--|
| | | test |
| | | observation |
| | | [2] |
| (d) | Iron | (II) ions react with peroxodisulfate ions. The products are iron(III) ions and sulfate ions. |
| | Cor | struct the equation for this reaction. |
| | | [1] |
| | | [Total: 8] |

| | | 8 |
|-----------|------|---|
| A5 | Pota | assium chlorate, $KClO_3$, decomposes to form potassium chloride and oxygen. |
| | | $2KClO_3(s) \rightarrow 2KCl(s) + 3O_2(g)$ |
| | (a) | Calculate the percentage by mass of oxygen in potassium chlorate. |
| | | |
| | | |
| | | |
| | | |
| | | [2] |
| | (b) | Calculate the maximum volume of oxygen formed at room temperature and pressure when 12.25 g of potassium chlorate is completely decomposed. |
| | | - 1.1.20 g or potacolarit cinerate to completely accompaced. |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | [3] |
| | (c) | Potassium chloride can be made by reacting potassium with chlorine. |

| (i) | Explain in terms of gain and loss of electrons, how potassium ions and chloride ions are formed when potassium reacts with chlorine. |
|------|--|
| | |
| | |
| | |
| | [3] |
| (ii) | Predict two physical properties of potassium chloride. |
| | |
| | |

[Total: 10]

| Dry | air c | ontains nitrogen, oxygen, argon and other gases. | |
|-----|-------|--|------|
| (a) | Stat | te the percentage compositions by volume of nitrogen and oxygen present in dry air. | |
| | nitro | ogen% | |
| | oxy | gen% | [1] |
| (b) | The | formula for oxygen gas is O ₂ . | |
| | (i) | Draw a 'dot-and-cross' diagram of an oxygen molecule. | |
| | | Show only the outer shell electrons. | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | [1] |
| | (ii) | What is the formula of argon gas? | |
| | | | .[1] |
| (c) | | nium is extracted from titanium(${ m IV}$) chloride by reduction with molten sodium in an argosphere and not in air. | gon |
| | Sug | gest why this reaction is carried out in an argon atmosphere and not in air. | |
| | | | |
| | | | .[2] |
| (d) | Stat | te one other use of argon. | |
| | | | [1] |
| | ••••• | [Total | |
| | | [Total | . 0] |

A6

Section B

Answer three questions from this section in the spaces provided.

The total mark for this section is 30.

B7 Ethenyl ethanoate, CH₃CO₂CH=CH₂, is manufactured by passing a mixture of ethanoic acid, ethene and oxygen over a catalyst at 200 °C.

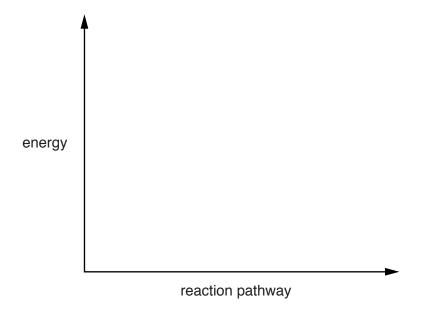
$$\mathsf{CH_3CO_2H} \ + \ \mathsf{CH_2=CH_2} \ + \ \ ^1\!\!/_2\mathsf{O_2} \ \longrightarrow \ \mathsf{CH_3CO_2CH=CH_2} \ + \ \mathsf{H_2O}$$

The reaction is exothermic.

(a) Draw an energy profile diagram for this reaction on the axes shown.

On your diagram label

- the reactants and products,
- the enthalpy change for the reaction,
- the activation energy.



[3]

(b) Ethenyl ethanoate is an unsaturated compound.

Describe a chemical test for an unsaturated compound.

test

observation

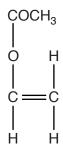
[2]

(c) The catalyst used in the manufacture of ethenyl ethanoate contains copper.

Copper reacts with concentrated nitric acid.

Complete the equation for this reaction.

(d) The structure of ethenyl ethanoate is shown.



Draw the structure of the addition polymer formed from ethenyl ethanoate.

| | | [2] |
|-----|---|------|
| (e) | State two pollution problems caused by non-biodegradable plastics. | |
| | | |
| | | [2] |
| | | .[-] |

[Total: 10]

B8 Ethanol can be manufactured by reacting ethene with steam in a closed reaction vessel.

