Centre No.						Paper Reference							Surname	Initial(s)
Candidate No.						6	2	4	5	/	0	1	Signature	

Paper Reference(s)

6245/01

Edexcel GCE

Chemistry

Advanced

Unit Test 5

(including synoptic assessment)

Tuesday 20 January 2009 – Morning

Time: 1 hour 30 minutes

Examiner's use only		

Team Leader's use only		

Question Number	Leave Blank
1	
2	
3	
4	
5	
6	
Total	

Materials required for examination	Items included with question papers
Nil	Nil

Candidates may use a calculator.

Instructions to Candidates

In the boxes above, write your centre number, candidate number, your surname, initial(s) and signature.
Check that you have the correct question paper. The paper reference is shown above.
Answer **ALL** the questions. Write your answers in the spaces provided in this question paper.
Do not use pencil. Use blue or black ink.
Show all the steps in any calculations and state the units.

Information for Candidates

The marks for individual questions and parts of questions are shown in round brackets: e.g. **(2)**.
The total mark for this paper is 75. There are 20 pages in this question paper. Any blank pages are indicated.
A Periodic Table is printed on the back cover of this paper.

Advice to Candidates

You are reminded of the importance of clear English and careful presentation in your answers.
You will be assessed on your Quality of Written Communication in this paper.

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Answer ALL the questions. Write your answers in the spaces provided.

1. (a) Complete the electronic configurations of a copper ion, Cu^{+}, and a copper ion, Cu^{2+}.

	1s	2s	2p	2p	2p	3s	3p	3p	3p	3d	3d	3d	3d	3d	4s
Cu^{+}	⇅	⇅	⇅	⇅	⇅	⇅	⇅	⇅	⇅						
Cu^{2+}	⇅	⇅	⇅	⇅	⇅	⇅	⇅	⇅	⇅						

(2)

(b) (i) Copper compounds containing the copper 2+ ion are blue in aqueous solution. Explain the origin of the colour.

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(3)

(ii) On heating, blue hydrated copper(II) sulphate, $CuSO_4.5H_2O$, turns white. Suggest why the anhydrous salt, $CuSO_4$, is white.

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(1)

N 3 3 9 1 9 A 0 2 2 0

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(c) A green chloride of copper, $CuCl_2$, was boiled with concentrated hydrochloric acid and metallic copper. After addition of a large volume of water, a white precipitate, **X**, was produced. The precipitate was washed with distilled water and dissolved in concentrated ammonia solution, giving a colourless solution of a copper complex, **Y**. When air was blown through the solution of **Y**, it turned dark blue producing a solution of a different complex of copper, **Z**.

Summary

$$\mathbf{CuCl_2} \xrightarrow{\text{HCl + Cu}} \mathbf{X} \xrightarrow{\text{ammonia solution}} \mathbf{Y} \xrightarrow{\text{air}} \mathbf{Z}$$

(i) Identify **X** and write an equation for its formation.

Identity of X ....

Equation ....

(2)

(ii) What type of reaction is taking place in the formation of **X**?

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(1)

(iii) The complex copper ion, **Y**, is linear. Suggest the formula for **Y**.

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(1)

(iv) Explain why **Y** is **not** coloured.

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(1)

(v) Write the formula of **Z**.

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(1)

Q1

(Total 12 marks)

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2. The equation for the reaction between 1-bromobutane and hydroxide ions is

$$CH_3CH_2CH_2CH_2Br + OH^- \rightarrow CH_3CH_2CH_2CH_2OH + Br^-$$

(a) Classify the reaction taking place.

....
(1)

(b) Data for the reaction of 1-bromobutane with hydroxide ions are shown in the table.

Expt	Initial concentration of 1-bromobutane /mol dm^{-3}	Initial concentration of hydroxide ions /mol dm^{-3}	Initial rate /mol dm^{-3} s^{-1}
1	0.01	0.01	0.012
2	0.01	0.03	0.036
3	0.04	0.03	0.144

(i) Calculate, showing your working, the order of the reaction with respect to 1-bromobutane and to the hydroxide ion. Hence write the rate equation.

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(3)

Leave blank

(ii) Write the mechanism for the reaction which is consistent with your rate equation. You should use RCH_2Br to represent 1-bromobutane.

(3)

(c) (i) One optical isomer of a tertiary bromoalkane reacts with aqueous hydroxide ions to produce a mixture that does **not** rotate the plane of monochromatic plane-polarised light.

Explain how this information suggests the mechanism is S_N1 but **not** S_N2.

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(4)

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(ii) The S_N1 mechanism is first order with respect to the **tertiary** bromoalkane and zero order with respect to the hydroxide ion. It takes place in two steps, one of which is rate-determining.

Explain what is meant by the term **rate-determining step** and explain what happens in this step. (You do **not** need to draw out the mechanism.)

