Surname	Centre Number	Candidate Number
Other Names		2

GCE AS/A level

1092/01

CHEMISTRY CH2

P.M. THURSDAY, 19 January 2012

1½ hours

FOR EXAMINER'S USE ONLY		
Section	Question	Mark
A	1-5	
B	6	
	7	
	8	
	9	
	10	
TOTAL MARK		

ADDITIONAL MATERIALS

In addition to this examination paper, you will need a:
- calculator;
- **Data Sheet** containing a **Periodic Table** supplied by WJEC. Refer to it for any **relative atomic masses** you require.

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen. Do not use gel pen or correction fluid.

Write your name, centre number and candidate number in the spaces at the top of this page.

Section A Answer **all** questions in the spaces provided.
Section B Answer **all** questions in the spaces provided.

Candidates are advised to allocate their time appropriately between **Section A (10 marks)** and **Section B (70 marks)**.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets at the end of each question or part-question.

The maximum mark for this paper is 80.

Your answers must be relevant and must make full use of the information given to be awarded full marks for a question.

You are reminded that marking will take into account the Quality of Written Communication used in all written answers.

SECTION A

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

1. 'Smart' alloys have an increasing importance in many applications.
State how 'smart' alloys differ from other alloys in the way in which they act when used for a particular purpose. [2]

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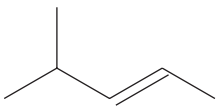
2. A small piece of sodium metal is added to water.
Give the equation for this reaction and suggest a pH value for the resulting solution. [2]

Equation .....

pH of solution .....

3. The skeletal formula of a hydrocarbon is shown below.



Give the **systematic name** of this hydrocarbon. [1]

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4. Police use a breathalyser to test motorists for the presence of alcohol.

(a) An early type of breathalyser required the motorist to breathe into a tube that contained acidified potassium dichromate. The alcohol in their breath was oxidised to ethanal and ethanoic acid. State the colour change that occurred if the test was positive. [1]

..... to .....

(b) Modern breathalysers use infrared spectroscopy to detect and measure the concentration of alcohol in breath. An absorption frequency at 2940 cm^{-1} is used rather than the frequency caused by the O—H bond, as this is also present in water.

(i) Use the Data Sheet to identify the bond that causes the absorption at 2940 cm^{-1}. [1]

.....

(ii) State which **one** of the following correctly describes any change in the absorption at 2940 cm^{-1} if the concentration of alcohol in the breath increases. [1]

A the frequency decreases to 2900 cm^{-1}

B the frequency increases to 3000 cm^{-1}

C the intensity of the absorption at 2940 cm^{-1} increases

D the absorption covers the range 2900 to 3000 cm^{-1}

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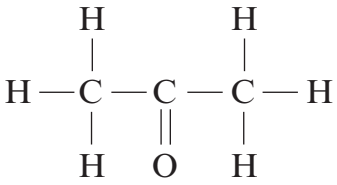
(iii) A false breathalyser reading can be given by a person who exhales propanone, as a result of an illness.



propanone

Identify the bond that would distinguish the infrared spectrum of propanone from that of an alcohol. Using the Data Sheet, state the absorption frequency of this bond. [1]

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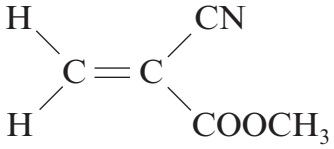
5. 'Superglue' is a liquid containing methyl 2-cyanopropenoate. In the presence of moisture this alkene rapidly polymerises, in a similar way to ethene.
Complete the table showing the structure of the repeating unit. [1]

Monomer	Repeating unit
	

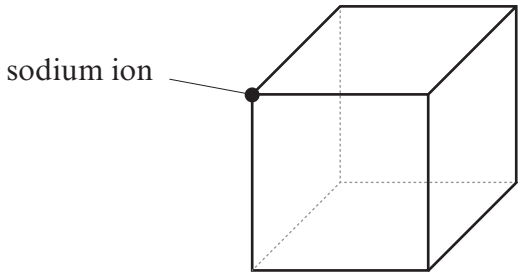
Total Section A [10]

Examiner only

SECTION B

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

6. *(a)* A section of the crystal structure of sodium chloride is shown below.



