Write your name here

Surname	Other names

Edexcel GCE

Centre Number	Candidate Number

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/

N 3 7 9 5 4 A 0 1 2 4

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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)

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)

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**

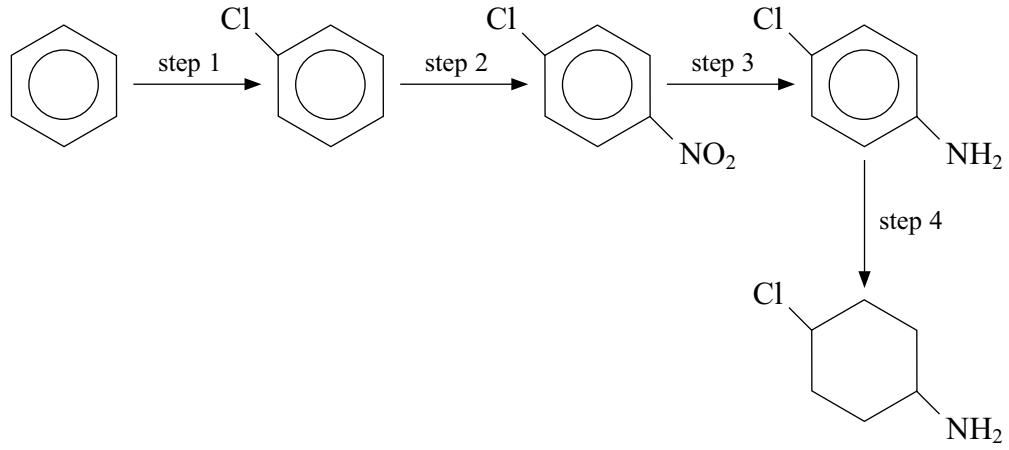
☒ **B**

☒ **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?

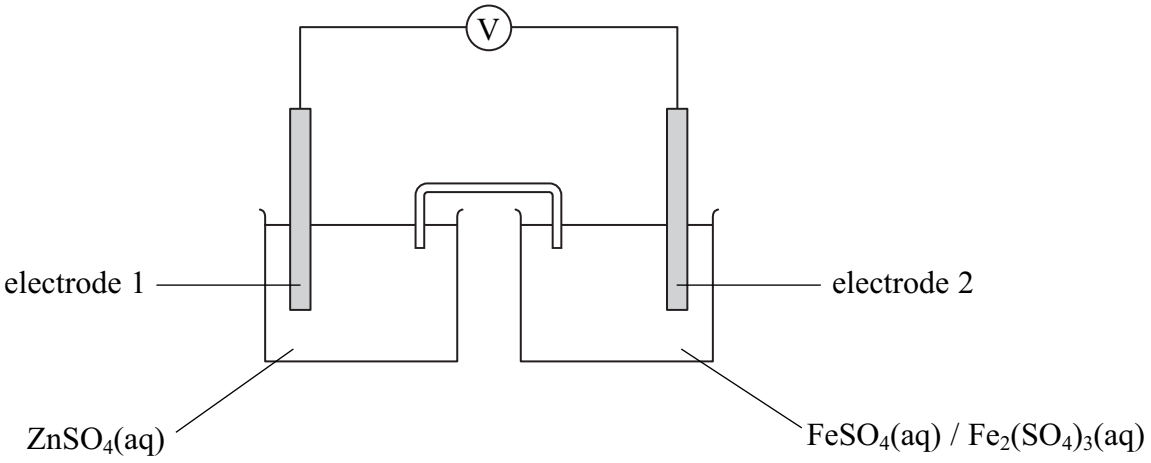
(1)

- ☒ **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

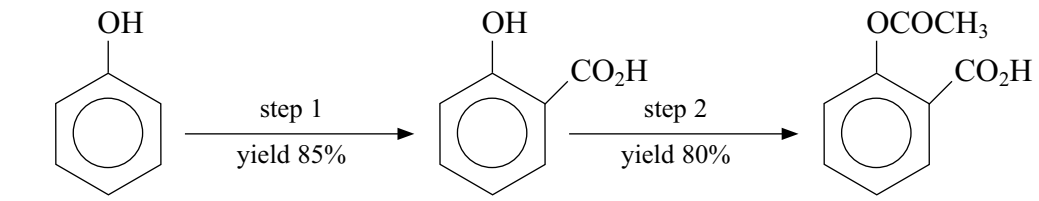
☒ **B** Reaction 2

☒ **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

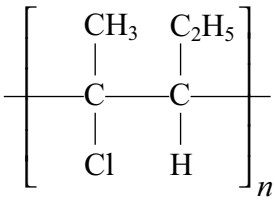
☒ **B** 61.20 g

☒ **C** 74.25 g

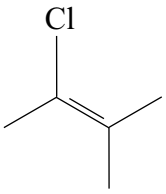
☒ **D** 90.00 g

(Total for Question 13 = 1 mark)

