Write your name here

| Surname | Other names |
|---|---|
| | |

Centre Number | | | | | |

Candidate Number | | | | |

# Edexcel GCE

# Chemistry
## Advanced
### Unit 5: General Principles of Chemistry II – Transition Metals and Organic Nitrogen Chemistry (including synoptic assessment)

Monday 31 January 2011 – Morning
**Time: 1 hour 40 minutes**

Paper Reference
**6CH05/01**

**You must have: Data Booklet**

**Candidates may use a calculator.**

Total Marks

## Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

## Information

- The total mark for this paper is 90.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- Questions labelled with an **asterisk** (*) are ones where the quality of your written communication will be assessed
  – *you should take particular care with your spelling, punctuation and grammar, as well as the clarity of expression, on these questions.*
- A Periodic Table is printed on the back cover of this paper.

## Advice

- Read each question carefully before you start to answer it.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

*Turn over* ▶

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7/7/5/5/2/


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## SECTION A

**Answer ALL the questions in this section. You should aim to spend no more than 20 minutes on this section. For each question, select one answer from A to D and put a cross in the box ☒. If you change your mind, put a line through the box ☒ and then mark your new answer with a cross ☒.**

**1** What type of bonding occurs between the metal ion and ligand in the complex ion $[Cu(H_2O)_6]^{2+}$?

☒ **A** Metallic

☒ **B** Ionic

☒ **C** Hydrogen

☒ **D** Dative covalent

**(Total for Question 1 = 1 mark)**

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**2** Which of these four amino acids could **not** rotate the plane of plane-polarised light?

☒ **A** $H_2NCH(CH_3)COOH$

☒ **B** $H_2NCH(CH_2COOH)COOH$

☒ **C** $H_2NCH_2COOH$

☒ **D** $H_2NCH(CH_2SH)COOH$

**(Total for Question 2 = 1 mark)**

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**3** In the solid state, the amino acid serine exists in the form

☒ **A** $H_3N^+CH(CH_2OH)COOH$

☒ **B** $H_3N^+CH(CH_2OH)CO_2^-$

☒ **C** $H_2NCH(CH_2OH)COOH$

☒ **D** $H_2NCH(CH_2OH)CO_2^-$

**(Total for Question 3 = 1 mark)**

---

**4** The best method for separating a mixture of amino acids in solution is

☒ **A** distillation.

☒ **B** solvent extraction.

☒ **C** chromatography.

☒ **D** recrystallization.

**(Total for Question 4 = 1 mark)**

---

**5** How many different peaks due to hydrogen atoms would you expect to see in a **low resolution** proton nmr spectrum of propanoic acid, $CH_3CH_2COOH$?

☒ **A** Two

☒ **B** Three

☒ **C** Five

☒ **D** Six

**(Total for Question 5 = 1 mark)**

**6** In a **high resolution** proton nmr spectrum of ethanoic acid, $CH_3COOH$, the peak due to the hydrogen atoms in the methyl group would be a

☒ **A** singlet.

☒ **B** doublet.

☒ **C** triplet.

☒ **D** quartet.

**(Total for Question 6 = 1 mark)**

**7** Which of these compounds will **not** form an amide in a reaction with ethanoyl chloride?

☒ **A** $NH_3$

☒ **B** $CH_3CH_2NH_2$

☒ **C** $CH_3CH_2NH(CH_3)$

☒ **D** $CH_3CH_2N(CH_3)_2$

**(Total for Question 7 = 1 mark)**

**Use this space for any rough working. Anything you write in this space will gain no credit.**

**8** This question concerns the following organic compounds.

**A** $CH_3COCl$

**B** $CH_3COOH$

**C** $CH_3COOCH_2CH_3$

**D** $C_6H_5OH$

Which compound is most likely to

(a) form the solution with the lowest pH when mixed with water?

**(1)**

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(b) burn with a smoky flame?

**(1)**

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(c) have a fruity smell?

