Write your name here

Surname	Other names

Pearson Edexcel GCE

Centre Number	Candidate Number

Chemistry

Advanced Subsidiary
Unit 2: Application of Core Principles of Chemistry

Tuesday 3 June 2014 – Afternoon
Time: 1 hour 30 minutes

Paper Reference
6CH02/01R

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 80.
- 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 ▶

P42991A

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6/6/6/6/

P 4 2 9 9 1 A 0 1 2 4

PEARSON

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 This question concerns the shapes of the hydrides of Group 5 elements.

(a) What is the approximate H—N—H bond angle in the ammonium ion, NH_4^+?

(1)

☒ **A** 90°

☒ **B** 104.5°

☒ **C** 107°

☒ **D** 109.5°

(b) Suggest the shape of the phosphine molecule, PH_3.

(1)

☒ **A** Trigonal planar

☒ **B** Trigonal pyramidal

☒ **C** Trigonal bipyramidal

☒ **D** Octahedral

(Total for Question 1 = 2 marks)

2 Graphite has a structure containing layers of carbon atoms in hexagonal rings.
Why is graphite a good conductor of electricity?

☒ **A** It has delocalized ions which can move and carry charge.

☒ **B** It has delocalized electrons which are mobile.

☒ **C** There are only weak London forces between the layers.

☒ **D** Each carbon atom in the layers has only three covalent bonds.

(Total for Question 2 = 1 mark)

3 The following system was allowed to reach equilibrium at 300 °C.

$$\underset{\text{Colourless}}{2HI(g)} \rightleftharpoons \underset{\text{Colourless}}{H_2(g)} + \underset{\text{Purple}}{I_2(g)} \qquad \Delta H = -53.0 \text{ kJ mol}^{-1}$$

(a) What would you see if the equilibrium mixture was cooled to 250 °C?

(1)

☒ **A** No visible change.

☒ **B** The colour gets lighter.

☒ **C** The mixture turns colourless.

☒ **D** The mixture goes a darker purple.

(b) The equilibrium mixture at 300 °C was compressed in a gas syringe to occupy a smaller volume. What would be seen immediately?

(1)

☒ **A** No visible change.

☒ **B** The colour gets lighter.

☒ **C** The mixture turns colourless.

☒ **D** The mixture goes a darker purple.

(Total for Question 3 = 2 marks)

4 A solution of iodine in aqueous potassium iodide is brown. The following equilibrium exists in this solution.

$$\underset{\text{Brown}}{I_2(aq)} + H_2O(l) \rightleftharpoons \underbrace{IO^-(aq) + I^-(aq) + 2H^+(aq)}_{\text{Colourless}}$$

What would be the effect, if any, on the colour of the solution if five drops of dilute sodium hydroxide solution were added to 5 cm^3 of the iodine solution?

☒ **A** No visible change.

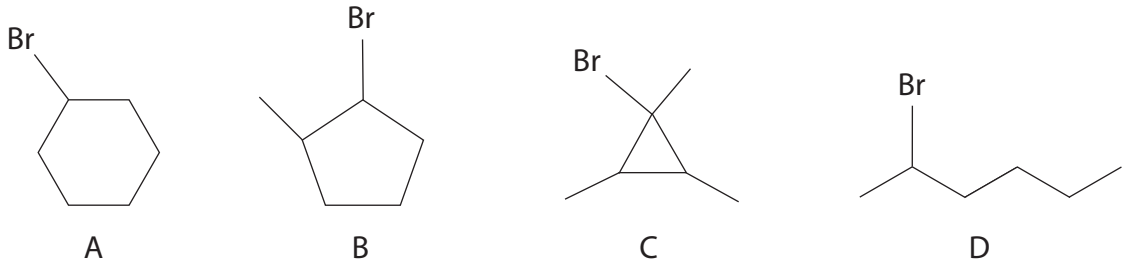
☒ **B** The colour gets lighter.

☒ **C** The mixture turns colourless.

☒ **D** The mixture goes a darker colour.

(Total for Question 4 = 1 mark)

5 The skeletal formulae of some 6-carbon bromoalkanes are shown below.



A B C D

(a) Which of the above bromoalkanes is **not** a structural isomer of the others?

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(b) Which of the above is **not** a secondary bromoalkane?