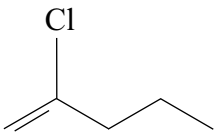
14 Which of the monomers **A to D** would form the polymer below?



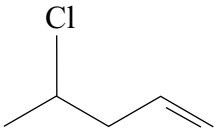
☒ **A**



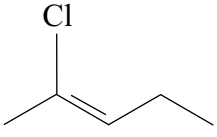
☒ **B**



☒ **C**



☒ **D**



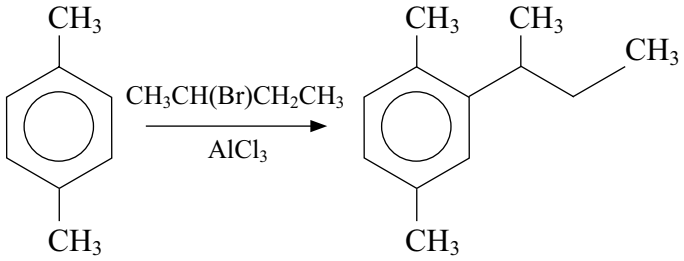
(Total for Question 14 = 1 mark)

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)

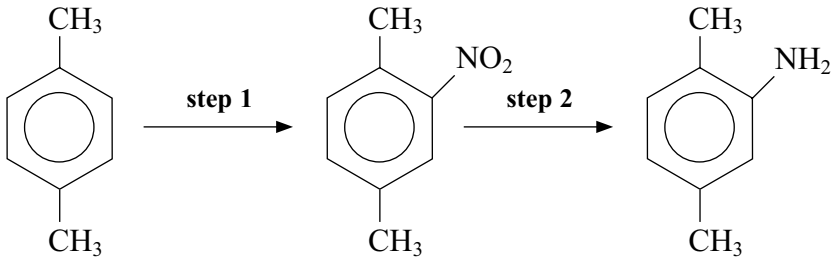
Equation

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)

(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)

(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)

(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)

$1s^2$ .....

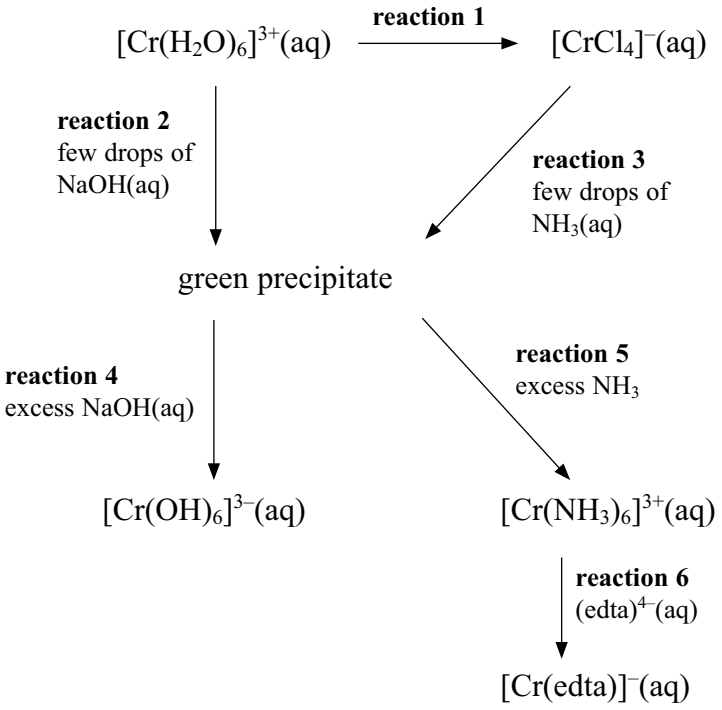
(ii) What shape would you expect this complex ion to be?

(1)

.....

(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)

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.....

(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)

.....