**(1)**

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(d) have an absorption in its IR spectrum at about 1795 $cm^{-1}$?

**(1)**

☒ **A**

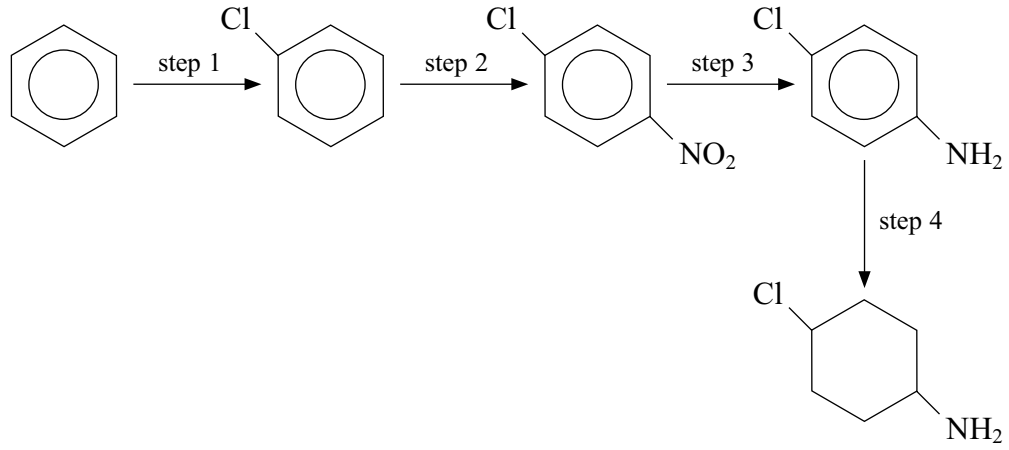
☒ **B**

☒ **C**

☒ **D**

**(Total for Question 8 = 4 marks)**

**9** This question is about the reaction scheme below.




Which step is most likely to need

(a) tin and concentrated hydrochloric acid?

**(1)**

- ☒ **A** Step 1
- ☒ **B** Step 2
- ☒ **C** Step 3
- ☒ **D** Step 4

(b) a catalyst of iron(III) chloride?

**(1)**

- ☒ **A** Step 1
- ☒ **B** Step 2
- ☒ **C** Step 3
- ☒ **D** Step 4

(c) a nickel catalyst?

