| 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)

Thursday 12 June 2008 – Afternoon

Time: 1 hour 30 minutes

Examiner's use only

| | | |
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Team Leader's use only

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| Question Number | Leave Blank |
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| 1 | |
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**Materials required for examination**
Nil

**Items included with question papers**
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 in the spaces provided in this question paper.
Do not use pencil. Use blue or black ink.
One of the questions in this paper must be answered with a cross in a box (☒). If you change your mind about an answer, put a line through the box (☒) and then mark your new answer with a cross (☒).
**Show all the steps in any calculations and state the units.**

### Information for Candidates

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

### 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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N 3 0 3 8 3 A 0 1 2 0

*Turn over*

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Leave blank

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

**1.** (a) Define the term **standard electrode potential**, making clear the meaning of *standard*.

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**(2)**

(b) Explain why a reference electrode is needed whenever a standard electrode potential is measured.

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**(1)**

(c) Hydrogen peroxide decomposes in a disproportionation reaction.

(i) Explain the meaning of **disproportionation**.

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**(2)**

Leave blank

(ii) Use the following information to derive the equation for the disproportionation of hydrogen peroxide.

Calculate $E^{\ominus}_{cell}$ and explain whether the reaction is thermodynamically feasible.

$$O_2 + 2H^+ + 2e^- \rightleftharpoons H_2O_2 \qquad E^{\ominus} = +0.68 \text{ V}$$

$$H_2O_2 + 2H^+ + 2e^- \rightleftharpoons 2H_2O \qquad E^{\ominus} = +1.77 \text{ V}$$

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**(3)**

(iii) Explain why your answer to (ii) does not necessarily show that hydrogen peroxide will disproportionate under standard conditions.

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**(1)**

**Q1**

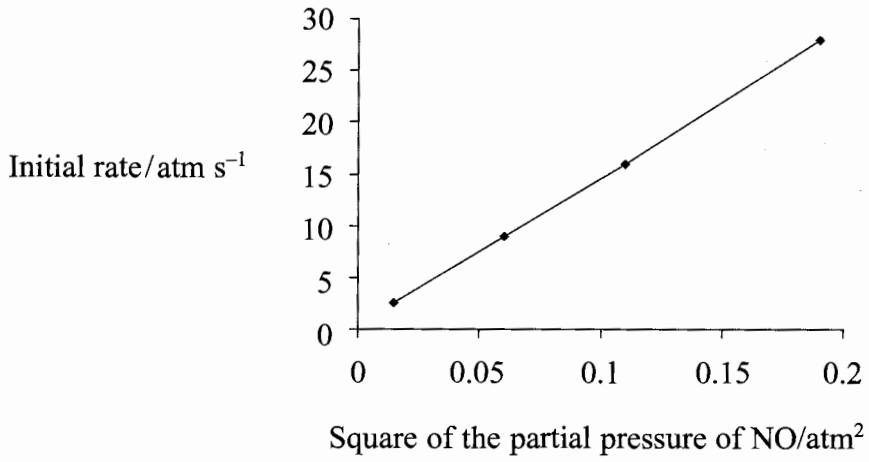
**(Total 9 marks)**

Leave blank

**2.** This question concerns the reaction between nitrogen monoxide and oxygen:

$$2NO(g) + O_2(g) \rightarrow 2NO_2(g)$$

(a) In a series of experiments designed to find the rate equation for this reaction, the following data were obtained. In each experiment the partial pressure of oxygen was the same.




(i) What is the order of reaction with respect to nitrogen monoxide?

Justify your answer.

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**(2)**

(ii) A new series of readings is taken with the partial pressure of oxygen doubled. The gradient of the line doubles.

State, with a reason, the order of reaction with respect to oxygen.

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**(1)**

Leave blank

(iii) Hence write the rate equation for the reaction.

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**(1)**

(iv) State the units of the rate constant.

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**(1)**

(v) Thunderstorms generate a small amount of nitrogen monoxide.

Suggest why it remains in the air for a considerable time, given that the activation energy for the reaction between oxygen and nitrogen monoxide is low at room temperature.

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**(1)**

**QUESTION 2 CONTINUES ON THE NEXT PAGE**

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(b) The rate of the decomposition of nitrous oxide

$$2N_2O(g) \rightarrow 2N_2(g) + O_2(g)$$

has been studied at different temperatures. The rate constant $k$ was determined at each temperature.

