Cambridge
O Level

Cambridge International Examinations
Cambridge Ordinary Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

4053211008

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.

CAMBRIDGE
International Examinations

[Turn over

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) Many plants cannot grow in soils which are too acidic.

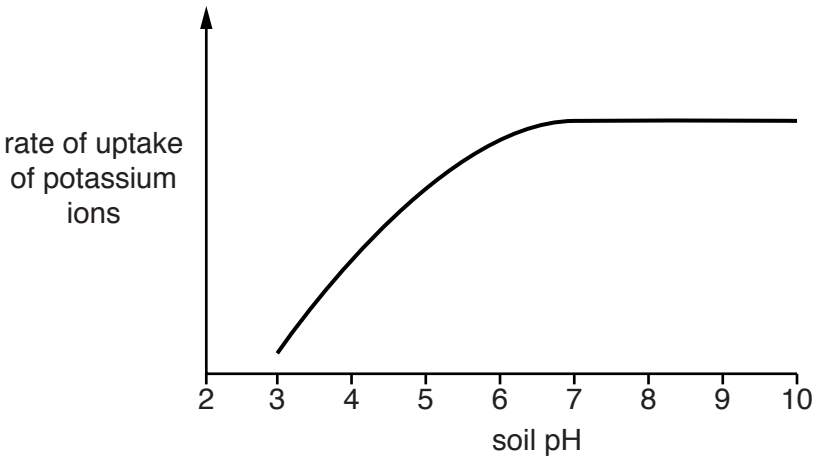
Describe and explain how soils which are too acidic can be treated to reduce the acidity.

.....

.....

.....[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]

A3 The alcohols are a homologous series with the general formula $C_nH_{2n+1}OH$.

(a) Deduce the molecular formula of the alcohol having eight carbon atoms.

.....[1]

(b) The table shows some information about different alcohols.

alcohol	formula	melting point /°C	boiling point /°C	density in g/cm^3
ethanol	C_2H_5OH	–117	79	0.789
propanol	C_3H_7OH	–126	98	0.804
butanol	C_4H_9OH	–89	117	
pentanol	$C_5H_{11}OH$	–79	138	0.815
hexanol	$C_6H_{13}OH$	–47	158	0.820

(i) Describe how the boiling point changes with the number of carbon atoms in the alcohol.

.....[1]

(ii) Estimate the density, in g/cm^3, of butanol.

.....[1]

(iii) What is the physical state of pentanol at room temperature and pressure? Explain your answer.

.....

.....

.....[1]

(c) How does viscosity change in the homologous series of alcohols?

Explain your answer.

.....

.....[2]

(d) Construct the equation for the complete combustion of propanol.

.....[2]

(e) Propanol can be oxidised to propanoic acid.

(i) Suggest the oxidising agent and describe the conditions used for this reaction.

.....

.....[2]

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

[1]

[Total: 11]

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

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

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 $S_2O_8^{2-}$ 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) Use the information in the table to describe how increasing the concentration of each of these ions affects the relative rate of reaction.

peroxodisulfate ions .....

.....

iodide ions .....

.....

[2]

(b) Iron(III) ions, Fe^{3+}, catalyse this reaction.

Explain how catalysts increase the rate of a reaction.

.....

.....[1]

(c) Iron(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?

.....[1]

(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.

Construct the equation for this reaction.

.....[1]

[Total: 8]

A5 Potassium 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.

[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.

.....

.....[2]

[Total: 10]

A6 Dry air contains nitrogen, oxygen, argon and other gases.

(a) State the percentage compositions by volume of nitrogen and oxygen present in dry air.

nitrogen ..... %

oxygen ..... % [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) Titanium is extracted from titanium(IV) chloride by reduction with molten sodium in an argon atmosphere and not in air.

Suggest why this reaction is carried out in an argon atmosphere and not in air.

.....

.....[2]

(d) State one other use of argon.

.....[1]

[Total: 6]

Section B

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

The total mark for this section is 30.

