UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education Ordinary Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

CHEMISTRY **5070/22**

Paper 2 Theory **May/June 2012**

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 a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, 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.

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.

For Examiner's Use	
Section A	
B6	
B7	
B8	
B9	
Total	

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

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Section A

For Examiner's Use

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

The total mark for this section is 45.

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

$^{8}_{4}Be$

$^{14}_{6}C$

$^{40}_{20}Ca$

$^{37}_{17}Cl^{-}$

$^{39}_{19}K^{+}$

$^{24}_{12}Mg^{2+}$

$^{20}_{10}Ne$

$^{17}_{8}O$

$^{16}_{8}O^{2-}$

$^{32}_{16}S^{2-}$

$^{28}_{14}Si^{4-}$

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

Which particle

(a) has only eight electrons,

..... [1]

(b) is attracted to the cathode during electrolysis,

..... [1]

(c) has only four electrons in its outer shell,

..... [1]

(d) has only eight neutrons,

..... [1]

(e) has only ten protons,

..... [1]

(f) has four occupied electron shells?

..... [1]

[Total: 6]

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A2 Small pieces of a silver coloured metal, **X**, were added to concentrated nitric acid. A brown gas, **Z**, and a colourless solution containing salt **Y** were formed.

For Examiner's Use

Analysis of a 0.0914 mol sample of **Z** showed it contained 1.28 g of nitrogen and 2.93 g of oxygen.

The small sample of the colourless solution was diluted with water and then divided into two portions.

- To one portion, aqueous sodium hydroxide was added drop by drop until it was in excess. A white precipitate, **W**, was formed that redissolved in the excess sodium hydroxide.
- To the other portion, aqueous ammonia was added drop by drop until it was in excess. A white precipitate, **W**, was formed that redissolved in the excess ammonia.

(a) (i) Name the white precipitate, **W**.

..... [1]

(ii) Construct the ionic equation, with state symbols, for the formation of **W**.

..... [2]

(b) Name **X** and **Y**.

X is .....

Y is ..... [2]

(c) (i) Calculate the relative formula mass, M_r, for gas **Z**.

M_r = ... [2]

(ii) Determine the molecular formula for **Z**.

molecular formula is ..... [2]

[Total: 9]

A3 The typical composition of solid domestic waste in a city is shown below.

For Examiner's Use

type of solid waste	percentage by mass
glass	9
metals	8
organic waste including food	22
paper	38
plastics	9
textiles	2
other	12

(a) The most abundant metals in the solid waste are aluminium, copper and iron. Describe **two** advantages of recycling these metals.

.....

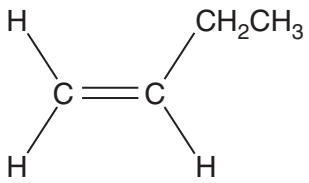
.....

.....

.....

..... [2]

(b) One of the polymer molecules in the plastic waste is made from the monomer shown below.



Draw the partial structure of the polymer formed from this monomer showing two repeats.

[2]

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(c) Many of the polymers found in the plastic waste are non-biodegradable.

For Examiner's Use

Describe **two** pollution problems caused by the disposal of non-biodegradable polymers.

.....

.....

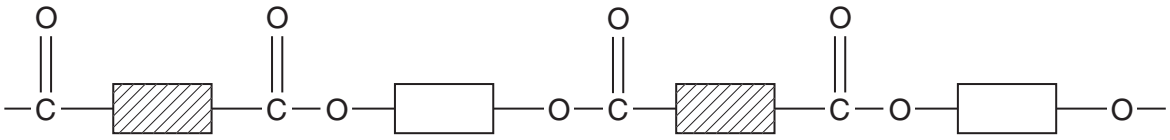
.....

.....

..... [2]

(d) *Terylene* and nylon are two of the textiles present in the solid waste.

The partial structure of *Terylene* is shown below.



(i) *Terylene* is a polyester.

What type of polymerisation is used to make *Terylene*?

..... [1]

(ii) Complete the diagram below to show the partial structure for nylon.