(i) Indicate, with a cross, the position of any chloride ion on this diagram. [1]

(ii) State the crystal co-ordination number of a **chloride** ion in the structure of sodium chloride. [1]

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(b) 'Rock salt', used on roads in winter, consists mainly of crystalline sodium chloride that is contaminated by a small quantity of insoluble mudstone.
Gwen added powdered rock salt to water and filtered out the insoluble material. She then evaporated the filtrate to dryness to produce pure white crystals of sodium chloride.
State **two** steps that she should have carried out to ensure that she obtained the **maximum** amount of sodium chloride from her rock salt crystals. [2]

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(c) The minerals 'rock salt', NaCl, and kainite, $KCl.MgSO_4.3H_2O$, both contain chloride ions.

(i) Give a chemical test that produces the same result for both of these compounds. You should state the reagent(s) used and the result of the test. [2]

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(ii) Give a chemical test, other than a flame test, that will show that these two compounds are different. You should assume that they are present as aqueous solutions.
Give the reagent(s) used and the result of the test for each compound. [2]

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(d) A common reaction of the halogens is the formation of the anion, X^-.

(i) State, in terms of electronic structure, why this occurs. [1]

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(ii) Give a reason why the tendency to form the X^- ion decreases down the halogen group. [1]

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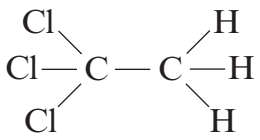
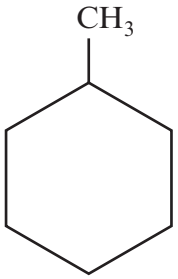
(e) One compound previously used in correction fluid was 1,1,1-trichloroethane, but this has been replaced by compounds such as methylcyclohexane, which has a much less adverse effect on the environment.



1,1,1-trichloroethane



methylcyclohexane

(i) Explain, in terms of bond strengths, why 1,1,1-trichloroethane has an effect on the ozone layer but methylcyclohexane does not. [2]

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(ii) Hept-1-ene is an isomer of methylcyclohexane.

$$CH_3—CH_2—CH_2—CH_2—CH_2—CH=CH_2$$

Describe a chemical test that gives a positive result for hept-1-ene but not for methylcyclohexane. [2]

Reagent(s) .....

Observation .....

Total [14]

Examiner only

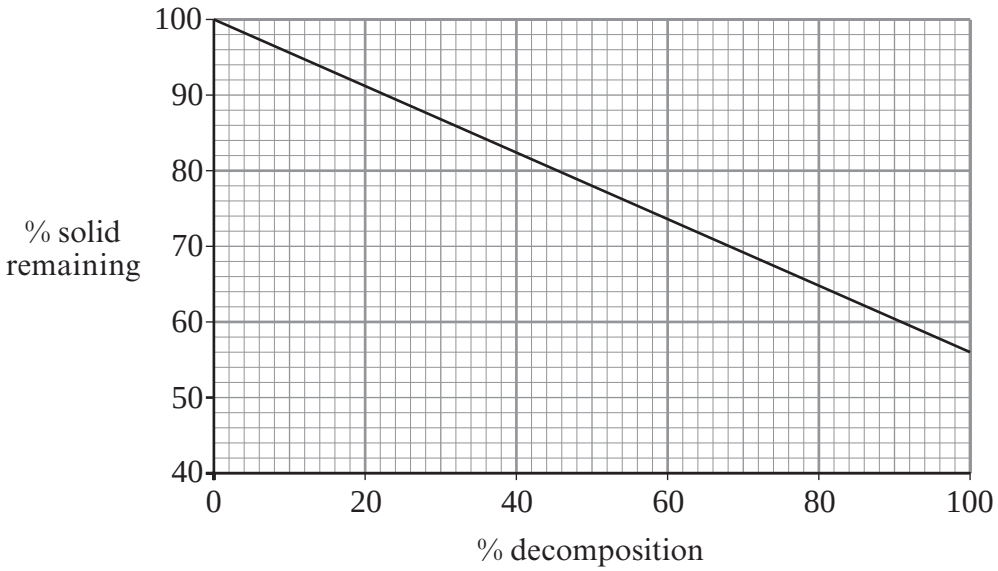
7. *(a)* In industry calcium oxide is made by heating limestone (a form of calcium carbonate) to a high temperature.

$$CaCO_3(s) \longrightarrow CaO(s) + CO_2(g)$$

(i) This experiment can be repeated in the laboratory by strongly heating a marble chip. Unless the temperature is high enough the reaction is often incomplete. In an experiment the following results were obtained.