The relationship between the rate constant and the temperature $T$ is given by the Arrhenius equation:

$$\ln k = \ln A - \frac{E_a}{R}\left(\frac{1}{T}\right)$$

where $E_a$ is the activation energy for the reaction, $R$ is the gas constant, and $k$ is the rate constant at temperature $T$.

(i) Given values of $k$ at different temperatures $T$, what graph would you plot and how would you use it to determine the activation energy?

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**(2)**

(ii) A plot of the data gave a straight line with gradient $-2.95 \times 10^4\ K^{-1}$.

Find the activation energy for the reaction, in kJ mol$^{-1}$, to **three** significant figures.
[The value of $R$ is 8.314 J K$^{-1}$ mol$^{-1}$]

**(2)**



N 3 0 3 8 3 A 0 6 2 0

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(iii) What is the oxidation number of nitrogen in nitrous oxide, $N_2O$?

Put a cross (☒) in the box of the correct answer. If you change your mind about an answer, put a line through the box (☒) and then mark your new answer with a cross (☒).

| | | |
|---|---|---|
| **A** | +2 | ☐ |
| **B** | +1 | ☐ |
| **C** | –1 | ☐ |
| **D** | –2 | ☐ |

**(1)**

**Q2**

**(Total 11 marks)**

Leave blank

**3.** Cyanide ions react with 2-bromo-2-methylpropane in the following way:

$$(CH_3)_3CBr + CN^- \rightarrow (CH_3)_3CCN + Br^-$$

The rate equation for this reaction is

$$\text{rate} = k[(CH_3)_3CBr]$$

(a) Which solvent would be used for this reaction?

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**(1)**

(b) (i) What information does this rate equation give about the mechanism of this reaction?

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**(2)**

Leave blank

(ii) Give the mechanism for this reaction consistent with the rate equation.

**(3)**

(c) Explain whether it would be possible, using low-resolution proton nmr spectra **alone**, to tell whether $(CH_3)_3CBr$ had been converted into $(CH_3)_3CCN$.

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**(1)**

Leave blank

(d) How do you show that bromine atoms are present in a bromoalkane?

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**(4)**

(e) The nitrile, $(CH_3)_3CCN$, can be converted into $(CH_3)_3CCOOCH_2CH_3$ in **two** steps.

(i) Identify the reagent required for the **first step**, and the formula of the organic product from this step.

**(2)**

(ii) Write the equation for the second step.

.....

.....

**(2)**

**Q3**

**(Total 15 marks)**

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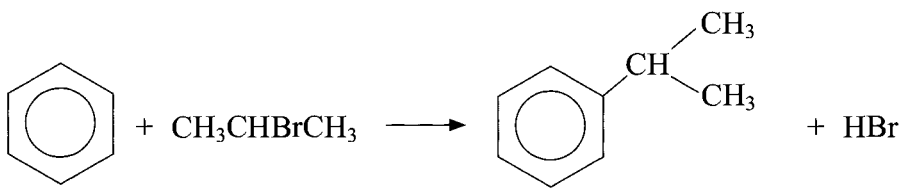
**4.** (a) Benzene reacts with 2-bromopropane in a Friedel-Crafts reaction to give 2-phenylpropane, $C_6H_5CH(CH_3)_2$, usually known as cumene.




**cumene**

Cumene is used to manufacture phenol and propanone.

(i) Identify a suitable catalyst for the reaction between benzene and 2-bromopropane.

.....

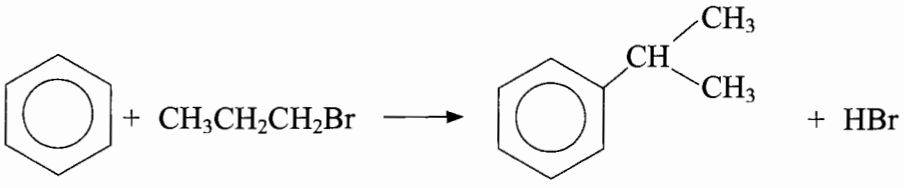
**(1)**

(ii) Give the mechanism for the reaction, including the formation of the electrophile.