(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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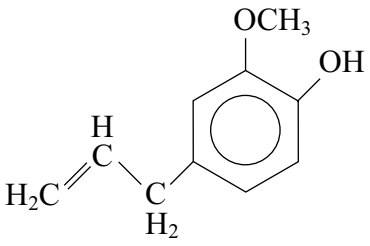
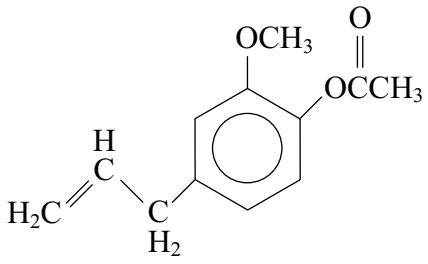
SECTION C

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



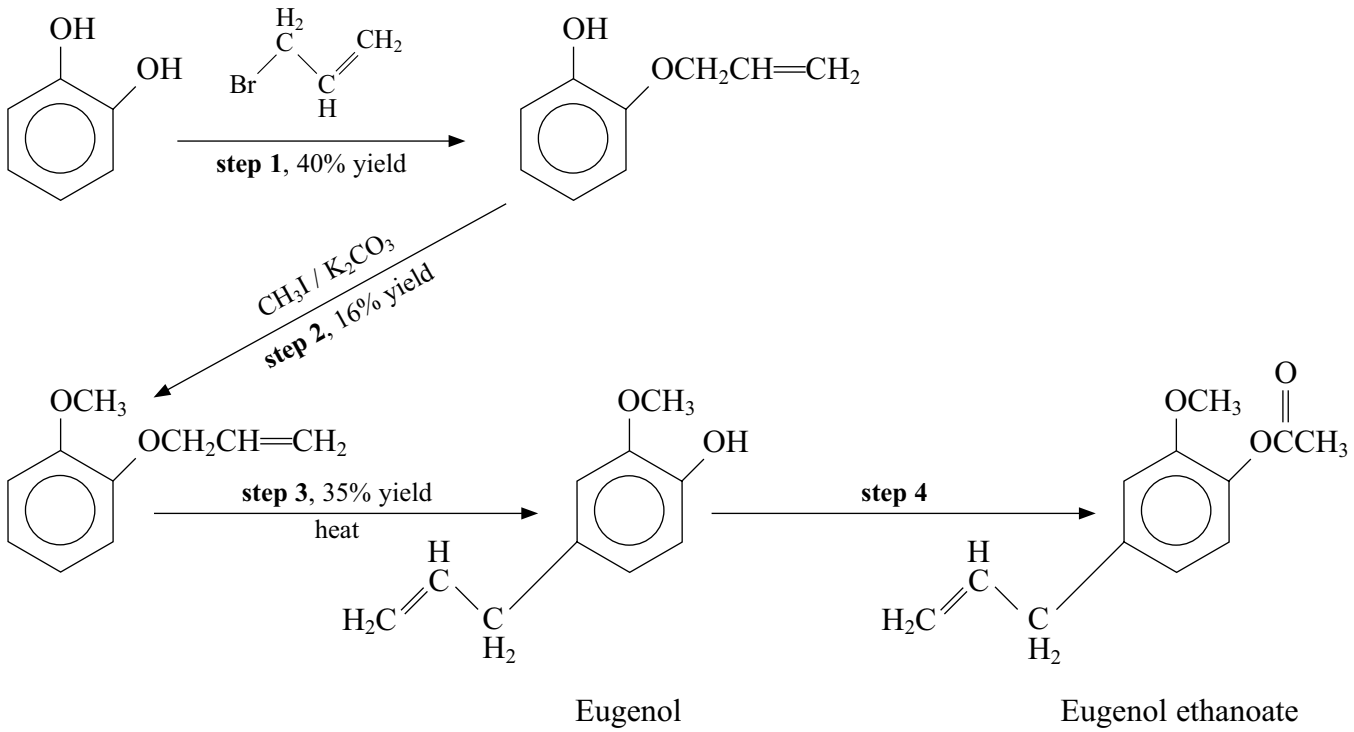
Eugenol ethanoate

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)

.....

.....

.....

.....

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

(1)

.....

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

(1)

.....

.....

(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)

(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)

*(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)

(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)											(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4											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							

Key

relative atomic mass
atomic symbol
name
atomic (proton) number

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