[1]

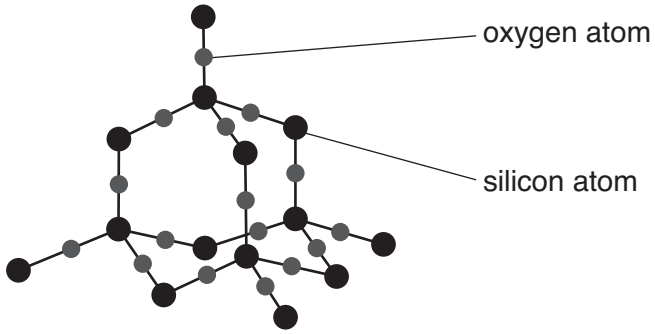
(iii) Give the name of one **type** of food that has molecules containing the same linkages as Terylene.

..... [1]

(e) Glass is made from sand.

For Examiner's Use

Pure sand has a giant molecular structure.



(i) What is the formula for pure sand?

..... [1]

(ii) Explain why sand has a very high melting point.

.....

.....

.....

..... [2]

(iii) Explain why sand does not conduct electricity.

.....

..... [1]

[Total: 13]

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A4 Many electricity generating power stations burn fossil fuels. The combustion of these fuels produces waste gases called flue gas.

For Examiner's Use

The flue gas contains nitrogen oxides, sulfur dioxide and carbon dioxide.

Nitrogen oxides and sulfur dioxide contribute towards acid rain and must be removed from the flue gas before it is allowed to reach the atmosphere.

(a) One of the nitrogen oxides is nitrogen monoxide, NO.

(i) Nitrogen monoxide is formed by the direct reaction between oxygen and nitrogen.

Construct the equation for this reaction.

..... [1]

(ii) When cold nitrogen monoxide comes into contact with oxygen it forms nitrogen dioxide, NO_2.

Construct the equation for this reaction.

..... [1]

(b) Some power stations spray the flue gas with seawater. This removes about 99% of the nitrogen dioxide and sulfur dioxide.
The gases react with water to form aqueous acids. Nitrogen dioxide forms nitric acid and another acid with the formula, HNO_2.

Construct the equation for this reaction.

..... [1]

(c) In other power stations the flue gases are reacted with moist calcium carbonate. This removes about 90% of the nitrogen dioxide and sulfur dioxide from the flue gas.

(i) Sulfur dioxide reacts with calcium carbonate to form solid calcium sulfite, $CaSO_3$.
Suggest the name of the other product of this reaction.

..... [1]

(ii) Nitrogen dioxide reacts with calcium carbonate to form two salts.
Suggest the name and formula of one of these salts.

name .....

formula ..... [2]

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[Turn over

(d) Suggest **two** advantages of treating flue gas with seawater rather than calcium carbonate.

For Examiner's Use

.....

.....

.....

..... [2]

(e) Carbon dioxide is a greenhouse gas. This is because its covalent bonds can absorb infra-red radiation.

Draw a 'dot-and-cross' diagram to show the bonding in a molecule of carbon dioxide. Show only the outer shell electrons.

[1]