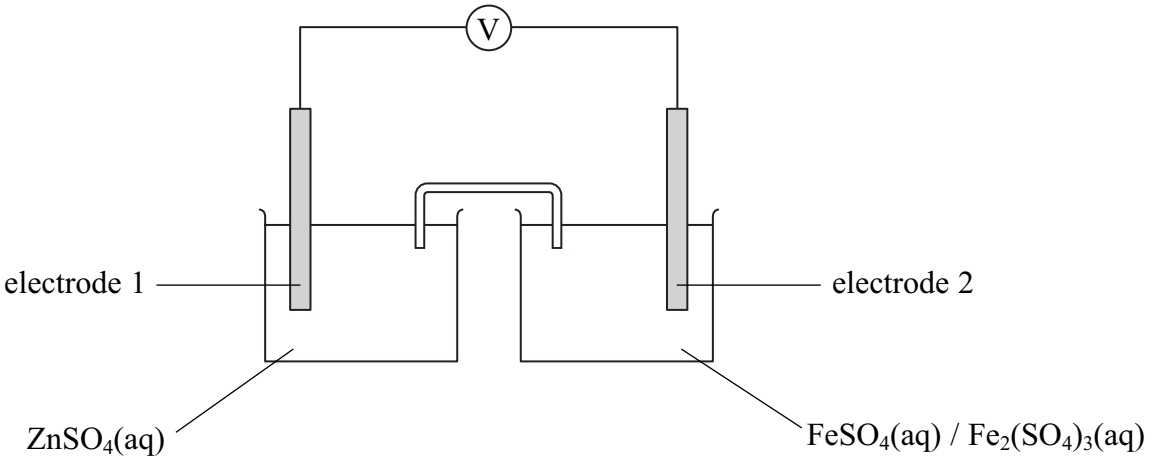
**(1)**

- ☒ **A** Step 1
- ☒ **B** Step 2
- ☒ **C** Step 3
- ☒ **D** Step 4

**(Total for Question 9 = 3 marks)**

**10** The apparatus below can be used to measure the value of $E_{cell}$ for the reaction

$$2Fe^{3+}(aq) + Zn(s) \rightarrow 2Fe^{2+}(aq) + Zn^{2+}(aq)$$




The electrodes are:

| | | electrode 1 | electrode 2 |
|---|---|---|---|
| ☒ | **A** | zinc | iron |
| ☒ | **B** | iron | zinc |
| ☒ | **C** | zinc | platinum |
| ☒ | **D** | platinum | platinum |

**(Total for Question 10 = 1 mark)**

**11** Copper reacts with silver ions according to the reaction below.

$$Cu(s) + 2Ag^{+}(aq) \rightarrow Cu^{2+}(aq) + 2Ag(s)$$

$E^{\ominus}_{cell}$ for this reaction is

☒ **A** +0.46 V

☒ **B** +1.14 V

☒ **C** +1.26 V

☒ **D** +1.94 V

**(Total for Question 11 = 1 mark)**

**12** $E^{\ominus}_{cell}$ for four reactions are shown in the table below.

| | $E^{\ominus}_{cell}$ / V |
|---|---|
| Reaction 1 | +1.10 |
| Reaction 2 | +0.65 |
| Reaction 3 | +0.10 |
| Reaction 4 | –1.30 |

Which reaction

(a) is thermodynamically not feasible?

**(1)**

☒ **A** Reaction 1

☒ **B** Reaction 2

☒ **C** Reaction 3

☒ **D** Reaction 4

(b) has the largest value for ln $K$?

**(1)**

☒ **A** Reaction 1

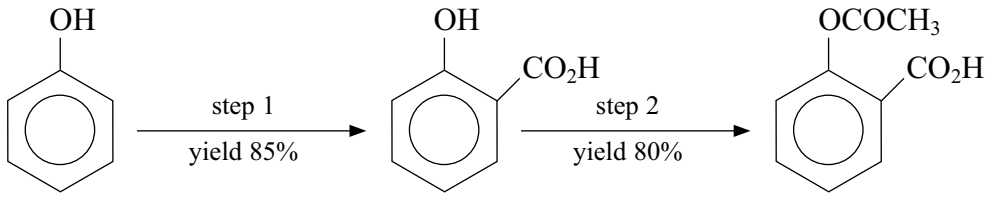
☒ **B** Reaction 2

☒ **C** Reaction 3

☒ **D** Reaction 4

**(Total for Question 12 = 2 marks)**

**13** Consider the reaction scheme below and calculate the mass of aspirin you would expect to form if you started with 47 g of phenol.




phenol, $M_r = 94$ aspirin, $M_r = 180$

☒ **A** 31.96 g

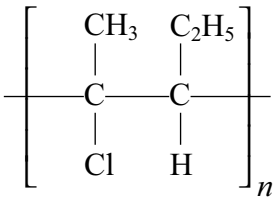
☒ **B** 61.20 g

☒ **C** 74.25 g

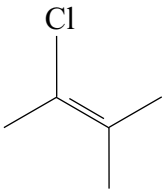
☒ **D** 90.00 g

**(Total for Question 13 = 1 mark)**

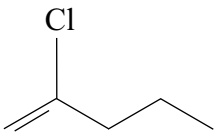
**14** Which of the monomers **A to D** would form the polymer below?



