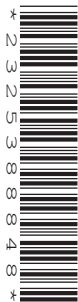CANDIDATE
NAME

CENTRE
NUMBER

CANDIDATE
NUMBER

CHEMISTRY **5070/21**

Paper 2 Theory **October/November 2013**

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.

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 16.
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 **16** printed pages.

UNIVERSITY *of* 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.

> **calcium oxide**
> **carbon dioxide**
> **carbon monoxide**
> **copper(II) sulfate**
> **ethanol**
> **ethene**
> **iron(II) chloride**
> **iron(III) chloride**
> **nitrogen dioxide**
> **silver chloride**
> **silver iodide**
> **sulfur dioxide**

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

Which compound is

(a) a solid, which when dissolved in water, gives a green precipitate with aqueous ammonia,

....[1]

(b) a colourless gas which is formed when limestone is heated strongly,

....[1]

(c) a gas which is formed in the atmosphere by lightning activity,

....[1]

(d) a basic oxide,

....[1]

(e) formed when ethane undergoes complete combustion,

....[1]

(f) a white salt which is insoluble in water?

....[1]

[Total: 6]

A2 Alkenes are a homologous series of unsaturated hydrocarbons.

(a) Give the general formula of alkenes.

....[1]

(b) In addition to having a general formula, state two **other** characteristics of a homologous series.

1 ....

2 ....[2]

(c) Alkenes can be made by cracking alkanes.

(i) Give **one** condition required for cracking.

....[1]

(ii) Tetradecane, $C_{14}H_{30}$, can be cracked to form an alkene containing eight carbon atoms and an alkane.

Construct an equation for this reaction.

[1]

(d) Ethene reacts with bromine to form 1,2-dibromoethane, CH_2BrCH_2Br.

Name this type of reaction.

....[1]

(e) Ethene reacts with hydrogen chloride to form the covalent compound chloroethane, CH_3CH_2Cl.

Suggest **two** physical properties of chloroethane.

1 ....

2 ....[2]

(f) Halogenoalkanes such as CCl_2F_2 are responsible for the depletion of ozone in the upper atmosphere.

Describe the importance of the ozone layer in the upper atmosphere.

....

....

....[2]

[Total: 10]

4

A3 Calcium, proton number 20, is an element in Group II of the Periodic Table.

(a) Give the electronic configuration for calcium.

....[1]

(b) Calcium has six naturally-occurring isotopes.

(i) State the meaning of the term *isotopes*.

....

....[1]

(ii) Complete the following table to show the number of sub-atomic particles in two of these isotopes.

isotope	number of protons	number of electrons	number of neutrons
^{42}Ca			
^{48}Ca			

[3]

(c) Calcium chloride can be formed by reacting calcium carbonate with dilute hydrochloric acid.

(i) Construct an equation for this reaction.

[1]

(ii) Write both the formula and the electronic configuration for the ions present in calcium chloride.

[2]

(d) (i) Name the products formed at the anode and cathode when molten calcium chloride is electrolysed.

anode ....

cathode ....[1]

(ii) Predict the product formed at the cathode when a dilute aqueous solution of calcium chloride is electrolysed.

....[1]

(iii) Explain why solid calcium chloride does not conduct electricity.

....[1]

[Total: 11]

A4 Nitrogen and oxygen are present in dry air.

   (a) What is the percentage composition by volume of each of these gases in dry air?

   nitrogen ....

   oxygen ....[2]

   (b) What method is used to separate these gases from each other?

   ....[1]

   (c) In a petrol engine, nitrogen and oxygen combine to form oxides of nitrogen such as nitrogen dioxide, NO_2.

   State one harmful effect that nitrogen dioxide has on the environment.

   ....[1]

   (d) One of the hydrocarbons in petrol is octane, C_8H_{18}.
   In a petrol engine, some of the octane reacts to form carbon monoxide and water.

   Construct an equation for this reaction.

   [2]

   (e) Catalytic converters are used to remove carbon monoxide and nitrogen dioxide from the exhaust gases of petrol engines.
   A catalyst containing rhodium and platinum or palladium is present in a catalytic converter.