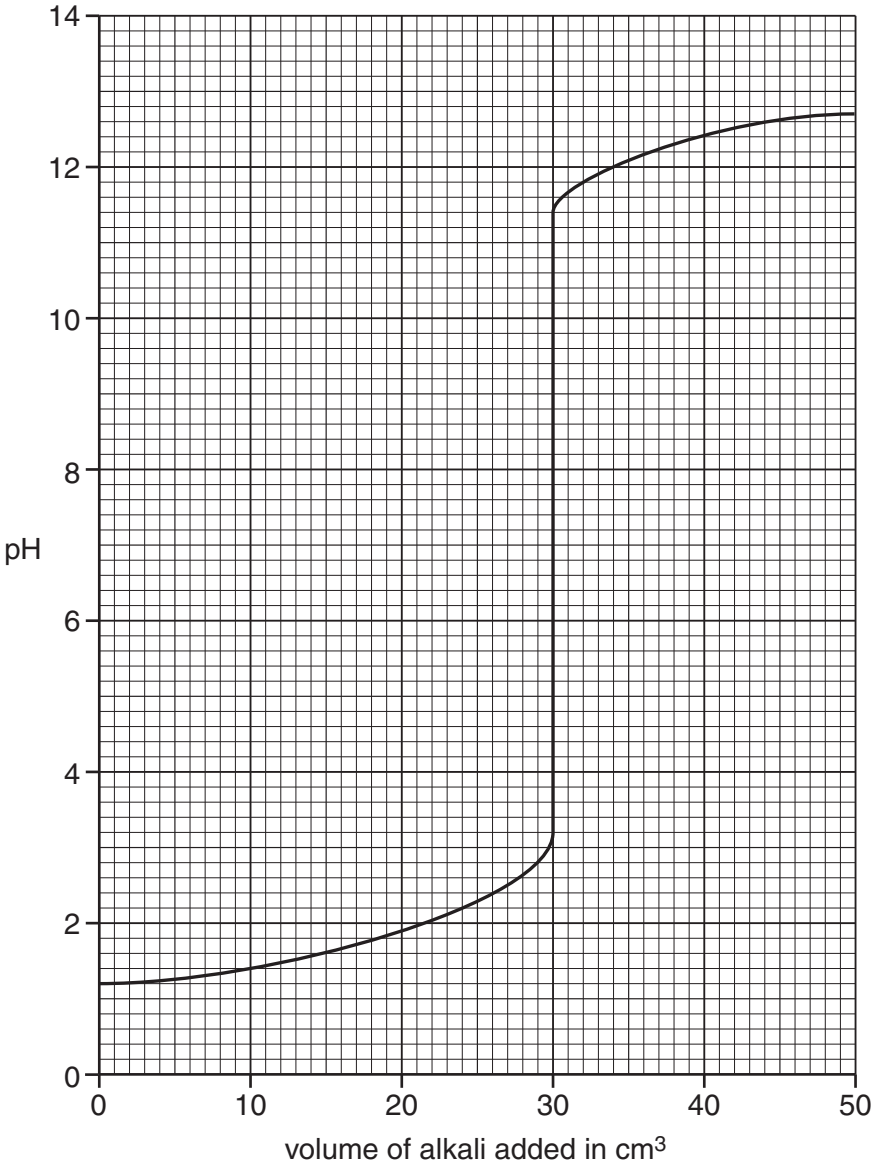
[Total: 9]

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A5 Aqueous potassium hydroxide, KOH, is added slowly from a burette into a flask containing 25.0 cm^3 of 0.0500 mol/dm^3 dilute sulfuric acid, H_2SO_4. At the same time the pH of the contents of the flask is measured until all of the aqueous potassium hydroxide has been added.

For Examiner's Use

The graph shows how the pH changes with the addition of the aqueous potassium hydroxide.



(a) What is the pH of 0.0500 mol/dm^3 sulfuric acid?

..... [1]

(b) Construct the equation for the reaction between sulfuric acid and potassium hydroxide.

..... [1]

For Examiner's Use

(c) **(i)** What volume of aqueous potassium hydroxide has been added when the mixture has a pH of 7?

volume = ... cm^3 [1]

(ii) Calculate the concentration, in mol/dm^3, of the aqueous potassium hydroxide.

concentration = ... mol/dm^3 [3]

(d) The experiment is repeated with 25.0 cm^3 of 0.0500 mol/dm^3 ethanoic acid, CH_3COOH, instead of 25.0 cm^3 of 0.0500 mol/dm^3 sulfuric acid.

Describe and explain any differences in the graph which would be obtained.

.....

.....

.....

..... [2]

[Total: 8]

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Section B

For Examiner's Use

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

The total mark for this section is 30.

B6 Hydrogen-oxygen fuel cells are used to generate electricity.
The overall reaction in a hydrogen-oxygen fuel cell is shown below.

$$2H_2(g) + O_2(g) \longrightarrow 2H_2O(g)$$

This reaction is exothermic.

(a) Explain the meaning of the term *exothermic*.

.....

..... [1]

(b) Explain, in terms of the energy changes associated with bond breaking and bond forming, why the reaction is exothermic.

.....

.....

.....

..... [2]

(c) A hydrogen-oxygen fuel cell uses 2000 dm^3 of hydrogen measured at room temperature and pressure.
Calculate the volume of oxygen, measured at room temperature and pressure, used by the fuel cell.
[One mole of any gas at room temperature and pressure occupies a volume of 24 dm^3.]

.....

.....

.....

volume of oxygen = ... dm^3 [2]

(d) The electrode reactions in an oxygen-hydrogen fuel shell are shown below.