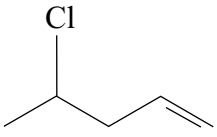

☒ **A**



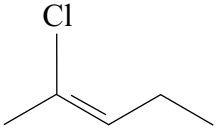

☒ **B**




☒ **C**




☒ **D**



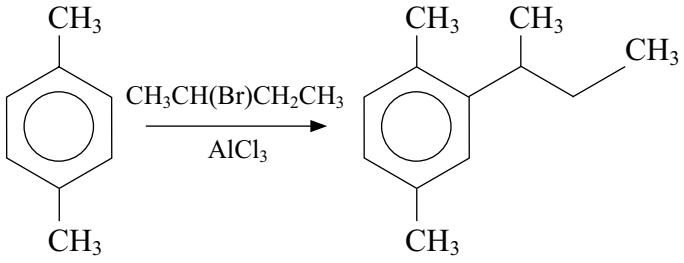

**(Total for Question 14 = 1 mark)**

**TOTAL FOR SECTION A = 20 MARKS**

## SECTION B

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

**15** In the reaction shown below, the aromatic compound 1,4-dimethylbenzene reacts with 2-bromobutane. The reaction is catalysed by aluminium chloride, $AlCl_3$, which dissolves in the reaction mixture.




1,4-dimethylbenzene

(a) (i) Name the type of reaction and the mechanism.

**(1)**

.....

(ii) Write the equation to show how the attacking species forms and give the mechanism for the reaction.

**(4)**

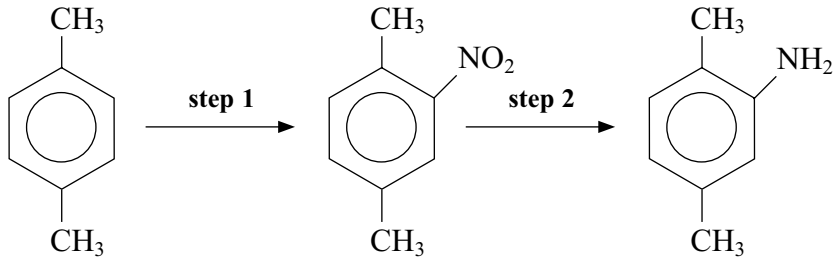
**Equation**

**Mechanism**

(b) The same reaction can also be carried out using a heterogeneous graphite catalyst under similar conditions. Assuming both reactions have a similar rate and yield, suggest one advantage of using the solid graphite catalyst instead of aluminium chloride. Justify your answer.

**(2)**

(c) A student proposed to synthesise the compound 2,5-dimethylphenylamine, used in the manufacture of dyes, following the scheme below.




1,4-dimethylbenzene 2,5-dimethylphenylamine

(i) What two reagents are needed for **step 1**?

**(2)**

(ii) Suggest why 1,4-dimethylbenzene is more reactive than benzene in reactions such as **step 1**.

**(2)**

(iii) What type of reaction occurs in **step 2**?

**(1)**

.....

*(iv) 2,5-dimethylphenylamine can be used to make azo-dyes. State the reagents and conditions needed to make an azo-dye from 2,5-dimethylphenylamine and phenol. Include equations for the organic reactions.

**(5)**

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**(Total for Question 15 = 17 marks)**

**16** The leaves of the rhubarb plant contain ethanedioic acid, $(COOH)_2$, a toxic white soluble solid. The acid is readily oxidized by potassium manganate(VII) under acidic conditions. A sample of 250 g of rhubarb leaves was finely chopped then soaked in warm water to release any ethanedioic acid present. The mixture was then filtered and made up to a volume of 500 $cm^3$ using distilled water. 10.0 $cm^3$ of the solution was then titrated with 0.0100 mol $dm^{-3}$ acidified potassium manganate(VII) solution from a burette, requiring 11.30 $cm^3$ to completely oxidize the sample.

(a) (i) Write the half equation for the oxidation of ethanedioic acid to form carbon dioxide, and the half equation for the reduction of manganate(VII) ions, $MnO_4^-$, in acidic solution to form manganese(II) ions. State symbols are **not** required.