   What is the function of a catalyst?

   ....[1]

 [Turn over

(f) In a catalytic converter, carbon monoxide and nitrogen dioxide undergo redox reactions. These reactions reduce the amount of carbon monoxide and nitrogen dioxide in car exhausts.

   (i) What is meant by the term *redox reaction*?

   ....

   ....[1]

   (ii) Explain how the redox reactions in the catalytic converter decrease the amounts of carbon monoxide and nitrogen dioxide in car exhausts.

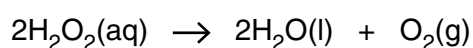   ....

   ....

   ....[2]

   [Total: 10]

A5 Hydrogen peroxide, H_2O_2, is a colourless liquid.

   (a) Calculate the percentage by mass of oxygen in hydrogen peroxide.

   ....% [2]

   (b) The enzyme catalase is present in yeast. The enzyme catalyses the decomposition of aqueous hydrogen peroxide.

   $$2H_2O_2(aq) \rightarrow 2H_2O(l) + O_2(g)$$

   The apparatus below is used to monitor this reaction.
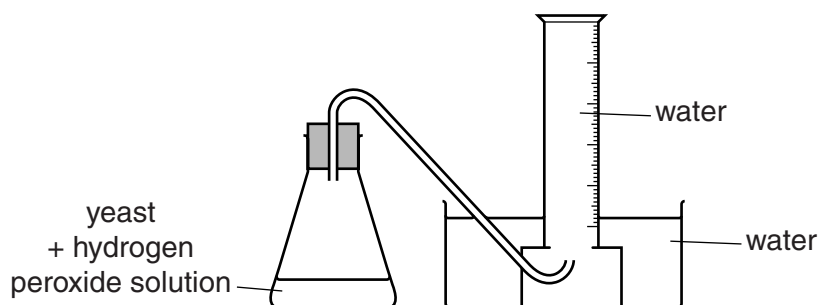
   What measurements should be taken in order to monitor the rate of this reaction?

   ....

   ....[2]

(c) Describe and explain the effect of increasing the concentration of hydrogen peroxide on the rate of this reaction.

....

....

....

....

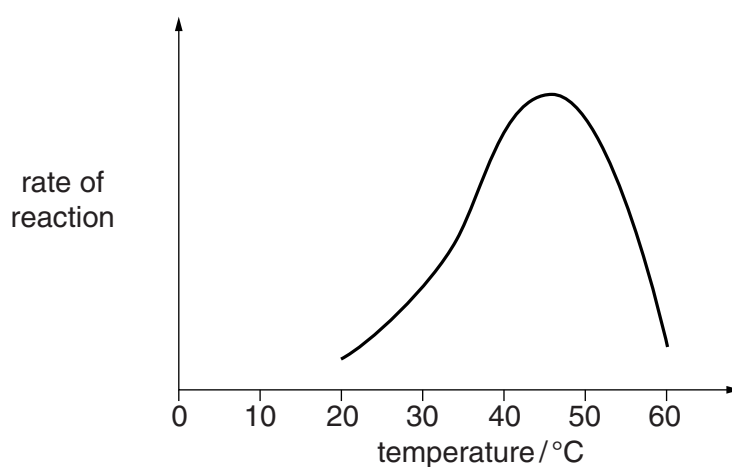..[3]

(d) The graph below shows how the rate of decomposition of hydrogen peroxide, catalysed by yeast, varies with temperature. All other conditions are kept constant.
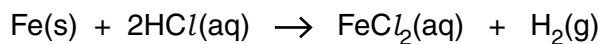

Suggest why the rate of reaction decreases rapidly from 45 °C to 60 °C.

....[1]

[Total: 8]

Section B

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

The total mark for this section is 30.

B6 Iron is extracted from its ore (haematite, Fe_2O_3) in a blast furnace.
Coke (carbon) and limestone (calcium carbonate) are also added to the furnace.