For Examiner's Use

Equation 1 $O_2(g) + 2H_2O(l) + 4e^- \longrightarrow 4OH^-(aq)$

Equation 2 $H_2(g) + 2OH^-(aq) \longrightarrow 2e^- + 2H_2O(l)$

Explain why the reaction in a fuel cell involves both oxidation **and** reduction.

.....

.....

.....

..... [2]

(e) Name one source of the hydrogen needed for a fuel-cell.

..... [1]

(f) State one advantage and one disadvantage of using an oxygen-hydrogen fuel cell.

advantage .....

.....

disadvantage .....

..... [2]

[Total: 10]

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B7 Many carbonates thermally decompose to form carbon dioxide and an oxide.

For Examiner's Use

Copper carbonate forms carbon dioxide and copper oxide.

$$CuCO_3 \rightarrow CuO + CO_2$$

Six 2.00 g samples of carbonates are heated strongly until there is no further change in mass. The table shows the mass of solid remaining at the end of the heating.

carbonate	mass before heating/g	mass after heating/g
calcium carbonate	2.00	1.12
copper(II) carbonate	2.00	1.29
iron(II) carbonate	2.00	1.24
magnesium carbonate	2.00	0.95
sodium carbonate	2.00	2.00
zinc carbonate	2.00	1.30

(a) What is the mass of carbon dioxide formed when 2.00 g of copper(II) carbonate is heated?

mass of carbon dioxide = ... g [1]

(b) The thermal stability of the carbonates is related to the reactivity of the metal.
Which carbonate is the **least** thermally stable?

..... [1]

(c) For each carbonate, a 2.00 g sample was heated.
Explain why the mass of carbon dioxide formed is different for each carbonate.

.....

..... [1]

(d) The decomposition of calcium carbonate forms carbon dioxide and calcium oxide.

(i) Draw the electronic configuration and state the charge on each of the ions in calcium oxide.

[2]

(ii) Explain why calcium oxide is used in a blast furnace.

.....

.....

..... [1]

(e) Copper(II) chloride can be prepared by the reaction between copper(II) carbonate and hydrochloric acid.

(i) Construct the ionic equation for this reaction.

.....

..... [1]

(ii) Describe the essential practical details for the preparation of a crystalline sample of copper(II) chloride.

.....

.....

.....

.....

.....

.....

..... [3]

[Total: 10]

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B8 Alkenes are a homologous series of organic compounds.
The table shows some information about the first six alkenes.

For Examiner's Use

name	molecular formula	melting point/°C	boiling point/°C
ethene	C_2H_4	–169	–104
propene	C_3H_6	–185	–48
butene	C_4H_8	–185	–6
pentene	C_5H_{10}	–165	30
hexene	C_6H_{12}	–139	63
heptene	C_7H_{14}		

(a) Draw the structure, showing all the atoms and bonds, of propene.

Use the structure to explain why propene is both a *hydrocarbon* and *unsaturated*.

.....

.....

.....

..... [3]

(b) There are several compounds with molecular formula C_4H_8, each has a different structure.
What name is given to compounds with the same molecular formula but different structures?

..... [1]

(c) Deduce the molecular formula for decene, an alkene with 10 carbon atoms per molecule.

..... [1]

(d) Explain why it is easier to predict the boiling point of heptene rather than its melting point.

.....

.....

..... [1]

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[Turn over

For Examiner's Use

(e) What is the physical state for butene at room temperature and pressure? Explain your answer.

physical state .....

explanation .....

..... [1]

(f) Many alkenes are manufactured by the cracking of long chain alkanes such as hexadecane, $C_{16}H_{34}$.
Construct an equation to show the cracking of hexadecane to form butane and butene only.

..... [1]

(g) Butene reacts with bromine and with steam.

(i) Give the molecular formula of the product with bromine.

..... [1]

(ii) Suggest the name of the product with steam.

..... [1]

[Total: 10]

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B9 Methanol, CH_3OH, is manufactured from carbon dioxide and hydrogen.

For Examiner's Use

$$CO_2(g) + 3H_2(g) \rightleftharpoons CH_3OH(g) + H_2O(g) \quad \Delta H = -49\,kJ/mol$$

The reaction is carried out in the presence of a catalyst containing copper. The conditions used are 70 atmospheres pressure and a temperature of 250 °C.