(1)

☒ **A**

☒ **B**

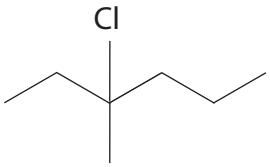
☒ **C**

☒ **D**

(Total for Question 5 = 2 marks)

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

6

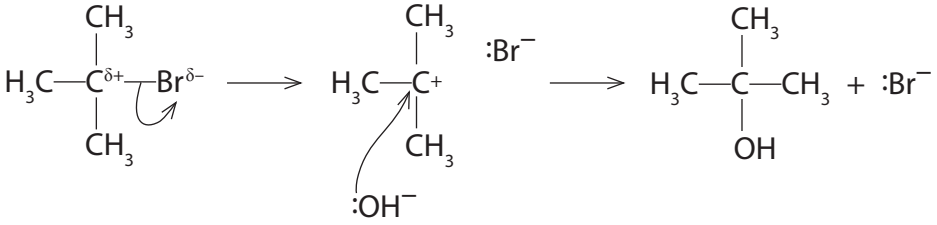


The molecule shown above is 3-chloro-3-methylhexane. It reacts with hot, alcoholic potassium hydroxide to produce a number of different alkenes. This reaction can be classified as

- ☒ **A** elimination.
- ☒ **B** oxidation.
- ☒ **C** reduction.
- ☒ **D** substitution.

(Total for Question 6 = 1 mark)

7 A reaction mechanism is shown below.



The hydroxide ion is acting as

- ☒ **A** an electrophile.
- ☒ **B** a catalyst.
- ☒ **C** a free radical.
- ☒ **D** a nucleophile.

(Total for Question 7 = 1 mark)

8 Which of the following reagents gives a **positive** result with a tertiary alcohol?

- ☒ **A** Acidified potassium dichromate(VI) solution
- ☒ **B** Phosphorus(V) chloride
- ☒ **C** Dilute sulfuric acid
- ☒ **D** Bromine water

(Total for Question 8 = 1 mark)

9 What effect does infrared radiation have on the covalent bonds in water molecules in the atmosphere?

- ☒ **A** They are broken to form free radicals.
- ☒ **B** They are broken into ions.
- ☒ **C** The bonds vibrate more vigorously.
- ☒ **D** There is no effect on the bonds.

(Total for Question 9 = 1 mark)

10 Alkanes are now being used as aerosol propellants as an alternative to CFCs. Although they have no effect on the ozone layer, they have the disadvantage of

- ☒ **A** having high reactivity.
- ☒ **B** being hard to evaporate.
- ☒ **C** being greenhouse gases.
- ☒ **D** having an unpleasant smell.

(Total for Question 10 = 1 mark)

11 One definition of the term 'carbon footprint' is

'the amount of carbon dioxide produced when a fuel is burned.'

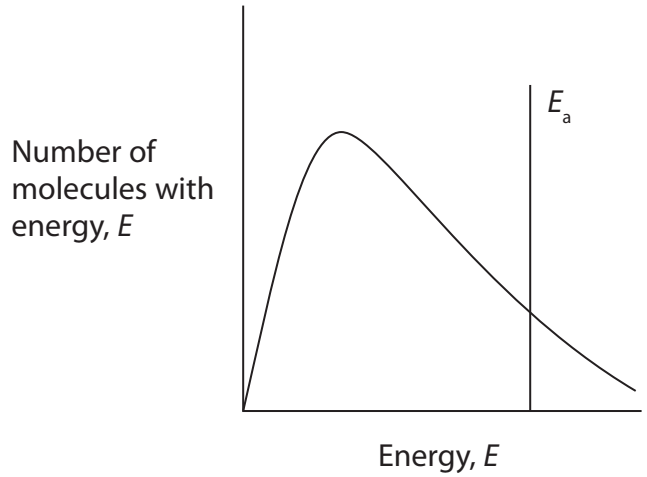
Fuel	Energy density / MJ l^{-1}	CO_2 produced on combustion / g l^{-1}
Paraffin	46	2580

Given the information above, what is the carbon footprint for paraffin in terms of grams of CO_2 produced per MJ of energy?

- ☒ **A** 46
- ☒ **B** 56.09
- ☒ **C** 2580
- ☒ **D** 118 680

(Total for Question 11 = 1 mark)

12 The diagram below shows the Maxwell-Boltzmann distribution of molecular energies for a catalysed reaction.



(a) If the temperature were **lowered**, what would be the effect on the shape of the curve?