**(2)**

(ii) Use your answers to (a)(i) to write the overall equation for the reaction, showing that the ratio of ethanedioic acid to manganate(VII) ions in the full equation is 5 : 2. State symbols are **not** required.

**(1)**

*(iii) Calculate the % by mass of the ethanedioic acid present in the leaves, giving your final answer to **two** decimal places.

**(5)**

(iv) What is the level of accuracy of a burette in each reading? Use your answer to calculate the percentage error in the titre volume of 11.30 $cm^3$.

**(2)**

(v) Suggest **two** reasons, other than the accuracy of the equipment used for measurements, why the results obtained in this experiment may be considered unreliable.

**(2)**

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(vi) A student risk assessment for this experiment suggested wearing gloves, but a supervisor said that this was unnecessary. Why do you think this precaution was suggested by the student and why was it rejected by the supervisor?

**(2)**

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(vii) An aqueous solution of $MnO_4^-$ ions contained a small amount of chloride ions, $Cl^-$, as an impurity. Use this fact, and items 70 and 85 from page 16 of the data booklet, to suggest why this solution went cloudy after a time.

**(2)**

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(b) An aqueous solution containing $Mn^{2+}$ ions is pale pink in colour due to the presence of the complex ion $[Mn(H_2O)_6]^{2+}(aq)$.

(i) Complete the electronic configuration of the $Mn^{2+}$ ion.

**(1)**

$1s^2$ .....

(ii) What shape would you expect this complex ion to be?

**(1)**

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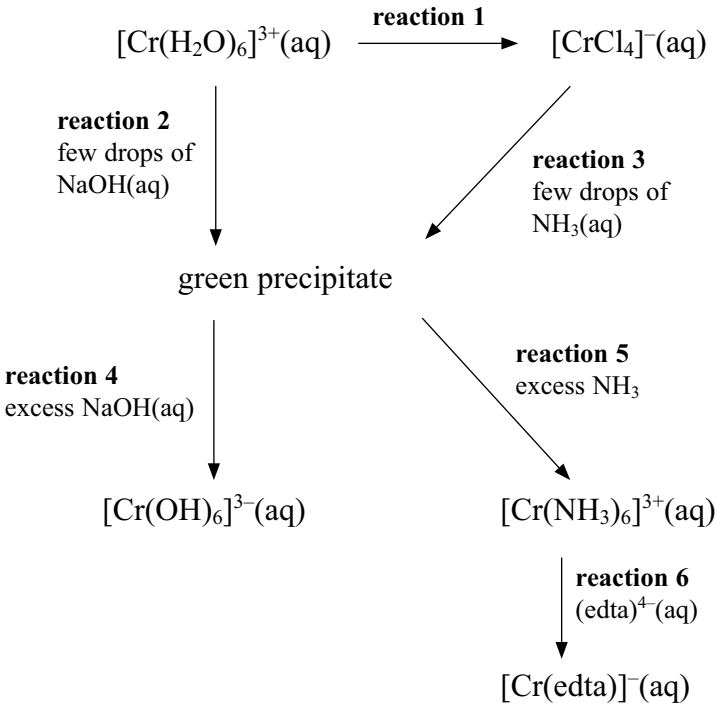
**(Total for Question 16 = 18 marks)**

**17** The reaction scheme below summarises some of the reactions of chromium ions in aqueous solution. Look carefully at the scheme and answer the questions that follow.




(a) (i) Explain why the $[Cr(H_2O)_6]^{3+}$ ion is coloured.

**(3)**

(ii) Suggest what reagent is needed for **reaction 1** and identify the type of reaction.

**(2)**

(b) (i) $[Cr(H_2O)_6]^{3+}$ ions react with water to form an acidic solution. Complete the equation for this reaction.

**(2)**

$[Cr(H_2O)_6]^{3+}(aq) + H_2O(l) \rightleftharpoons$ ..... + .....

