

CANDIDATE
NAME

--

CENTRE
NUMBER

--	--	--	--	--

CANDIDATE
NUMBER

--	--	--	--



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.

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.



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]

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]

A3 The alkanes are a homologous series of hydrocarbons.

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

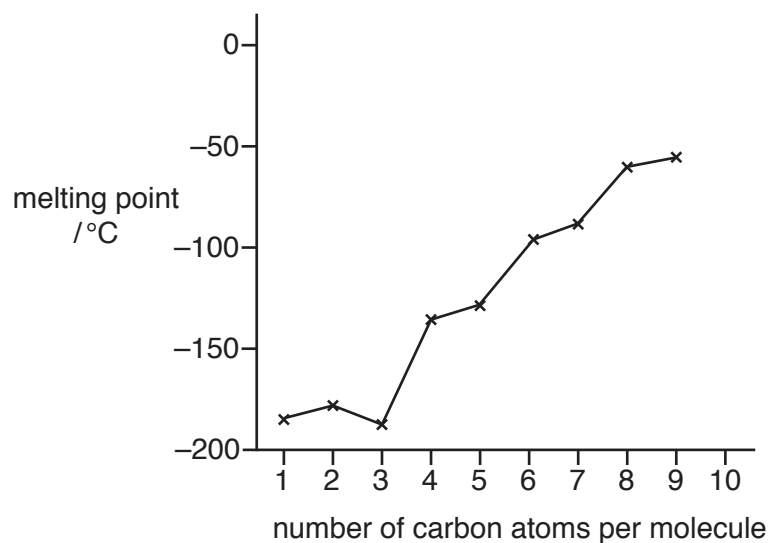
.....
.....[2]

(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} .

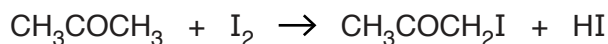
..... [2]

- (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]

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



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]

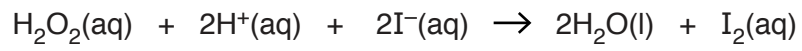
(d) Astatine, At, is a halogen.

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

Construct the ionic equation for this reaction.

.....[1]

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



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

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

[Total: 8]

A5 Nickel carbonyl, $\text{Ni}(\text{CO})_4$, reacts with hydrogen iodide.



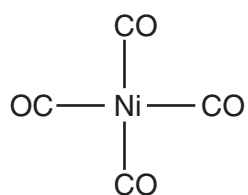
(a) Calculate the percentage by mass of nickel in nickel carbonyl.

..... % [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]

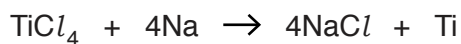
(b) State **two** trends in the properties of the alkali metals.

.....
.....[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.



Suggest why sodium reduces titanium(IV) chloride.

.....[1]

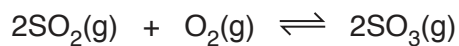
[Total: 6]

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.



The reaction is exothermic.

- (a)** Name the catalyst used in this reaction.

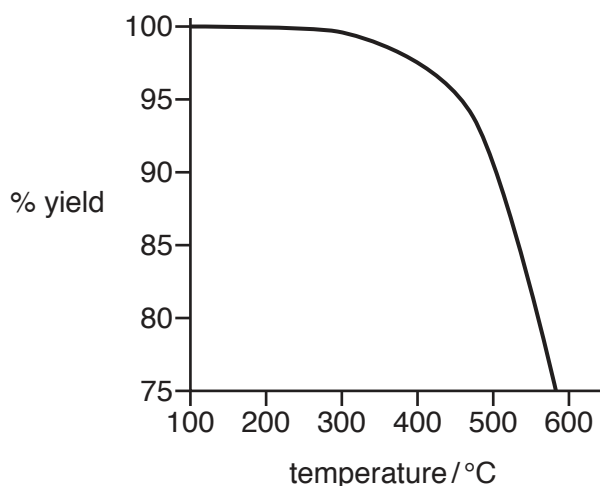
.....[1]

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

Show only the outer shell electrons.