(1)

☒ **A** The peak would shift to the left and be higher.

☒ **B** The peak would shift to the left and be lower.

☒ **C** The peak would shift to the right and be higher.

☒ **D** The peak would shift to the right and be lower.

(b) Which of the following would shift the activation energy line to the right?

(1)

☒ **A** An increase in reactant concentration.

☒ **B** The removal of the product.

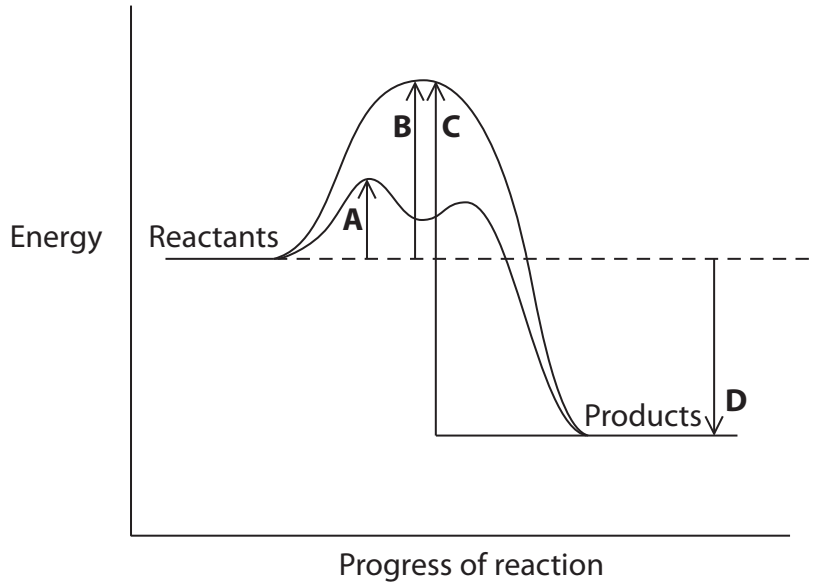
☒ **C** The removal of the catalyst.

☒ **D** The use of smaller particles with a larger surface area.

(Total for Question 12 = 2 marks)

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

13 Which of the arrows, **A**, **B**, **C**, **D**, indicates the activation energy for a **catalysed** reaction on the reaction profile shown?



☒ **A**

☒ **B**

☒ **C**

☒ **D**

(Total for Question 13 = 1 mark)

14 Which of the following molecules is polar?

☒ **A** CO_2

☒ **B** SO_2

☒ **C** SO_3

☒ **D** O_2

(Total for Question 14 = 1 mark)

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

15 Although they have the same relative molecular mass, the boiling temperatures of hexane (69 °C) and 2,2-dimethylbutane (49 °C) are significantly different. The reason for this is that

☒ **A** the intermolecular forces are stronger between hexane molecules because it has more electrons.

☒ **B** there are significantly stronger permanent dipole forces between hexane molecules.

☒ **C** the covalent bonds in hexane are stronger and so it requires more energy to break them.

☒ **D** the molecular shape of hexane molecules allows them to form stronger London forces.

(Total for Question 15 = 1 mark)

16 Which of the following reactions is the most likely to occur with chlorine in hot, concentrated sodium hydroxide solution?