Mass of marble chip before heating = 3.24 g
Mass of solid after heating = 2.01 g

Use the graph to help you calculate the percentage decomposition of the marble chip into calcium oxide and carbon dioxide. [2]



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(ii) The solid from (i) was carefully added to cold distilled water in order to produce a solution of calcium hydroxide, together with unreacted solid calcium carbonate. The solubility of calcium hydroxide in water was found from the resulting solution. The instructions that were being followed stated

- add the solid to about 1200 cm^3 of distilled water
- stir the mixture for ten minutes
- filter the mixture

I. State why the solid was added to **distilled** water. [1]

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II. State why the mixture was stirred for ten minutes. [1]

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(iii) 1.00 dm^3 of the solution, produced in (ii), was then titrated with hydrochloric acid of a known concentration.

$$Ca(OH)_2 + 2HCl \longrightarrow CaCl_2 + 2H_2O$$

It was found that 0.0450 mol of hydrochloric acid reacted with all the calcium hydroxide present in the solution.

I. State the number of moles of calcium hydroxide that reacted with the hydrochloric acid. [1]

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II. Calculate the solubility of calcium hydroxide in this solution in $g\,dm^{-3}$.
[The molar mass of calcium hydroxide is 74.1 $g\,mol^{-1}$] [1]

.....

Solubility = ... $g\,dm^{-3}$

(iv) Calcium carbonate will also react with hydrochloric acid.
State why any unreacted calcium carbonate from the marble chip cannot interfere with the experiment in (iii). [1]

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Examiner only

(b) Dolomite, $MgCO_3.CaCO_3$, is a mineral found in Italy. State the colour given by dolomite in a flame test, giving a reason for your choice. [2]

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(c) A solution of calcium hydroxide is reacted with aqueous sulfuric acid. A faint white precipitate is seen, as the calcium ions react with the sulfate ions. Give the **ionic** equation for this reaction. [1]

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(d) The hard mineral fluorapatite, $CaF_2.3Ca_3(PO_4)_2$, is found in tooth enamel.
One weakness with this material is that there are tiny holes between each 'molecule' of fluorapatite and these may be a cause of sensitive teeth.
Recently a manufacturer has suggested that nano-sized fluorapatite particles in a toothpaste may help solve this problem by filling the holes. Suggest what should be done before this nano-sized material is licensed for use. [1]

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(e) Fluorapatite occurs naturally as a rock and can be used to make the fertiliser 'superphosphate'. 5.0 tonnes of fluorapatite give a maximum yield of 8.6 tonnes of superphosphate.
Calculate the mass of superphosphate made from 5000 tonnes of fluorapatite if the percentage yield is 93%. [2]

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(f) Radium and calcium are elements in Group 2. Explain why radium carbonate, $RaCO_3$, has a similar formula to calcium carbonate, $CaCO_3$. [1]

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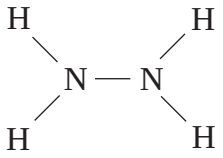
Total [14]

8. *(a)* In 1941 the Germans began to develop a rocket-powered aircraft, the Me 163, for use in the Second World War. The fuel used was based on hydrazine, which reacted with hydrogen peroxide, H_2O_2.



hydrazine

(i) Steam was needed to mix the rocket fuel and the hydrogen peroxide. This was produced by mixing some hydrogen peroxide with the catalyst calcium manganate, $Ca(MnO_4)_2$.
Deduce the oxidation state (number) of manganese in calcium manganate. [1]

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(ii) The aqueous hydrogen peroxide used contained 76.5 g of hydrogen peroxide in 100 cm^3 of its solution. Calculate the concentration of the hydrogen peroxide in mol dm^{-3}. [2]

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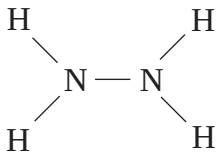
(iii) Hydrazine contains a polar covalent bond between a nitrogen and a hydrogen atom. State what is meant by a *polar covalent bond* and explain how this arises. [2]



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(iv) Hydrazine is a weak base and forms hydrazinium chloride, $N_2H_5^+Cl^-$, which contains a co-ordinate bond. State what is meant by the term *co-ordinate bond*. [1]

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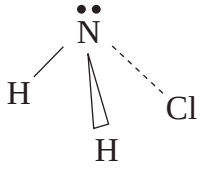
(v) Hydrazine is manufactured from the compound monochloramine, NH_2Cl.