(a) If the temperature of the reaction mixture is **increased** to 400 °C, explain, in terms of collisions between reacting particles, what happens to the speed of the forward reaction.

.....

.....

.....

..... [2]

(b) If the pressure of the reaction mixture is **decreased** to 50 atmospheres, explain what happens to the position of equilibrium.

.....

.....

.....

..... [2]

(c) In the reaction when 3.0 moles of hydrogen react, 49 kJ of heat energy is released.

Calculate how much heat energy is released when 500 kg of hydrogen react.

heat energy = ... kJ [2]

(d) Methanol can be used as a fuel.

Construct the equation for the complete combustion of methanol.

..... [1]

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[Turn over

(e) Methanol can be oxidised to form methanoic acid.

For Examiner's Use

(i) State the reagents and conditions needed for this reaction.

.....

..... [2]

(ii) Draw the structure of methanoic acid.

[1]

[Total: 10]

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DATA SHEET
The Periodic Table of the Elements

Group																	
I	II										III	IV	V	VI	VII	0
							1 H Hydrogen 1									4 He Helium 2
7 Li Lithium 3	9 Be Beryllium 4										11 B Boron 5	12 C Carbon 6	14 N Nitrogen 7	16 O Oxygen 8	19 F Fluorine 9	20 Ne Neon 10
23 Na Sodium 11	24 Mg Magnesium 12										27 Al Aluminium 13	28 Si Silicon 14	31 P Phosphorus 15	32 S Sulfur 16	35.5 Cl Chlorine 17	40 Ar Argon 18
39 K Potassium 19	40 Ca Calcium 20	45 Sc Scandium 21	48 Ti Titanium 22	51 V Vanadium 23	52 Cr Chromium 24	55 Mn Manganese 25	56 Fe Iron 26	59 Co Cobalt 27	59 Ni Nickel 28	64 Cu Copper 29	65 Zn Zinc 30	70 Ga Gallium 31	73 Ge Germanium 32	75 As Arsenic 33	79 Se Selenium 34	80 Br Bromine 35	84 Kr Krypton 36
85 Rb Rubidium 37	88 Sr Strontium 38	89 Y Yttrium 39	91 Zr Zirconium 40	93 Nb Niobium 41	96 Mo Molybdenum 42	Tc Technetium 43	101 Ru Ruthenium 44	103 Rh Rhodium 45	106 Pd Palladium 46	108 Ag Silver 47	112 Cd Cadmium 48	115 In Indium 49	119 Sn Tin 50	122 Sb Antimony 51	128 Te Tellurium 52	127 I Iodine 53	131 Xe Xenon 54
133 Cs Caesium 55	137 Ba Barium 56	139 La Lanthanum 57 *	178 Hf Hafnium 72	181 Ta Tantalum 73	184 W Tungsten 74	186 Re Rhenium 75	190 Os Osmium 76	192 Ir Iridium 77	195 Pt Platinum 78	197 Au Gold 79	201 Hg Mercury 80	204 Tl Thallium 81	207 Pb Lead 82	209 Bi Bismuth 83	209 Po Polonium 84	210 At Astatine 85	222 Rn Radon 86
223 Fr Francium 87	226 Ra Radium 88	227 Ac Actinium 89 †															

140 Ce Cerium 58	141 Pr Praseodymium 59	144 Nd Neodymium 60	147 Pm Promethium 61	150 Sm Samarium 62	152 Eu Europium 63	157 Gd Gadolinium 64	159 Tb Terbium 65	162 Dy Dysprosium 66	165 Ho Holmium 67	167 Er Erbium 68	169 Tm Thulium 69	173 Yb Ytterbium 70	175 Lu Lutetium 71
232 Th Thorium 90	231 Pa Protactinium 91	238 U Uranium 92	237 Np Neptunium 93	244 Pu Plutonium 94	243 Am Americium 95	247 Cm Curium 96	247 Bk Berkelium 97	251 Cf Californium 98	252 Es Einsteinium 99	257 Fm Fermium 100	258 Md Mendelevium 101	259 No Nobelium 102	260 Lr Lawrencium 103

* 58–71 Lanthanoid series
† 90–103 Actinoid series

Key: a = relative atomic mass; X = atomic symbol; b = atomic (proton) number

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