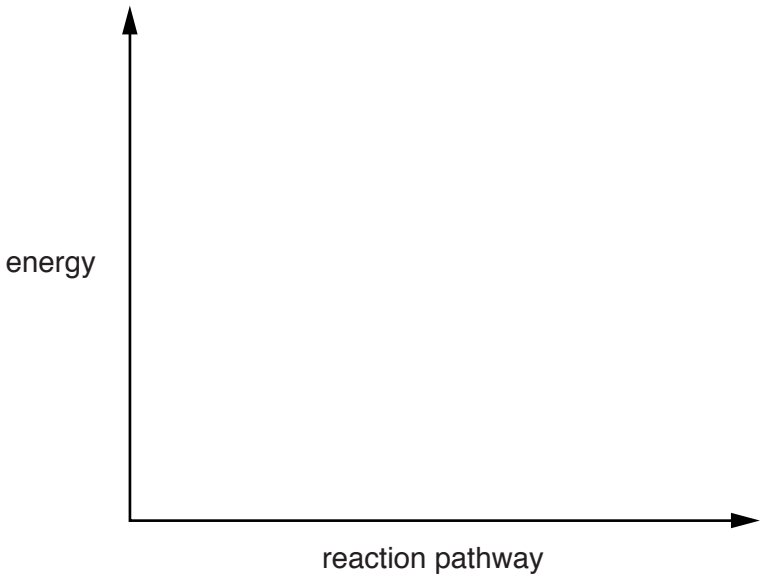
B7 Ethenyl ethanoate, $CH_3CO_2CH=CH_2$, is manufactured by passing a mixture of ethanoic acid, ethene and oxygen over a catalyst at 200 °C.

$$CH_3CO_2H + CH_2=CH_2 + \tfrac{1}{2}O_2 \rightarrow CH_3CO_2CH=CH_2 + H_2O$$

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]

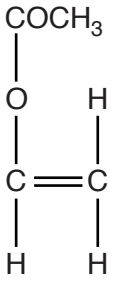
(c) The catalyst used in the manufacture of ethenyl ethanoate contains copper.

Copper reacts with concentrated nitric acid.

Complete the equation for this reaction.

$$Cu + ...HNO_3 \rightarrow Cu(NO_3)_2 + ...H_2O + ...NO_2$$ [1]

(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.

$$C_2H_4(g) + H_2O(g) \rightleftharpoons C_2H_5OH(g)$$

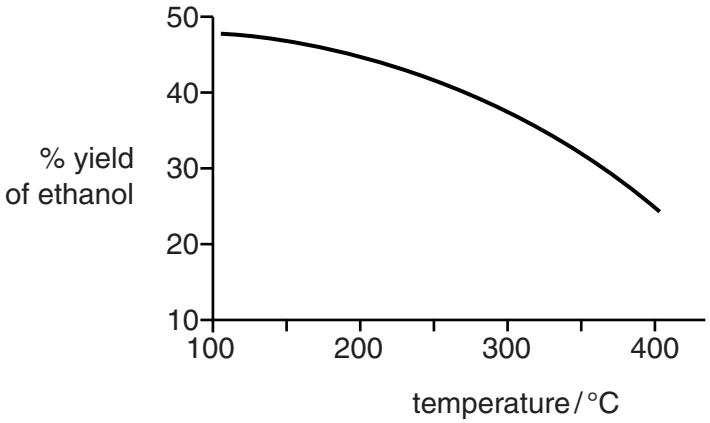
The reaction is exothermic.

(a) State **two** conditions for this reaction.

.....

.....[2]

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



(i) Describe how, 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]

(c) Describe how, and explain why, the position of equilibrium changes when the pressure is increased.

.....

.....

.....[2]

(d) Ethanol reacts with methanoic acid, HCO_2H, to form ethyl methanoate and water.

Construct the equation for this reaction.

.....[1]

[Total: 10]

B9 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.

$$\underset{\text{tin(II) oxide}}{2SnO} + O_2 \rightarrow \underset{\text{tin(IV) oxide}}{2SnO_2}$$

When a sample of 13.5 g of tin(II) oxide is reacted with oxygen, 12.7 g of tin(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 lithium hydroxide with dilute nitric acid.

$$LiOH + HNO_3 + 2H_2O \rightarrow LiNO_3.3H_2O$$

(a) Explain how you would carry out this procedure to obtain pure dry crystals of hydrated lithium nitrate.

.....

.....

.....

.....

.....

.....

.....

.....[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.

$$2LiNO_3.3H_2O(s) \rightarrow Li_2O(s) + 2NO_2(g) + \tfrac{1}{2}O_2(g) + 6H_2O(l)$$

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

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.)