☒ **A** $Cl_2 + 2NaOH \rightarrow NaCl + NaClO + H_2O$

☒ **B** $2Cl_2 + 4NaOH \rightarrow 3NaCl + NaClO_2 + 2H_2O$

☒ **C** $3Cl_2 + 6NaOH \rightarrow 5NaCl + NaClO_3 + 3H_2O$

☒ **D** $4Cl_2 + 8NaOH \rightarrow 7NaCl + NaClO_4 + 4H_2O$

(Total for Question 16 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS

SECTION B

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

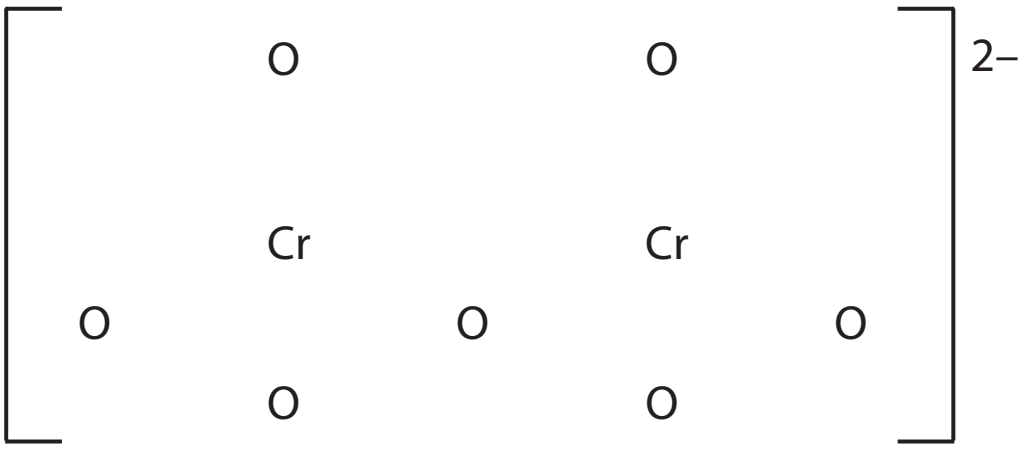
17 Potassium dichromate(VI), $K_2Cr_2O_7$, can be used to accurately determine the concentration of other chemicals, such as sodium thiosulfate, $Na_2S_2O_3$.

(a) The dichromate(VI) ion has two chromium atoms sharing one oxygen to give two tetrahedral units. Each chromium atom uses six electrons in bonding and expands its outer shell to accommodate a total of 12 electrons.

Complete the dot and cross diagram for this ion below. Only show outer shell electrons.

Use **x** for chromium electrons and • for oxygen electrons. Use the symbol * to represent the extra electrons which give the ion its charge.

(3)



(b) Four chemistry students were given a solution of sodium thiosulfate with a concentration of **approximately** 0.1 mol dm^{-3} and asked to determine its **exact** concentration using potassium dichromate(VI) solution. They were each given separate tasks to carry out as described below.

(i) The first student was given the task of making up a potassium dichromate(VI) solution. A mass of 14.71 g of $K_2Cr_2O_7$ was weighed out, dissolved in deionized water, the volume made up to 250 cm^3 in a volumetric flask and the mixture shaken.

Calculate the concentration of this potassium dichromate(VI) solution, in mol dm^{-3}.

Use the Periodic Table as a source of data.

(2)

(ii) The second student was asked to calculate the mass of potassium iodide that would be required to add to 0.00250 mol of potassium dichromate(VI) to ensure complete reaction. The equation for the reaction is

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

Calculate the minimum mass of potassium iodide, KI, required and hence suggest a suitable mass to use if the potassium iodide is to be in excess.

You **must** show your working and your mass should be reasonable.

(2)

Minimum mass required ..... g

Suitable mass to use ..... g

(iii) The third student was given the following equation.

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

This student was asked to estimate the titration reading at the end-point if a solution that contained 0.00260 mol of iodine was in the conical flask and the concentration of sodium thiosulfate was about 0.16 mol dm^{-3}.

Calculate the volume of sodium thiosulfate solution, in cm^3, that would have been added at the end-point of the titration.

(2)

*(iv) The fourth student was given the following experimental information.

0.1 g of potassium dichromate(VI) was dissolved in a total volume of 25.00 cm^3. An excess of potassium iodide and acid was added and then used in a titration with the sodium thiosulfate solution of concentration approximately 0.1 mol dm^{-3}. The titre was 25.15 cm^3.

The student suggested that the greatest uncertainty in the result arose from the mass that was measured and that the procedure was unreliable.

Explain why these views were justified. No calculation is required.

(2)

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(c) (i) Acidified sodium dichromate(VI) solution is commonly used for the oxidation of alcohols. It is important not to use hydrochloric acid in this reagent mixture because the chloride ions are oxidized to chlorine.

Write the ionic half-equation for the oxidation of chloride ions. State symbols are not required.

(1)

(ii) Fumes of hydrogen chloride gas can be identified by bringing the fumes into contact with another gas, **X**. Identify gas **X** and state the observation you would make.

(2)

Gas **X** .....

Observation .....

(d) Potassium bromide can be distinguished from potassium chloride by its reaction with silver nitrate solution, followed by the addition of aqueous ammonia solution.

State what you would see on the addition of silver nitrate solution to potassium bromide solution.

How could both dilute and concentrated ammonia be used to confirm that silver bromide is formed, rather than silver chloride?