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(2)

Q2

(Total 13 marks)

Leave blank

3. Benzene and propene both react with electrophiles. Propene undergoes addition but benzene undergoes substitution.

(a) (i) Write the mechanism for the addition of hydrogen bromide to propene to form 2-bromopropane.

(3)

(ii) State why 2-bromopropane is the major product.

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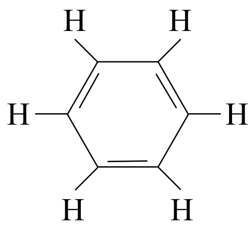
(1)

Leave blank

(b) Use the average bond enthalpy data below to calculate the enthalpy of hydrogenation of the hypothetical molecule cyclohexa-1,3,5-triene, C_6H_6, to form cyclohexane, C_6H_{12}.



(g) + $3H_2(g) \longrightarrow C_6H_{12}(g)$

Bond	Average bond enthalpy / kJ mol^{-1}
C—C	347
C=C	612
C—H	413
H—H	436

(3)

N 3 3 9 1 9 A 0 8 2 0

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(c) The measured enthalpy change for the hydrogenation of benzene is –208 kJ mol^{-1}. The difference between this value and the answer in (b) is called the delocalisation (stabilisation) energy. The structure shown for cyclohexa-1,3,5-triene assumes three **localised** π-bonds.

(i) Explain how the **delocalised** π-bond system in benzene is formed. Include a diagram in your answer.

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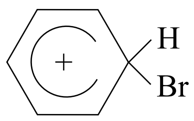
(2)

(ii) The first step in the reaction of benzene with bromine, in the presence of a catalyst, is the addition of Br^+ to the benzene ring forming:



Explain why the second step results in the overall reaction being substitution rather than addition.

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(2)

Leave blank

(d) An azo dye can be produced from benzene. The azo dye produced is very impure. It can be purified by recrystallisation as follows.

- Dissolve the solid azo dye in the minimum volume of hot ethanol.
- Filter the mixture while it is hot.
- Cool the filtrate in ice to crystallise the solid.
- Filter the mixture.
- Wash the solid with the minimum volume of ice-cold ethanol.
- Dry the solid.

(i) What essential property must be shown by a solvent for it to be suitable for use in recrystallisation?

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(1)

(ii) State which process removes insoluble impurities.

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(1)

(iii) Explain how soluble impurities are removed during the purification.

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(1)

(iv) Why is the solid washed with solvent after the second filtration?

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(1)

(v) State ONE feature of the procedure that ensures the maximum yield of pure azo dye at the end of the purification.

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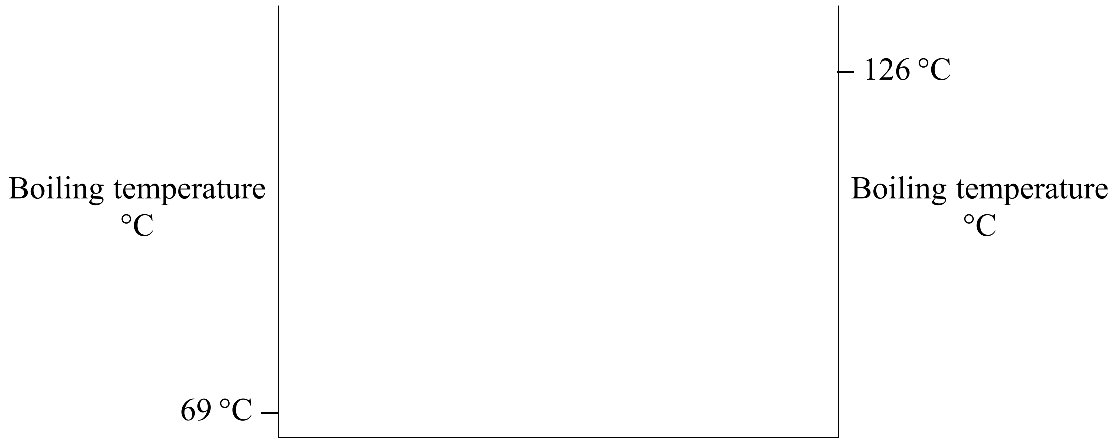
(1)

Q3

(Total 16 marks)

Leave blank

4. Draw a boiling temperature/composition diagram for a mixture of octane (boiling temperature 126 °C) and hexane (boiling temperature 69 °C) and then **use the diagram to explain** how fractional distillation of a mixture of 50% octane and 50% hexane can be used to produce pure hexane.



Q4

(Total 5 marks)

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5. (a) Cinnamon oil is an aromatic oil which has the following percentage composition by mass:

Carbon 81.82%: Hydrogen 6.06%: Oxygen 12.12%.

The molar mass of the compound is 132 g mol^{-1}.

Use this information to confirm that the molecular formula of cinnamon oil is C_9H_8O.

(3)

(b) Cinnamon oil has the following reactions. For each reaction state what structural information is gained from the test result.