[1]

(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]

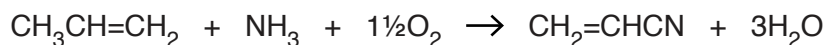
(e) Sulfur trioxide oxidises hydrogen bromide to form sulfur dioxide, bromine and water.

Construct the equation for this reaction.

..... [1]

[Total: 10]

B8 Propenenitrile, $\text{CH}_2=\text{CHCN}$, is made by passing a mixture of propene, ammonia and oxygen over a catalyst at 450°C .

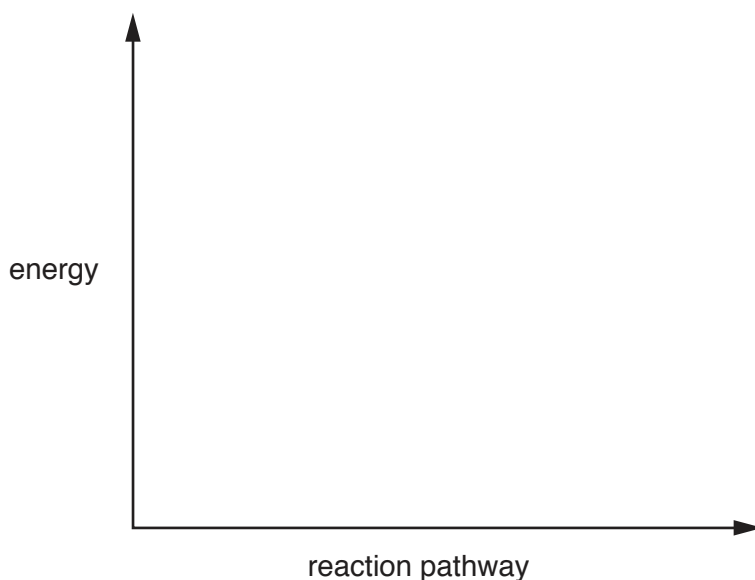


The reaction is exothermic.

(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.



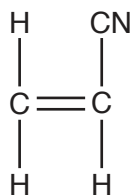
[3]

(b) Propenenitrile decolourises aqueous bromine.

Explain why.

.....
[1]

(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]

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

[3]

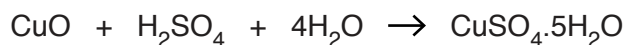
(e) A 11.09g sample of an oxide of copper contains 9.86g of copper.

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.



(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 cm³ of 2.00 mol/dm³ 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]

BLANK PAGE

Permission to reproduce items where third-party owned material protected by copyright is included has been sought and cleared where possible. Every reasonable effort has been made by the publisher (UCLES) to trace copyright holders, but if any items requiring clearance have unwittingly been included, the publisher will be pleased to make amends at the earliest possible opportunity.

To avoid the issue of disclosure of answer-related information to candidates, all copyright acknowledgements are reproduced online in the Cambridge International Examinations Copyright Acknowledgements Booklet. This is produced for each series of examinations and is freely available to download at www.cie.org.uk after the live examination series.

Cambridge International Examinations is part of the Cambridge Assessment Group. Cambridge Assessment is the brand name of University of Cambridge Local Examinations Syndicate (UCLES), which is itself a department of the University of Cambridge.