(3)

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(Total for Question 17 = 17 marks)

18 This is a question about Group 2 elements and their compounds.

*(a) Explain why the first ionization energy of calcium (590 kJ mol^{-1}) is greater than that of strontium (550 kJ mol^{-1}).

(2)

(b) (i) Describe how you would carry out a flame test on a sample of a Group 2 metal salt.

(2)

(ii) What result of the flame test would confirm the presence of a barium salt?

(1)

*(iii) Explain, in terms of electronic transitions, how the result of the flame test arises.

(3)

(c) Barium reacts with water to form a clear, colourless solution.

(i) Give the name or formula of the barium compound formed.

(1)

.....

(ii) State **another** observation that would be made when barium reacts with water.

(1)

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.....

(d) Barium reacts with chlorine gas to form barium chloride as shown in the equation below.

$$Ba(s) + Cl_2(g) \rightarrow BaCl_2(s)$$

(i) Use the changes in oxidation numbers to show that this is a redox reaction.

(2)

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(ii) Write the ionic equation for the reaction between barium chloride solution and dilute sulfuric acid. Include state symbols in the equation.

(2)

(iii) The reaction in (d)(ii) is used to test for sulfate ions.

Why is dilute hydrochloric acid added with the barium chloride solution in this test?

(1)

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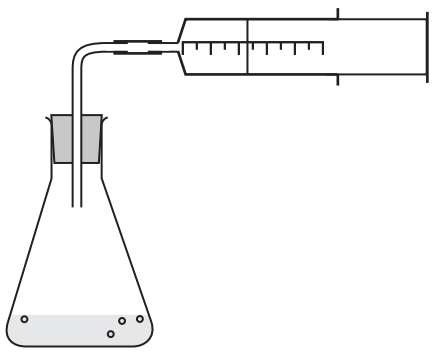
(e) Magnesium carbonate, $MgCO_3$, readily reacts with hydrochloric acid.

(i) Write the equation for this reaction. State symbols are not required.

(1)

*(ii) The rate of the reaction between powdered magnesium carbonate and dilute hydrochloric acid was monitored using the experimental apparatus shown below.



State two factors that would **decrease** the rate of this reaction, other than by changing the reaction temperature.

Explain how these two factors decrease the reaction rate.

(4)

Factor 1 .....

Explanation 1 .....

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Factor 2 .....

Explanation 2 .....

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(f) Suggest why pressure has little or no effect on the rate of the reaction of magnesium oxide and hydrochloric acid, the equation for which is given below.

$$MgO(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2O(l)$$

(1)

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(Total for Question 18 = 21 marks)

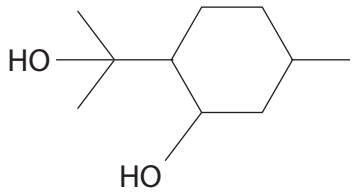
TOTAL FOR SECTION B = 38 MARKS

SECTION C

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

19 Insect-borne diseases, such as malaria, affect the lives of millions of people. Chemists are constantly finding new compounds to combat the transmission of these diseases. One such compound is the insect repellent commonly called *p*-menthane-3,8-diol (this is not its systematic name). It is used to protect both humans and animals.

The structure of *p*-menthane-3,8-diol is shown below.



p-menthane-3,8-diol is found naturally in the leaves of *Eucalyptus citriodora*, which is native to Australia and is commonly known as 'Lemon Bush'. It can be extracted from these leaves but is currently commercially prepared by chemical synthetic pathways. However, the commercially-made chemical has been found by some scientists to be less effective than the natural leaf extract.

It is possible that *p*-menthane-3,8-diol can kill microorganisms and it is this additional potential use and others which are being investigated by the chemical industry.

p-menthane-3,8-diol should not be confused with either methane or methanol.

(a) *p*-menthane-3,8-diol has two alcohol functional groups. Classify the type of alcohol group on the far left of the structure drawn above and explain the meaning of the term 'functional group'.

(2)

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(b) Give the molecular formula of *p*-menthane-3,8-diol.

(1)

.....

(c) *p*-menthane-3,8-diol is found in the oily extract from the leaves of the 'Lemon Bush'.

One method used to extract the oil is described below.

Initially, the leaves are ground up using a pestle and mortar with some sand and an organic solvent, such as cyclohexane.

(i) Suggest why sand is used.

(1)

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*(ii) The solvent cyclohexane forms intermolecular forces with other organic molecules when they dissolve.