(i) Cinnamon oil reacts with a solution of 2,4-dinitrophenylhydrazine to give a yellow precipitate.

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(1)

(ii) Cinnamon oil reacts with ammoniacal silver nitrate solution to give a silver mirror.

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(1)

(iii) Cinnamon oil reacts with excess hydrogen bromide to give a product which has a molecular formula C_9H_9OBr.

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(1)

Leave blank

(c) Cinnamon oil's structure is based on a benzene ring with a single unbranched side chain.

(i) Use this information and your answers from (b) to suggest a structural formula for cinnamon oil.

(1)

(ii) Draw the structure of the product of the reaction between cinnamon oil and hydrogen bromide, HBr. Mark the chiral carbon atom with an asterisk (*).

(2)

(iii) Explain why, when cinnamon oil reacts with bromine in the presence of anhydrous aluminium chloride, several different compounds are formed.

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(2)

Q5

(Total 11 marks)

Leave blank

6. This question concerns the chemistry of chromium and its compounds.

(a) State what you would **see** when a solution of sodium hydroxide is added slowly, until in excess, to a solution containing chromium(III) ions.

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(2)

(b) Consider the following reaction:

$$2CrO_4^{2-}(aq) + 2H^+(aq) \rightleftharpoons Cr_2O_7^{2-}(aq) + H_2O(l)$$

(i) Explain the effect of changing the pH on the position of this equilibrium.

Higher pH ....

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Lower pH..

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(2)

(ii) Explain, with reference to chromium, why this is **not** a redox reaction.

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(1)

(c) Use the information in the table below to answer the questions that follow.

	$E^\ominus$ /V
$Cr^{2+}(aq) + 2e^- \rightleftharpoons Cr(s)$	–0.90
$Zn^{2+}(aq) + 2e^- \rightleftharpoons Zn(s)$	–0.76
$Cr^{3+}(aq) + e^- \rightleftharpoons Cr^{2+}(aq)$	–0.41

Leave blank

(i) Write the equation for the reduction of Cr^{3+} ions to Cr^{2+} ions with zinc. State symbols are **not** required.

(1)

(ii) Write the equation for the reduction of Cr^{2+} ions to chromium metal with zinc. State symbols are **not** required.

(1)

(iii) Calculate the $E^{\ominus}_{cell}$ values for each of the above reactions.

State, with a reason, what the final product of the reaction between Cr^{3+} ions and zinc will be.

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(2)

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(d) Standard potassium dichromate(VI) solution can be used to find the amount of iron(II) sulphate, $FeSO_4$, in an iron(II) sulphate tablet.

A tablet of mass 4.00 g was dissolved in dilute sulphuric acid and the solution made up to 250 cm^3 with water. A 25.0 cm^3 portion of the solution was titrated with a solution of potassium dichromate(VI) of concentration 0.0136 mol dm^{-3}. The mean titre was 19.00 cm^3.

The reaction is as follows:

$$Cr_2O_7^{2-}(aq) + 14H^+(aq) + 6Fe^{2+}(aq) \rightarrow 2Cr^{3+}(aq) + 6Fe^{3+}(aq) + 7H_2O(l)$$

Calculate the percentage of iron(II) sulphate in the tablet.

(5)

Leave blank

(e) Alcohols are primary, secondary or tertiary.

Describe how you would classify alcohols in these groups by heating them with acidified potassium dichromate(VI) solution and, where necessary, carrying out a further test on the product. You should include any reagents and give the expected observations. Equations are **not** required.

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(4)

Q6

(Total 18 marks)

TOTAL FOR PAPER: 75 MARKS

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THE PERIODIC TABLE

Key

Molar mass g mol⁻¹
Symbol
Name
Atomic number

Period	Group 1	Group 2											Group 3	Group 4	Group 5	Group 6	Group 7	Group 0
1	1 H Hydrogen 1																	4 He Helium 2
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
3	23 Na Sodium 11	24 Mg Magnesium 12											27 Al Aluminium 13	28 Si Silicon 14	31 P Phosphorus 15	32 S Sulphur 16	35.5 Cl Chlorine 17	40 Ar Argon 18
4	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	63.5 Cu Copper 29	65.4 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
5	85 Rb Rubidium 37	88 Sr Strontium 38	89 Y Yttrium 39	91 Zr Zirconium 40	93 Nb Niobium 41	96 Mo Molybdenum 42	99 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
6	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	210 Po Polonium 84	210 At Astatine 85	222 Rn Radon 86
7	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	163 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	(242) Pu Plutonium 94	(243) Am Americium 95	(247) Cm Curium 96	(245) Bk Berkelium 97	(251) Cf Californium 98	(254) Es Einsteinium 99	(253) Fm Fermium 100	(256) Md Mendelevium 101	(254) No Nobelium 102	(257) Lr Lawrencium 103