A probable shape for a molecule of monochloramine is as shown above. The bond angles H—$\hat{N}$—H and H—$\hat{N}$—Cl are around 107°.

Use the valence shell electron pair repulsion theory (VSEPR) and the information given to explain the shape and bond angles. [2]

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(b) (i) The decomposition of hydrogen peroxide may involve hydroxyl radicals.

State why this is described as a radical. [1]

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(ii) Another reaction that produces radicals is the reaction of chlorine with methane.

I. Give the equation for the reaction of a methyl radical and chlorine. [1]

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II. State why the reaction in I above is described as a propagation reaction. [1]

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(iii) Radicals are involved in the cracking of petroleum fractions at 600 °C.

One of the products obtained by cracking is an alkane of molar mass 100 g.
Deduce the molecular formula of this alkane. [1]

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(iv) Radicals are produced by the homolytic bond fission of a covalent bond.
State what is meant by the term *homolytic bond fission*. [1]

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Total [13]

Examiner only

9. During 2010 a serious leak of petroleum (crude oil) occurred in the Gulf of Mexico. This loss of millions of litres of petroleum caused an environmental and ecological disaster.

(a) Petroleum consists largely of a mixture of alkanes that do not dissolve in sea water but form a surface layer. The main reason that these alkanes cannot dissolve in water is because they are unable to hydrogen bond with water. Explain what is meant by *hydrogen bonding* and use this to explain why alkanes do not dissolve in water. [4]

QWC [1]

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(b) (i) Some of the leaking oil was collected by tankers and taken to oil refineries. The petroleum was then separated into fractions by the process of fractional distillation. Describe what is meant by *fractional distillation*. [2]

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(ii) One of the fractions was then further refined into fuel for vehicles.
During refining, most of the sulfur compounds present in the fuel are removed in order to reduce the amount of oxides of sulfur released in exhaust gases.
One stage in the process is to convert unpleasant-smelling thioalcohols (R—SH) into disulfides (R—S—S—R) using copper chloride, $CuCl_2$.

$$2R—SH + 2CuCl_2 \longrightarrow R—S—S—R + 2CuCl + 2HCl$$

Explain, using the oxidation states (numbers) of copper, why copper chloride, $CuCl_2$, is reduced in this reaction. You should assume that the oxidation state of chlorine is –1. [2]

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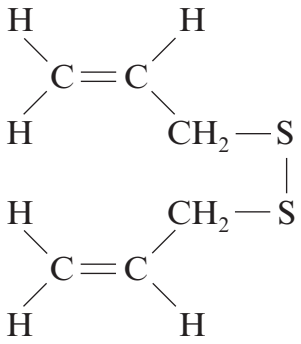
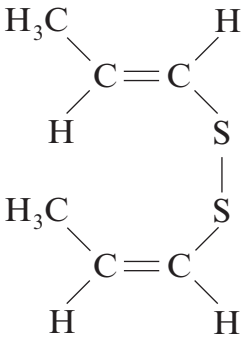
Examiner only

(c) Compounds **A** and **B** are organic compounds of sulfur found naturally in some foods.



compound **A**
found in garlic



compound **B**
produced on cooking onions

(i) These two compounds are structural isomers. State what is meant by the term *structural isomer.* [1]

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(ii) Explain why only compound **B** can exist as E-Z isomers.
Your answer should comment on the atoms/groups involved and the reason why these give rise to E-Z isomerism. [2]

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(iii) Compound **A** is sold by the chemical suppliers at £48.00 for 100 g. The material sold is only 73% pure but this is satisfactory for the purposes needed.
Calculate the cost of 1 mol of compound **A**, which has a molecular formula $C_6H_{10}S_2$. [2]