(ii) The pH of an aqueous solution of $[Cu(H_2O)_6]^{2+}$ is higher than that of an aqueous solution of $[Cr(H_2O)_6]^{3+}$ of the same concentration. Suggest why this is so.

**(2)**

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(c) Give the formula of the green precipitate formed in **reactions 2 and 3**.

**(1)**

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(d) By considering the nature of the reactants in **reaction 4**, explain why the green precipitate reacts as shown in the scheme. Suggest how you could reverse **reaction 4**.

**(3)**

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(e) Write the equation for **reaction 6** and use this to explain, in terms of the entropy change, why the complex $[Cr(edta)]^-$ is relatively more stable than $[Cr(NH_3)_6]^{3+}$.

**(2)**

**Equation**

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**(Total for Question 17 = 15 marks)**

**TOTAL FOR SECTION B = 50 MARKS**

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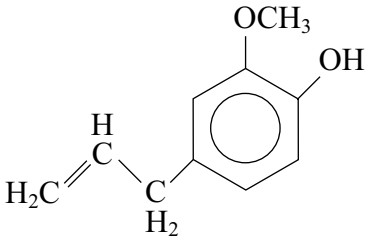
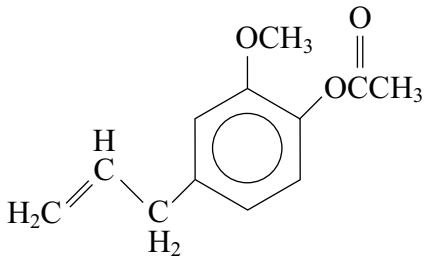
## SECTION C

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

**18** Eugenol, a pale yellow oil, and eugenol ethanoate are phenol-derived compounds found in the evergreen clove tree *Eugenia aromaticum*.