(a) Describe the essential reactions taking place in the blast furnace.

....

....

....

....

....

....

....[4]

(b) Steel is an alloy made by the addition of carbon or metals to iron.
Use the diagrams below to explain why an alloy of iron and manganese is less malleable
than pure iron.

Key

◯ iron atoms

⬤ manganese atoms

iron   alloy of iron and manganese

....

....

....

....[2]

(c) Iron reacts with dilute hydrochloric acid to form iron(II) chloride.

$$Fe(s) + 2HCl(aq) \longrightarrow FeCl_2(aq) + H_2(g)$$

A student added 2.1 g of iron to 50 cm^3 of 0.10 mol/dm^3 hydrochloric acid.

(i) Calculate the amount, in moles, of iron present.

.... mol [1]

(ii) Calculate the amount, in moles, of hydrochloric acid present.

.... mol [1]

(iii) Calculate the volume of hydrogen formed in this reaction, measured at room temperature and pressure.

....cm^3 [2]

[Total: 10]

B7 (a) A compound of carbon, hydrogen and chlorine contains 0.48 g of carbon, 0.08 g of hydrogen and 1.42 g of chlorine.

(i) Deduce the empirical formula of this compound.

[2]

(ii) The relative molecular mass of this compound is 99.

Deduce the molecular formula of this compound.

[1]

(b) Chloroethene is another compound containing carbon, hydrogen and chlorine.
The structure of chloroethene is shown below.

$$\begin{array}{cc} H & Cl \\ | & | \\ C = C \\ | & | \\ H & H \end{array}$$
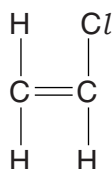
Draw a section of the polymer formed when chloroethene undergoes polymerisation to form poly(chloroethene).

[2]

(c) Poly(chloroethene) is an addition polymer but nylon is a condensation polymer.

Describe the difference between an addition polymer and a condensation polymer in terms of how they are formed from their monomers.

....

....

....

....[1]

(d) Chloroethene is made by reacting ethene with hydrogen chloride and oxygen in the presence of a catalyst of copper(II) chloride, $CuCl_2$. The other product of the reaction is water.

   (i) Construct an equation for this reaction.

[1]

   (ii) Copper(II) chloride is made by heating copper(II) oxide, CuO, with hydrochloric acid.

   Construct an equation for this reaction.

[1]

   (iii) Copper is a transition element.

   State **two** physical properties of copper which are different from those of a typical Group I element such as sodium.

   1 ....

   2 ....[2]

[Total: 10]

                                                                                 [Turn over

B8 Zinc sulfide is a compound that can be made by heating zinc powder with sulfur powder.

(a) Describe **two** differences between a mixture of zinc and sulfur and a compound of zinc and sulfur.
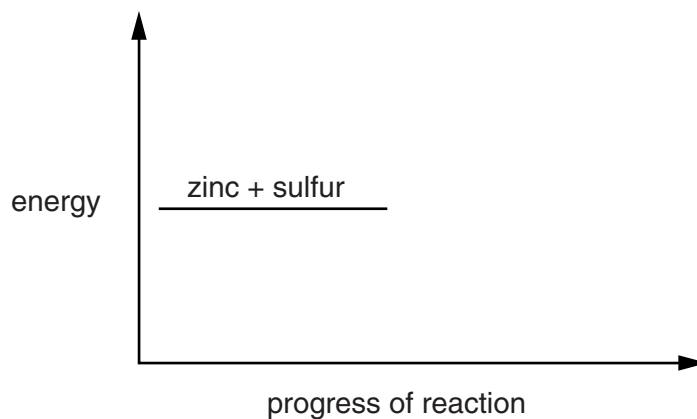
1 ....

....

2 ....

....[2]

(b) The reaction between zinc and sulfur is exothermic.

Complete the energy profile diagram for this reaction.
On your diagram label
the product,
the enthalpy change for the reaction, ΔH.

energy | zinc + sulfur

progress of reaction

[2]

(c) Part of the structure of zinc sulfide is shown below.