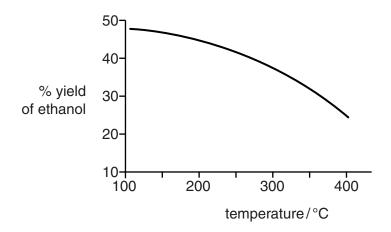
$$\mathsf{C_2H_4(g)} \ + \ \mathsf{H_2O(g)} \ \Longleftrightarrow \ \mathsf{C_2H_5OH(g)}$$

The reaction is exothermic.

(a) State two conditions for this reaction.

.....

(b) The graph shows the percentage yield of ethanol at different temperatures.



| (1) | Describe now, and explain why, the percentage yield changes with temperature. |
|------|---|
| | |
| | |
| | |
| | [3] |
| (ii) | Suggest why the reaction is carried out at 300 °C and not at 200 °C. |
| | |
| | |
| | [2] |
| | cribe how, and explain why, the position of equilibrium changes when the pressure is eased. |
| | |
| | |

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(c)

| (d) | Ethanol reacts with methanoic acid, HCO ₂ H, to form ethyl methanoate and water. |
|-----|---|
| | Construct the equation for this reaction. |
| | [1] |
| | [Total: 10] |

| В9 | Tin and silver are metals. | | | | | | | | |
|----|----------------------------|---|-----|--|--|--|--|--|--|
| | (a) | State two properties which are characteristic of most metals. | | | | | | | |
| | | | | | | | | | |
| | | | [2] | | | | | | |
| | (b) | Draw a labelled diagram to show how a tin rod can be electroplated with silver. | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | [3] | | | | | | |
| | (c) | A 9.50 g sample of a chloride of tin contains 5.95 g of tin. | | | | | | | |
| | | Deduce the empirical formula of this chloride of tin. | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | empirical formula | [2] | | | | | | |

| (| d) | Tin(II |) oxide | reacts | with | oxygen | to form | tin(IV |) oxide. |
|---|----|--------|---------|--------|------|--------|---------|--------|----------|
| | | | | | | | | | |

When a sample of 13.5g of $tin({\rm II})$ oxide is reacted with oxygen, 12.7g of $tin({\rm IV})$ oxide is formed.

Calculate the percentage yield of tin(IV) oxide.

| % | [3] |
|-------|-----|
| | |

[Total: 10]

| B10 A student prepared some | crystals of hydrated | lithium nitrate by | reacting aqueous | s lithium hydroxide |
|------------------------------------|----------------------|--------------------|------------------|---------------------|
| with dilute nitric acid | | | | |

$${\rm LiOH} \ + \ {\rm HNO_3} \ + \ 2{\rm H_2O} \ \rightarrow \ {\rm LiNO_3.3H_2O}$$

| (a) | Explain how you would carry out this procedure to obtain pure dry crystals of hydrated lithium nitrate. |
|-----|--|
| | initale. |
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| | [4] |
| (b) | The student used 20.0 cm ³ of 0.500 mol/dm ³ of lithium hydroxide to prepare the crystals. |
| | Calculate the maximum mass of hydrated lithium nitrate crystals that could be made. |
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| | g [3] |
| (c) | A sample of hydrated lithium nitrate is heated in a test-tube. |
| ` , | $2 \text{LiNO}_3.3 \text{H}_2 \text{O(s)} \rightarrow \text{Li}_2 \text{O(s)} + 2 \text{NO}_2(\text{g}) + \frac{1}{2} \text{O}_2(\text{g}) + 6 \text{H}_2 \text{O(l)}$ |
| | · |
| | What is observed during this reaction? |
| | [1] |
| (d) | Explain why lithium oxide conducts electricity when molten. |
| | [1] |

| (e) | Predict the products of electrolysis of molten lithium oxide at | |
|-----|---|----|
| | the anode (positive electrode), | |
| | the cathode (negative electrode). | |
| | | [1 |

[Total: 10]

