Cambridge
O Level

Cambridge International Examinations
Cambridge Ordinary Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

4121908726

CHEMISTRY **5070/22**

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.

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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.

A1 Choose from the following compounds to answer the questions below.

$BaCl_2$
C_2H_4
C_3H_4
C_3H_8
CO
CO_2
K_2SO_4
Na_3PO_4
SO_2
$ZnSO_4$

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

Give a compound which

(a) is an acidic atmospheric pollutant from volcanic eruptions,

.....[1]

(b) is a saturated hydrocarbon,

.....[1]

(c) dissolves in water to form an aqueous solution which gives a white precipitate on addition of aqueous sodium hydroxide,

.....[1]

(d) reduces iron(III) oxide to iron in the blast furnace,

.....[1]

(e) contributes to the process of eutrophication.

.....[1]

[Total: 5]

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A2 Farmers add fertilisers such as ammonium sulfate to the soil to increase the rate of plant growth.

(a) Write the formulae of the ions present in ammonium sulfate.

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

(b) Describe a test for ammonium ions.

test .....

observation .....
[2]

(c) When ammonia dissolves in water, ammonium ions and hydroxide ions are formed.

Write the ionic equation for the reaction of aqueous ammonia with sulfuric acid.

.....[1]

[Total: 5]

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A3 The alkanes are a homologous series of hydrocarbons.

(a) State **two** properties of a homologous series.

.....

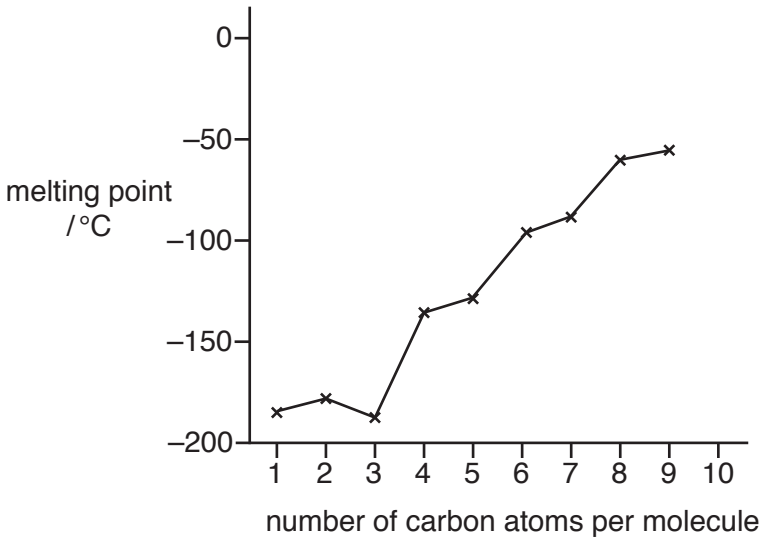
.....[2]

(b) Draw the structures of the branched and unbranched alkanes having four carbon atoms.

Show all the atoms and all the bonds.

[2]

(c) The graph shows how the melting points of the first nine unbranched alkanes vary with the number of carbon atoms per molecule.



(i) Describe how the melting points of these alkanes change with the number of carbon atoms.

.....

.....

.....[2]

(ii) Use the graph to estimate the melting point of the unbranched alkane which has ten carbon atoms.

.....°C [1]

(d) **(i)** Construct the equation for the complete combustion of pentane, C_5H_{12}.

.....[2]

(ii) Name the products of the incomplete combustion of pentane and explain why the incomplete combustion of hydrocarbons is hazardous to health.

.....

.....[2]

[Total: 11]

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A4 Propanone, CH_3COCH_3, reacts with iodine, I_2, to form colourless products.

$$CH_3COCH_3 + I_2 \rightarrow CH_3COCH_2I + HI$$

The reaction is catalysed by hydrochloric acid.

The table shows how the relative rate of this reaction changes when different concentrations of propanone, iodine and hydrochloric acid are used.

experiment	concentration of CH_3COCH_3 in mol/dm^3	concentration of I_2 in mol/dm^3	concentration of hydrochloric acid in mol/dm^3	relative rate of reaction
1	0.025	0.024	0.12	5.1
2	0.050	0.024	0.12	10.2
3	0.050	0.024	0.06	5.1
4	0.050	0.012	0.06	5.1

(a) Describe how increasing the concentration of each of these substances affects the relative rate of reaction.

propanone .....

iodine .....

hydrochloric acid .....

[3]

(b) Increasing the temperature increases the rate of this reaction.