Eugenol



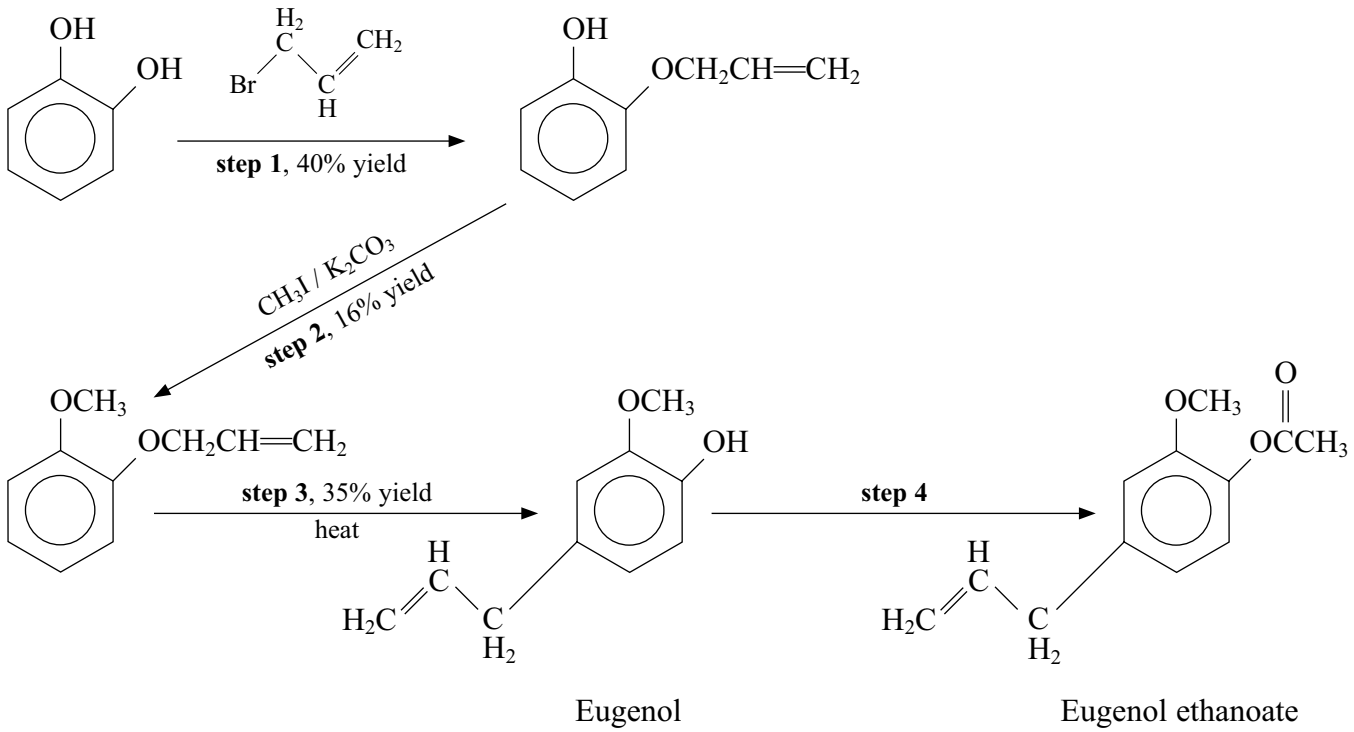

Eugenol ethanoate

Eugenol is used in perfumes, the manufacture of food flavourings and as a local anaesthetic. Eugenol ethanoate is mainly used in perfumes and aftershaves. Although used for many years, both compounds are classified as harmful and have been tested to determine their toxicity by ingestion. However, humans would need to consume very large amounts to reach toxic levels.

The compounds are the main constituents of clove oil which can be extracted from the dried buds of *Eugenia aromaticum's* flowers. Traditionally the oil is extracted by steam distillation, though a greater yield of oil can be obtained using a Soxhlet extractor to pass a chlorinated solvent through the dried buds several times to dissolve the clove oil. An alternative technique uses carbon dioxide as a solvent. Above a temperature of 304 K and a high pressure of 73.8 atm, carbon dioxide behaves as a supercritical fluid and when passed through the clove buds, it dissolves the clove oil. Releasing the pressure causes the carbon dioxide to turn back into a gas, leaving the clove oil behind. A summary of the characteristics of the clove oil obtained by the three extraction techniques is shown in the table below.

| Extraction method | Mass of oil per 100 g of dried buds / g | % eugenol and eugenol ethanoate in the oil produced | Extraction time / h | Colour and texture | Use of organic solvent |
|---|---|---|---|---|---|
| Supercritical carbon dioxide | 19.6 | 78.4 | 2 | pale yellow oil | no |
| Steam distillation | 11.5 | 53.5 | 4–6 | brown-yellow oil | yes |
| Soxhlet extraction | 41.8 | 40.1 | 6 | brown paste | yes |

Both molecules can also be manufactured synthetically in the laboratory. A reaction scheme for synthesising both molecules is summarised below.




Eugenol Eugenol ethanoate

(a) (i) 0.328 g of eugenol produced synthetically was burnt completely in excess oxygen, producing 0.880 g of carbon dioxide and 0.216 g of water. Use these data to show they are consistent with the molecular formula of eugenol.

**(4)**

(ii) Describe a chemical test you could carry out to confirm the presence of a carbon-carbon double bond in the product of **step 1**. What would you expect to see?

**(2)**

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(iii) What technique would you use to heat the reactants in **step 3** to minimise the loss of any volatile material?

**(1)**

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(iv) Suggest what reagent(s) could be used in **step 4**.

**(1)**

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(b) (i) Draw and label the apparatus suitable for extracting clove oil from clove buds by steam distillation in the laboratory.

**(3)**

(ii) The distillate formed is a mixture of water and clove oil with a significant amount of oil dissolved in the water. Outline the steps that have to be taken to obtain the dry oil.

**(3)**

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(c) Toxicity data for substances such as eugenol are generally obtained by tests on animals such as rats and guinea pigs. In the case of eugenol, do you think such tests are reasonable? Briefly justify your answer.