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The Periodic Table of Elements

| | = | 2 He | helium 4 | 10 | Ne | neon 20 | 18 | Ā | argon 40 | 36 | 궃 | krypton 84 | 54 | Xe | xenon 131 | 98 | 몬 | radon | | | |
|--------|-----|---------|---------------|---------------|--------------|------------------------------|----|-------|------------------|----|----|-----------------|----|----------|------------------|-------|-------------|-----------------|--------|-----------|--------------------|
| | II/ | | | 6 | ш | fluorine 19 | 17 | Cl | chlorine 35.5 | 35 | Ŗ | bromine 80 | 53 | н | iodine 127 | 85 | Ą | astatine - | | | |
| | > | | | 8 | 0 | oxygen 16 | 16 | ഗ | sulfur 32 | 34 | Se | selenium 79 | 52 | <u>a</u> | tellurium 128 | 84 | Ро | polonium – | 116 | ^ | livermorium - |
| | > | | | 7 | z | nitrogen 14 | 15 | ₾ | phosphorus 31 | 33 | As | arsenic 75 | 51 | Sp | antimony 122 | 83 | Ξ | bismuth 209 | | | |
| | ≥ | | | 9 | ပ | carbon 12 | 14 | Si | silicon 28 | 32 | Ge | germanium 73 | 50 | Sn | tin 119 | 82 | Ъ | lead 207 | 114 | Εl | flerovium — |
| | = | | | 2 | В | boron 11 | 13 | A^l | aluminium 27 | 31 | Ga | gallium 70 | 49 | In | indium 115 | 81 | 11 | thallium 204 | | | |
| | | | | | | | | | | 30 | Zu | zinc 65 | 48 | р | cadmium 112 | 80 | Нĝ | mercury 201 | 112 | C | copernicium — |
| | | | | | | | | | | 29 | Cn | copper 64 | 47 | Ag | silver 108 | 62 | Αn | gold 197 | 111 | Rg | roentgenium - |
| Group | | | | | | | | | | 28 | Z | nickel 59 | 46 | Pq | palladium 106 | 78 | 귙 | platinum 195 | 110 | Ds | darmstadtium - |
|) D | | | | | | | | | | 27 | ပိ | cobalt 59 | 45 | R | rhodium 103 | 77 | 'n | iridium 192 | 109 | Ĭ | meitnerium - |
| | | - I | hydrogen 1 | | | | | | | 26 | Fe | iron 56 | 44 | R | ruthenium 101 | 92 | SO | osmium 190 | 108 | Hs | hassium - |
| | | | | | | | | | | 25 | Mn | manganese 55 | 43 | ည | technetium - | 75 | Re | rhenium 186 | 107 | ВР | bohrium – |
| | | | | _ | pol | ass | | | | 24 | ပ် | chromium 52 | 42 | Mo | molybdenum 96 | 74 | ≥ | tungsten 184 | 106 | Sg | seaborgium - |
| | | | Key | atomic number | atomic symbo | name relative atomic mass | | | | 23 | > | vanadium 51 | 41 | qN | niobium 93 | 73 | Та | tantalum 181 | 105 | В | dubnium - |
| | | | | | atc | re | | | | 22 | j | titanium 48 | 40 | Zr | zirconium 91 | 72 | Έ | hafnium 178 | 104 | 꿉 | rutherfordium - |
| | | | | | | | | | | 21 | Sc | scandium 45 | 39 | > | yttrium 89 | 57-71 | lanthanoids | | 89–103 | actinoids | |
| | = | | | 4 | Be | beryllium 9 | 12 | Mg | magnesium 24 | 20 | Ca | calcium 40 | 38 | Š | strontium 88 | 56 | Ba | barium 137 | 88 | Ra | radium |
| | _ | | | က | := | lithium 7 | 1 | Na | sodium 23 | 19 | × | potassium 39 | 37 | & | rubidium 85 | 55 | Cs | caesium 133 | 87 | Ļ | francium - |

| rı Lu | lutetium 175 | 103 | ۲ | lawrencium - |
|--------------------|---------------------|-----|----------------|---------------------|
| 70 Yb | ytterbium 173 | 102 | N _o | nobelium |
| ш <u>Т</u> | thulium 169 | 101 | Md | mendelevium - |
| ₈₈ Г | erbium 167 | 100 | Fm | fermium - |
| 67 Ho | holmium 165 | 66 | Es | einsteinium - |
| 66 Dy | dysprosium 163 | 86 | ರ | californium - |
| 99 99 | terbium 159 | 97 | Æ | berkelium |
| 64 Gd | gadolinium 157 | 96 | Cm | curium |
| 63 Eu | europium 152 | 92 | Am | americium - |
| 62 Sm | samarium 150 | 94 | Pu | plutonium |
| 61 Pm | promethium - | 93 | Ν | neptunium - |
| ° PN | neodymium 144 | 92 | \supset | uranium 238 |
| 59 Pr | praseodymium 141 | 91 | Ра | protactinium 231 |
| SB Ce | cerium 140 | 06 | Т | 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.)