Explain why, in terms of kinetic particle theory.

.....

.....

.....[2]

(c) Iodine has several isotopes.

What are isotopes?

.....

.....[1]

(d) Astatine, At, is a halogen.

Aqueous iodine reacts with aqueous astatide ions, At^-, to produce astatine.

Construct the ionic equation for this reaction.

.....[1]

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(e) Aqueous hydrogen iodide reduces hydrogen peroxide to water.

$$H_2O_2(aq) + 2H^+(aq) + 2I^-(aq) \rightarrow 2H_2O(l) + I_2(aq)$$

Explain how iodide ions act as a reducing agent in this reaction.

.....

.....[1]

[Total: 8]

A5 Nickel carbonyl, $Ni(CO)_4$, reacts with hydrogen iodide.

$$Ni(CO)_4(l) + 2HI(g) \rightarrow NiI_2(s) + H_2(g) + 4CO(g)$$

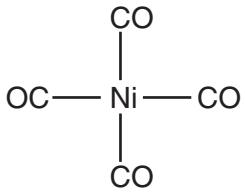
(a) Calculate the percentage by mass of nickel in nickel carbonyl.

..... % [2]

(b) Calculate the maximum volume of gas formed at room temperature and pressure when 1.71 g of nickel carbonyl reacts completely with hydrogen iodide.

maximum volume of gas formed ..... [3]

(c) The structure of a nickel carbonyl molecule is shown.



Predict **two** physical properties of nickel carbonyl.

.....

.....[2]

(d) The proton numbers and accurate relative atomic masses of cobalt and nickel are shown in the table.

	cobalt	nickel
proton number	27	28
relative atomic mass	58.9	58.7

Suggest why cobalt has a higher relative atomic mass than nickel.

.....

.....

.....[2]

(e) An aqueous solution of hydrogen iodide is a strong acid.

What is meant by the term *strong acid*?

.....

.....[1]

[Total: 10]

A6 Sodium and rubidium are alkali metals.

(a) Explain how metals conduct electricity.

.....[1]

(b) State **two** trends in the properties of the alkali metals.

.....

.....[2]

(c) Name the products formed when rubidium reacts with water.

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

(d) Titanium is extracted from titanium(IV) chloride by reduction with molten sodium.

$$TiCl_4 + 4Na \rightarrow 4NaCl + Ti$$

Suggest why sodium reduces titanium(IV) chloride.

.....[1]

[Total: 6]

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Section B

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

The total mark for this section is 30.

B7 In the contact process, sulfur trioxide is made by the catalytic oxidation of sulfur dioxide. In a closed container the following equilibrium is set up.

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$$

The reaction is exothermic.

(a) Name the catalyst used in this reaction.

.....[1]

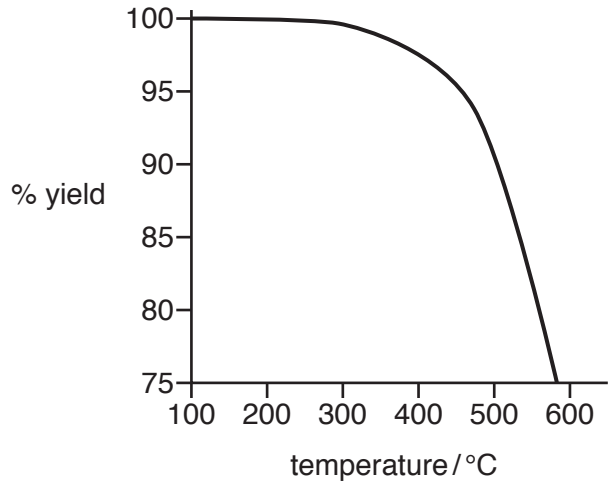
(b) Draw a 'dot-and-cross' diagram of an oxygen molecule.

Show only the outer shell electrons.

[1]

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(c) The graph shows the percentage yield of sulfur trioxide at different temperatures.



(i) Describe how, and explain why, the percentage yield of sulfur trioxide changes with temperature.

.....

.....

.....

.....[3]

(ii) Suggest why the reaction is carried out at 450 °C and not at 250 °C.

.....

.....

.....[2]

(d) Describe how, and explain why, the position of equilibrium changes when the pressure increases.

.....

.....

.....[2]

(e) Sulfur trioxide oxidises hydrogen bromide to form sulfur dioxide, bromine and water.

Construct the equation for this reaction.