**(1)**

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*(d) Evaluate the three extraction methods for obtaining clove oil using information from the table. Give **one** reason why the synthetic route of obtaining eugenol, shown on page 20, is less preferable than extraction from clove buds.

**(5)**

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**(Total for Question 18 = 20 marks)**

**TOTAL FOR SECTION C = 20 MARKS**
**TOTAL FOR PAPER = 90 MARKS**

# The Periodic Table of Elements

| 1 | 2 | | | | | | | | | | | 3 | 4 | 5 | 6 | 7 | 0 (8) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | | | | (18) |
| | | | | | | | 1.0 H hydrogen 1 | | | | | | | | | | 4.0 He helium 2 |
| (1) | (2) | | Key | | | | | | | | | (13) | (14) | (15) | (16) | (17) | |
| 6.9 Li lithium 3 | 9.0 Be beryllium 4 | | relative atomic mass<br>**atomic symbol**<br>name<br>atomic (proton) number | | | | | | | | | 10.8 B boron 5 | 12.0 C carbon 6 | 14.0 N nitrogen 7 | 16.0 O oxygen 8 | 19.0 F fluorine 9 | 20.2 Ne neon 10 |
| 23.0 Na sodium 11 | 24.3 Mg magnesium 12 | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | 27.0 Al aluminium 13 | 28.1 Si silicon 14 | 31.0 P phosphorus 15 | 32.1 S sulfur 16 | 35.5 Cl chlorine 17 | 39.9 Ar argon 18 |
| 39.1 K potassium 19 | 40.1 Ca calcium 20 | 45.0 Sc scandium 21 | 47.9 Ti titanium 22 | 50.9 V vanadium 23 | 52.0 Cr chromium 24 | 54.9 Mn manganese 25 | 55.8 Fe iron 26 | 58.9 Co cobalt 27 | 58.7 Ni nickel 28 | 63.5 Cu copper 29 | 65.4 Zn zinc 30 | 69.7 Ga gallium 31 | 72.6 Ge germanium 32 | 74.9 As arsenic 33 | 79.0 Se selenium 34 | 79.9 Br bromine 35 | 83.8 Kr krypton 36 |
| 85.5 Rb rubidium 37 | 87.6 Sr strontium 38 | 88.9 Y yttrium 39 | 91.2 Zr zirconium 40 | 92.9 Nb niobium 41 | 95.9 Mo molybdenum 42 | [98] Tc technetium 43 | 101.1 Ru ruthenium 44 | 102.9 Rh rhodium 45 | 106.4 Pd palladium 46 | 107.9 Ag silver 47 | 112.4 Cd cadmium 48 | 114.8 In indium 49 | 118.7 Sn tin 50 | 121.8 Sb antimony 51 | 127.6 Te tellurium 52 | 126.9 I iodine 53 | 131.3 Xe xenon 54 |
| 132.9 Cs caesium 55 | 137.3 Ba barium 56 | 138.9 La* lanthanum 57 | 178.5 Hf hafnium 72 | 180.9 Ta tantalum 73 | 183.8 W tungsten 74 | 186.2 Re rhenium 75 | 190.2 Os osmium 76 | 192.2 Ir iridium 77 | 195.1 Pt platinum 78 | 197.0 Au gold 79 | 200.6 Hg mercury 80 | 204.4 Tl thallium 81 | 207.2 Pb lead 82 | 209.0 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 | [261] Rf rutherfordium 104 | [262] Db dubnium 105 | [266] Sg seaborgium 106 | [264] Bh bohrium 107 | [277] Hs hassium 108 | [268] Mt meitnerium 109 | [271] Ds darmstadtium 110 | [272] Rg roentgenium 111 | | | | | | | |

Elements with atomic numbers 112-116 have been reported but not fully authenticated

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

* Lanthanide series

* Actinide series