**(4)**

Leave blank

(b) If benzene and 1-bromopropane, $CH_3CH_2CH_2Br$, are reacted under similar conditions to those in part (a), the product is still cumene although 1-phenylpropane $C_6H_5CH_2CH_2CH_3$ might have been the expected product.




**cumene**

(i) Draw the structure of the carbocation which would initially be formed.

**(1)**

(ii) Suggest, in terms of relative stabilities of carbocations, what happens to the carbocation in (i) which results in cumene as the product of the reaction rather than 1-phenylpropane.

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**(2)**

(c) Phenol reacts with the benzenediazonium cation, $C_6H_5N_2^+$, in alkaline conditions to give an azo dye.

(i) State the reagents needed to convert phenylamine into a solution containing $C_6H_5N_2^+$ ions.

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**(2)**

(ii) Explain why the temperature of the reaction in (c)(i) needs to be kept between 0 °C and 10 °C.

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**(2)**

Leave blank

(iii) Give the structural formula of the **product** from the reaction between benzenediazonium chloride and phenol.

**(2)**

(iv) Suggest why compounds with an N=N group, such as the product given in (iii), show geometric isomerism.

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**(2)**

(d) (i) How would you show that propanone is a carbonyl compound **and** is a ketone, not an aldehyde?

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**(3)**

Leave blank

(ii) A characteristic reaction of the carbonyl group, C=O, is nucleophilic addition. The C=C double bond reacts by electrophilic addition.

Suggest the reason for the difference.

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**(2)**

(iii) Give the mechanism for the nucleophilic addition reaction between propanone and hydrogen cyanide in the presence of a catalyst of cyanide ions, $CN^-$.

**(3)**

**Q4**

**(Total 24 marks)**

Leave blank

**5.** (a) (i) Complete the electronic configurations of:

Cr: [Ar].....

Cu: [Ar].....

**(1)**

(ii) The electronic configurations of chromium and of copper are not readily predictable from a consideration of the elements on either side of them in the first transition series in the Periodic Table.

State how these electronic configurations differ from others in the first transition series and explain why this difference arises.

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**(2)**

(b) Chromium can form the ion $[Cr(H_2O)_6]^{3+}$ in aqueous solution.

(i) Draw the structure of this ion so as to clearly show its shape.

**(1)**

(ii) How are the bonds between the water ligands and the metal ion formed?

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**(1)**

Leave blank

(iii) Write an equation to show what happens initially when a solution containing hydroxide ions is added to a solution of $[Cr(H_2O)_6]^{3+}$ ions.

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**(2)**

(iv) State what you would **see** as dilute sodium hydroxide is gradually added to a solution of $[Cr(H_2O)_6]^{3+}$ until it is in excess.

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**(2)**

(v) What property of chromium(III) hydroxide is shown by the reaction in part (iv)?

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**(1)**

**QUESTION 5 CONTINUES ON THE NEXT PAGE**

Leave blank

(c) (i) A 1.00 g sample of a metal alloy that contains chromium was converted into 250 $cm^3$ of an acidified solution of potassium dichromate(VI).

25.0 $cm^3$ of this solution was added to an excess of potassium iodide solution.

$$Cr_2O_7^{2-} + 6I^- + 14H^+ \rightarrow 2Cr^{3+} + 3I_2 + 7H_2O$$

The iodine liberated was titrated with 0.100 mol $dm^{-3}$ sodium thiosulphate solution.

$$I_2 + 2S_2O_3^{2-} \rightarrow 2I^- + S_4O_6^{2-}$$

The mean (average) titre was 37.2 $cm^3$.

Calculate the amount (moles) of iodine liberated and hence the percentage, by mass, of chromium in the alloy.

**(5)**

(ii) In titrations involving iodine, starch is usually added near the end-point to make the colour change clearer, although in many cases it is not really necessary.

Suggest why starch **is** necessary in the titration in (i).

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**(1)**

**Q5**

**(Total 16 marks)**

**TOTAL FOR PAPER: 75 MARKS**

**END**

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N 3 0 3 8 3 A 0 1 9 2 0

# THE PERIODIC TABLE

| Period | 1 | 2 | | | | | | | | | | | 3 | 4 | 5 | 6 | 7 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Group** | | | | | | | | | | | | | | | | | |
| 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 | | | | | | | | | | | | | | | |

**Key**

Molar mass g mol$^{-1}$

Symbol

Name

Atomic number

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 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 |