Identify these intermolecular forces and explain how they arise.

(3)

Type of intermolecular force .....

How they arise .....

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.....

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(iii) How could the sand and other solid residue be removed from the mixture?

(1)

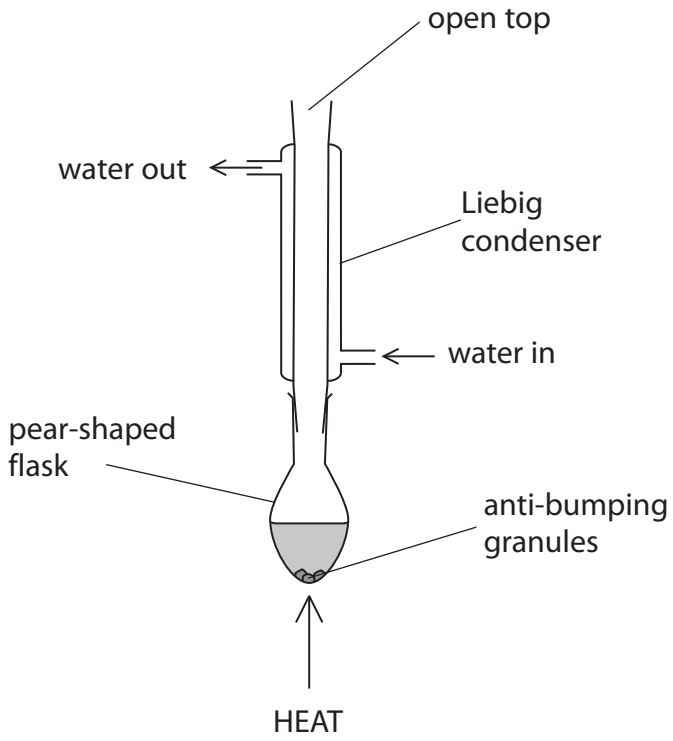
.....

(iv) At this stage, either anhydrous magnesium sulfate or calcium chloride is added. Suggest the reason for this.

(1)

.....

*(v) A student suggested using the following apparatus to remove the cyclohexane from the mixture.



Explain, in terms of the processes that occur in the above apparatus, why this method is unsuitable to remove the cyclohexane.

Suggest how this apparatus could be adjusted for a successful separation.

DATA

- Boiling temperatures: *p*-menthane-3,8-diol 266 °C; cyclohexane 81 °C

(4)

(d) Spectroscopic techniques can be used to confirm the presence and identity of organic molecules such as *p*-menthane-3,8-diol.

(i) Suggest how infrared spectroscopy could be used to confirm the presence of the functional group in a molecule such as *p*-menthane-3,8-diol.

(1)

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(ii) Suggest the identity of two fragment ions, with a *m/e* value of more than 13 but less than 20, that could be observed in a mass spectrum of *p*-menthane-3,8-diol.

(2)

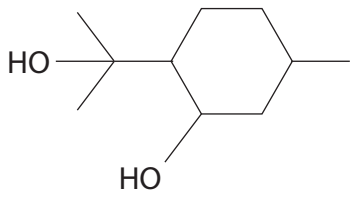
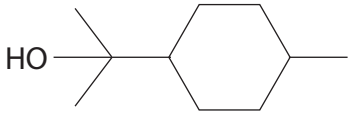
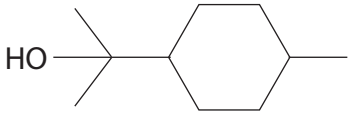
First fragment ion .....

Second fragment ion .....

(e) One reason why the synthetic *p*-menthane-3,8-diol may be less effective than the natural extract is because there are many isomers of this molecule.

Complete the structures below to show two structural isomers of *p*-menthane-3,8-diol which have the same number of alcohol functional groups and the same carbon skeleton.

(2)

p-menthane-3,8-diol		
		

*(f) State two key principles of sustainability, and how the chemical industry might achieve these, when mass-producing a molecule such as *p*-menthane-3,8-diol.

(4)

Principle 1 .....

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.....

Principle 2 .....

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(Total for Question 19 = 22 marks)

TOTAL FOR SECTION C = 22 MARKS
TOTAL FOR PAPER = 80 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 atomic symbol name 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

* Lanthanide series	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
* Actinide series	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

P 4 2 9 9 1 A 0 2 4 2 2 4

PMT