.....[1]

[Total: 10]

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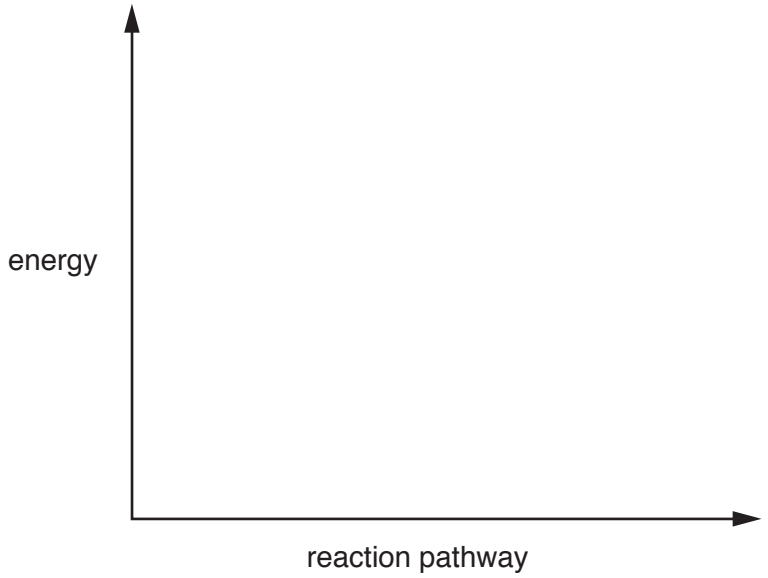
B8 Propenenitrile, CH_2=CHCN, is made by passing a mixture of propene, ammonia and oxygen over a catalyst at 450 °C.

$$CH_3CH{=}CH_2 + NH_3 + 1½O_2 \rightarrow CH_2{=}CHCN + 3H_2O$$

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) Propenenitrile decolourises aqueous bromine.

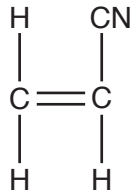
Explain why.

.....

.....[1]

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(c) The structure of propenenitrile is shown.



Draw the structure of the addition polymer formed from propenenitrile.

[2]

(d) The catalyst used in the reaction to make propenenitrile is molybdenum. Molybdenum is a transition element.

(i) State **two** physical properties of molybdenum.

.....

.....[2]

(ii) Molybdenum reacts with chlorine at room temperature to form molybdenum(VI) chloride, $MoCl_6$. Molybdenum(VI) chloride has a melting point of 254 °C.

Construct an equation for this reaction, including state symbols.

.....[2]

[Total: 10]

B9 Both copper and magnesium are metals.

(a) Explain why magnesium reacts with hydrochloric acid but copper does not.

.....[1]

(b) Brass is an alloy of copper and zinc. The table shows how the composition of brass influences its relative strength.

composition of brass		relative strength
% copper	% zinc	
90	10	2.6
80	20	3.0
70	30	3.3
60	40	3.6

How does the composition of brass affect its strength?

.....

.....[1]

(c) Use your knowledge of the structure of metals to explain why brass is stronger than pure copper.

You may include a labelled diagram in your answer.

.....

.....

.....

.....[3]

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(d) Draw a labelled diagram to show how a steel rod can be electroplated with copper.

[3]

(e) A 11.09 g sample of an oxide of copper contains 9.86 g of copper.

Deduce the empirical formula of this oxide of copper.

empirical formula .....[2]

[Total: 10]

B10 A student prepared some crystals of hydrated copper(II) sulfate by reacting excess insoluble copper(II) oxide with dilute sulfuric acid.

$$CuO + H_2SO_4 + 4H_2O \rightarrow CuSO_4.5H_2O$$

(a) Describe how you would obtain pure dry crystals of hydrated copper(II) sulfate from the reaction mixture.

.....

.....

.....

.....

.....

.....[3]

(b) The student used 15.0 cm^3 of 2.00 mol / dm^3 sulfuric acid to prepare the crystals.

Calculate the maximum mass of hydrated copper(II) sulfate crystals that could be made.

..... g [3]

(c) Aqueous ammonia is added to aqueous copper(II) sulfate until the ammonia is in excess.

What is observed as the aqueous ammonia is added?

.....

.....[2]

(d) An aqueous solution of copper(II) sulfate is electrolysed using inert electrodes.

Predict the products of this electrolysis at

the anode (positive electrode), ...

the cathode (negative electrode). .....
[2]

[Total: 10]

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The Periodic Table of Elements

Group																	
I	II											III	IV	V	VI	VII	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.)