Key
● Zn ions
○ S ions
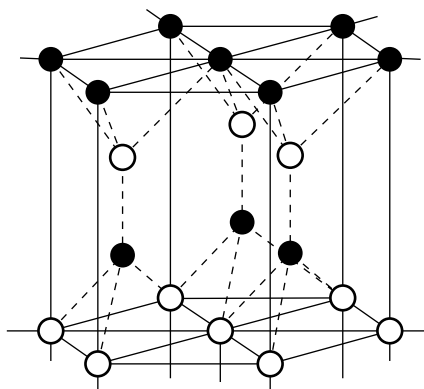
Deduce the empirical formula of zinc sulfide from this structure.

....[1]
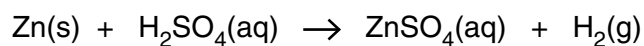
(d) Zinc sulfide reacts with hydrochloric acid to form hydrogen sulfide.
An aqueous solution of hydrogen sulfide behaves as a weak acid.

Describe what is meant by the term *weak acid*.

....

....[1]

(e) Zinc sulfate can be made by reacting zinc with dilute sulfuric acid.

$$Zn(s) + H_2SO_4(aq) \longrightarrow ZnSO_4(aq) + H_2(g)$$

(i) Write an ionic equation for this reaction.

[1]

(ii) Describe how you would prepare crystals of pure, dry zinc sulfate using this reaction.

....

....

....

....

....[3]

[Total: 10]

B9 Ethanoic acid reacts with sodium hydroxide to form water and a salt.

(a) Give the formula of the salt.

....[1]
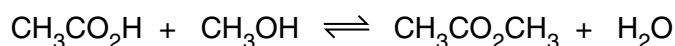
(b) The reaction between ethanoic acid and sodium hydroxide is described as a neutralisation reaction.

Write the simplest ionic equation for this reaction.

....[1]

(c) Ethanoic acid reacts with methanol to form an ester and water.

$$CH_3CO_2H \ + \ CH_3OH \ \rightleftharpoons \ CH_3CO_2CH_3 \ + \ H_2O$$

The reaction is endothermic.

(i) Describe what happens to the position of this equilibrium when the concentration of methanol is **increased**. Explain your answer.

....

....[1]

(ii) Describe what happens to the position of this equilibrium when the temperature of the reaction mixture is **decreased**. Explain your answer.

....

....[1]

(d) The structure of the ester methyl benzoate is shown below.
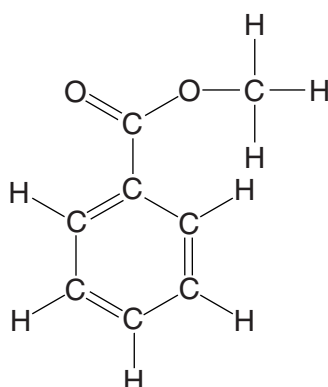
Deduce the molecular formula for methyl benzoate.

....[1]

(e) Sodium hydroxide is an alkali.

Give the formula of the ion present in sodium hydroxide which causes it to be alkaline.

....[1]

(f) A student titrated a metal hydroxide with $0.200\,mol/dm^3$ hydrochloric acid.
It required $12.5\,cm^3$ of hydrochloric acid to neutralise $25.0\,cm^3$ of $0.0500\,mol/dm^3$ metal hydroxide solution.

   (i) Calculate the amount, in moles, of hydrochloric acid used.

.... mol [1]

  (ii) Calculate the amount, in moles, of metal hydroxide present.

.... mol [1]

 (iii) Construct an equation for this reaction.
Use the letter **M** to represent the metal in the metal hydroxide solution.

[1]

(g) Name a metal hydroxide which can be used to treat excess acidity in soils.

....[1]

[Total: 10]

DATA SHEET
The Periodic Table of the Elements

Group

I	II		III	IV	V	VI	VII	0
								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		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		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		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							

Transition elements:

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
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
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
227 **Ac** Actinium 89 †									

1
H
Hydrogen
1

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

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

Key

a	
X	
b	

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

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