The Periodic Table of Elements

Group																	
I	II	III										IV	V	VI	VII	VIII	
		<div style="display: flex; justify-content: space-between;"> <div style="border: 1px solid black; padding: 5px;"> 1 H hydrogen 1 </div> <div style="border: 1px solid black; padding: 5px;"> 2 He helium 4 </div> </div>															
		<div style="display: flex; justify-content: space-between;"> <div style="border: 1px solid black; padding: 5px;"> 3 Li lithium 7 </div> <div style="border: 1px solid black; padding: 5px;"> 4 Be beryllium 9 </div> <div style="border: 1px solid black; padding: 5px;"> 5 B boron 11 </div> <div style="border: 1px solid black; padding: 5px;"> 6 C carbon 12 </div> <div style="border: 1px solid black; padding: 5px;"> 7 N nitrogen 14 </div> <div style="border: 1px solid black; padding: 5px;"> 8 O oxygen 16 </div> <div style="border: 1px solid black; padding: 5px;"> 9 F fluorine 19 </div> <div style="border: 1px solid black; padding: 5px;"> 10 Ne neon 20 </div> </div>															
		<div style="display: flex; justify-content: space-between;"> <div style="border: 1px solid black; padding: 5px;"> 11 Na sodium 23 </div> <div style="border: 1px solid black; padding: 5px;"> 12 Mg magnesium 24 </div> <div style="border: 1px solid black; padding: 5px;"> 13 Al aluminium 27 </div> <div style="border: 1px solid black; padding: 5px;"> 14 Si silicon 28 </div> <div style="border: 1px solid black; padding: 5px;"> 15 P phosphorus 31 </div> <div style="border: 1px solid black; padding: 5px;"> 16 S sulfur 32 </div> <div style="border: 1px solid black; padding: 5px;"> 17 Cl chlorine 35.5 </div> <div style="border: 1px solid black; padding: 5px;"> 18 Ar argon 40 </div> </div>															
		<div style="display: flex; justify-content: space-between;"> <div style="border: 1px solid black; padding: 5px;"> 19 K potassium 39 </div> <div style="border: 1px solid black; padding: 5px;"> 20 Ca calcium 40 </div> <div style="border: 1px solid black; padding: 5px;"> 21 Sc scandium 45 </div> <div style="border: 1px solid black; padding: 5px;"> 22 Ti titanium 48 </div> <div style="border: 1px solid black; padding: 5px;"> 23 V vanadium 51 </div> <div style="border: 1px solid black; padding: 5px;"> 24 Cr chromium 52 </div> <div style="border: 1px solid black; padding: 5px;"> 25 Mn manganese 55 </div> <div style="border: 1px solid black; padding: 5px;"> 26 Fe iron 56 </div> <div style="border: 1px solid black; padding: 5px;"> 27 Co cobalt 59 </div> <div style="border: 1px solid black; padding: 5px;"> 28 Ni nickel 59 </div> <div style="border: 1px solid black; padding: 5px;"> 29 Cu copper 64 </div> <div style="border: 1px solid black; padding: 5px;"> 30 Zn zinc 65 </div> <div style="border: 1px solid black; padding: 5px;"> 31 Ga gallium 70 </div> <div style="border: 1px solid black; padding: 5px;"> 32 Ge germanium 73 </div> <div style="border: 1px solid black; padding: 5px;"> 33 As arsenic 75 </div> <div style="border: 1px solid black; padding: 5px;"> 34 Se selenium 79 </div> <div style="border: 1px solid black; padding: 5px;"> 35 Br bromine 80 </div> <div style="border: 1px solid black; padding: 5px;"> 36 Kr krypton 84 </div> </div>															
		<div style="display: flex; justify-content: space-between;"> <div style="border: 1px solid black; padding: 5px;"> 37 Rb rubidium 85 </div> <div style="border: 1px solid black; padding: 5px;"> 38 Sr strontium 88 </div> <div style="border: 1px solid black; padding: 5px;"> 39 Y yttrium 89 </div> <div style="border: 1px solid black; padding: 5px;"> 40 Zr zirconium 91 </div> <div style="border: 1px solid black; padding: 5px;"> 41 Nb niobium 93 </div> <div style="border: 1px solid black; padding: 5px;"> 42 Mo molybdenum 96 </div> <div style="border: 1px solid black; padding: 5px;"> 43 Tc technetium — </div> <div style="border: 1px solid black; padding: 5px;"> 44 Ru ruthenium 101 </div> <div style="border: 1px solid black; padding: 5px;"> 45 Rh rhodium 103 </div> <div style="border: 1px solid black; padding: 5px;"> 46 Pd palladium 106 </div> <div style="border: 1px solid black; padding: 5px;"> 47 Ag silver 108 </div> <div style="border: 1px solid black; padding: 5px;"> 48 Cd cadmium 112 </div> <div style="border: 1px solid black; padding: 5px;"> 49 In indium 115 </div> <div style="border: 1px solid black; padding: 5px;"> 50 Sn tin 119 </div> <div style="border: 1px solid black; padding: 5px;"> 51 Sb antimony 122 </div> <div style="border: 1px solid black; padding: 5px;"> 52 Te tellurium 128 </div> <div style="border: 1px solid black; padding: 5px;"> 53 I iodine 127 </div> <div style="border: 1px solid black; padding: 5px;"> 54 Xe xenon 131 </div> </div>															
		<div style="display: flex; justify-content: space-between;"> <div style="border: 1px solid black; padding: 5px;"> 55 Cs caesium 133 </div> <div style="border: 1px solid black; padding: 5px;"> 56 Ba barium 137 </div> <div style="border: 1px solid black; padding: 5px;"> 57–71 lanthanoids </div> <div style="border: 1px solid black; padding: 5px;"> 72 Hf hafnium 178 </div> <div style="border: 1px solid black; padding: 5px;"> 73 Ta tantalum 181 </div> <div style="border: 1px solid black; padding: 5px;"> 74 W tungsten 184 </div> <div style="border: 1px solid black; padding: 5px;"> 75 Re rhenium 186 </div> <div style="border: 1px solid black; padding: 5px;"> 76 Os osmium 190 </div> <div style="border: 1px solid black; padding: 5px;"> 77 Ir iridium 192 </div> <div style="border: 1px solid black; padding: 5px;"> 78 Pt platinum 195 </div> <div style="border: 1px solid black; padding: 5px;"> 79 Au gold 197 </div> <div style="border: 1px solid black; padding: 5px;"> 80 Hg mercury 201 </div> <div style="border: 1px solid black; padding: 5px;"> 81 Tl thallium 204 </div> <div style="border: 1px solid black; padding: 5px;"> 82 Pb lead 207 </div> <div style="border: 1px solid black; padding: 5px;"> 83 Bi bismuth 209 </div> <div style="border: 1px solid black; padding: 5px;"> 84 Po polonium — </div> <div style="border: 1px solid black; padding: 5px;"> 85 At astatine — </div> <div style="border: 1px solid black; padding: 5px;"> 86 Rn radon — </div> </div>															
		<div style="display: flex; justify-content: space-between;"> <div style="border: 1px solid black; padding: 5px;"> 87 Fr francium — </div> <div style="border: 1px solid black; padding: 5px;"> 88 Ra radium — </div> <div style="border: 1px solid black; padding: 5px;"> 89–103 actinoids </div> <div style="border: 1px solid black; padding: 5px;"> 104 Rf rutherfordium — </div> <div style="border: 1px solid black; padding: 5px;"> 105 Db dubnium — </div> <div style="border: 1px solid black; padding: 5px;"> 106 Sg seaborgium — </div> <div style="border: 1px solid black; padding: 5px;"> 107 Bh bohrium — </div> <div style="border: 1px solid black; padding: 5px;"> 108 Hs hassium — </div> <div style="border: 1px solid black; padding: 5px;"> 109 Mt meitnerium — </div> <div style="border: 1px solid black; padding: 5px;"> 110 Ds darmstadtium — </div> <div style="border: 1px solid black; padding: 5px;"> 111 Rg roentgenium — </div> <div style="border: 1px solid black; padding: 5px;"> 112 Cn copernicium — </div> <div style="border: 1px solid black; padding: 5px;"> 113 Nh nihonium — </div> <div style="border: 1px solid black; padding: 5px;"> 114 Fl flerovium — </div> <div style="border: 1px solid black; padding: 5px;"> 115 Lv livermorium — </div> <div style="border: 1px solid black; padding: 5px;"> 116 Ts tennessine — </div> <div style="border: 1px solid black; padding: 5px;"> 117 Og oganeson — </div> </div>															

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	europlium 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
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	mendeleevium —	102	No	nobelium —	103	Lr	lawrencium —

actinoids

The volume of one mole of any gas is 24 dm³ at room temperature and pressure (r.t.p.)