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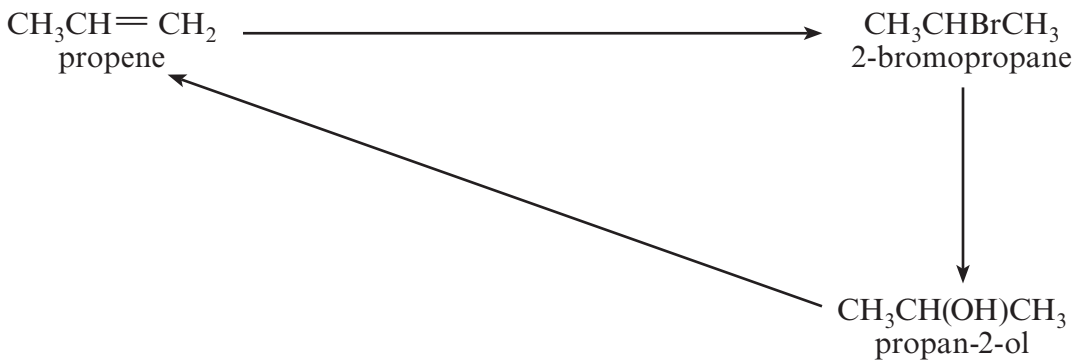
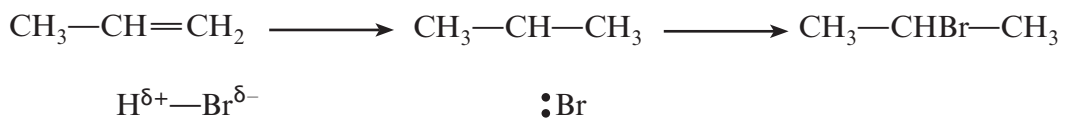
Total [14]

Examiner only

10. *(a)* This question is about the compounds and reactions shown in the diagram below.



(i) The addition of hydrogen bromide to propene gives 2-bromopropane as the main product. Complete the outline mechansim below, inserting curly arrows and charges where appropriate. [2]



(ii) The reaction of 2-bromopropane to give propan-2-ol is an example of a nucleophilic substitution reaction. Suggest a nucleophile that can be used for this reaction and give a reason why this is classed as a substitution reaction. [2]

Nucleophile .....

Reason .....

.....

(iii) The production of propene from propan-2-ol is an example of an elimination reaction. Another elimination reaction is the reaction of bromoethane with sodium hydroxide.

$$CH_3CH_2Br + NaOH \longrightarrow CH_2=CH_2$$

Complete the equation by giving the formulae of the other products. [1]

Examiner only

(b) A primary alcohol was oxidised to a carboxylic acid. The mass spectrum of the acid showed a molecular ion at m/z 88.
Use the information provided to write a displayed formula for the acid. [3]

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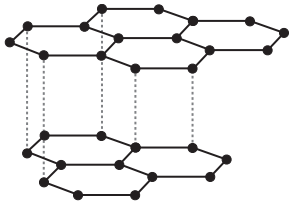
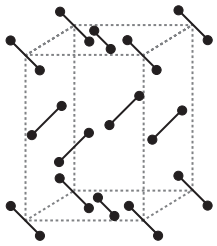
(c) Both carbon and iodine are non-metallic elements. The crystalline structures of graphite and iodine are shown below.



graphite



iodine

Solid iodine exists as a molecular crystal, I_2.

Explain why graphite is able to conduct electricity but iodine is a non-conductor.
Your answer should focus on the bonding present in each solid element. [5]
QWC [2]

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Total [15]

Section B Total [70]

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GCE AS/A level

1092/01-A

CHEMISTRY – DATA SHEET
FOR USE WITH CH2

P.M. THURSDAY, 19 January 2012

Infrared Spectroscopy characteristic absorption values

Bond	Wavenumber / cm^{-1}
C—Br	500 to 600
C—Cl	650 to 800
C—O	1000 to 1300
C═C	1620 to 1670
C═O	1650 to 1750
C≡N	2100 to 2250
C—H	2800 to 3100
O—H	2500 to 3550
N—H	3300 to 3500

THE PERIODIC TABLE