Write your name here

Surname	Other names

Pearson Edexcel
International
Advanced Level

Centre Number | | | | | |

Candidate Number | | | | |

Chemistry

Advanced Subsidiary
Unit 2: Application of Core Principles of Chemistry

Wednesday 26 October 2016 – Morning
Time: 1 hour 30 minutes

Paper Reference
WCH02/01

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 ▶

P50706A

6/6/6/5/2/

P 5 0 7 0 6 A 0 1 2 8

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 What are the shapes of the BF_3 and PH_3 molecules?

	BF_3	PH_3
☒ **A**	pyramidal	pyramidal
☒ **B**	pyramidal	trigonal planar
☒ **C**	trigonal planar	pyramidal
☒ **D**	trigonal planar	trigonal planar

(Total for Question 1 = 1 mark)

2 What are the C—C—C bond angles in diamond and graphite?

	Diamond	Graphite
☒ **A**	109.5°	109.5°
☒ **B**	109.5°	120°
☒ **C**	120°	109.5°
☒ **D**	120°	120°

(Total for Question 2 = 1 mark)

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

3 Which describes the polarity of the C—Cl bond and the polarity of the molecule trichloromethane, $CHCl_3$?

	Polarity of C—Cl bond	Polarity of molecule
☒ **A**	non-polar	non-polar
☒ **B**	non-polar	polar
☒ **C**	polar	non-polar
☒ **D**	polar	polar

(Total for Question 3 = 1 mark)

4 Which isomer, with the formula C_7H_{16}, will have the **lowest** boiling temperature?

☒ **A** $CH_3CH_2CH_2CH_2CH_2CH_2CH_3$

☒ **B** $(CH_3)_2CHCH_2CH_2CH_2CH_3$

☒ **C** $CH_3CH_2C(CH_3)_2CH_2CH_3$

☒ **D** $(CH_3)_2CHC(CH_3)_3$

(Total for Question 4 = 1 mark)

5 Which is a disproportionation reaction?

☒ **A** $CaCO_3 \rightarrow CaO + CO_2$

☒ **B** $2H_2O_2 \rightarrow 2H_2O + O_2$

☒ **C** $2H_2S + 3O_2 \rightarrow 2SO_2 + 2H_2O$

☒ **D** $Mg(OH)_2 \rightarrow MgO + H_2O$

(Total for Question 5 = 1 mark)

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

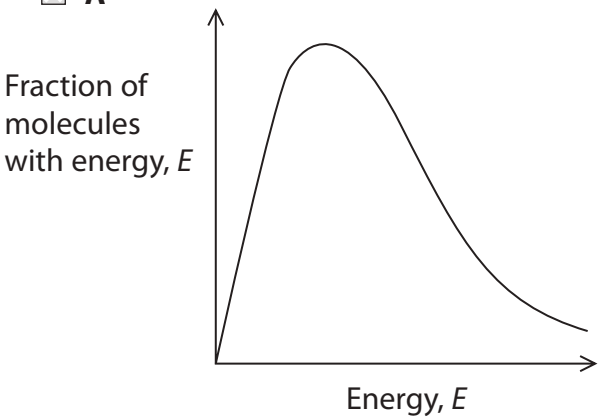
6 Which shows the trend in solubility of the hydroxides and sulfates of the Group 2 elements going **up** the group from barium to magnesium?

	Solubility of Group 2 hydroxides	Solubility of Group 2 sulfates
☒ **A**	decreases	decreases
☒ **B**	decreases	increases
☒ **C**	increases	decreases
☒ **D**	increases	increases

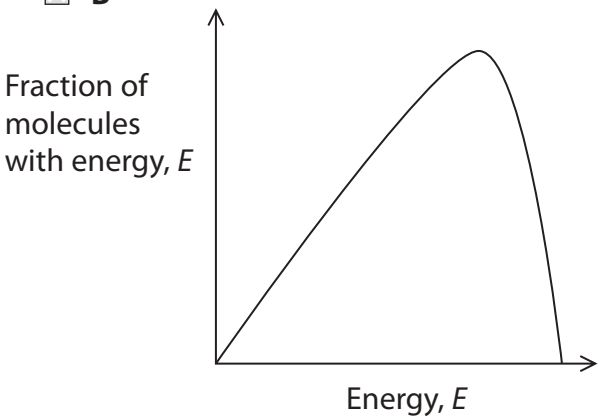
(Total for Question 6 = 1 mark)

7 Which diagram shows a Maxwell-Boltzmann distribution of molecular energies?

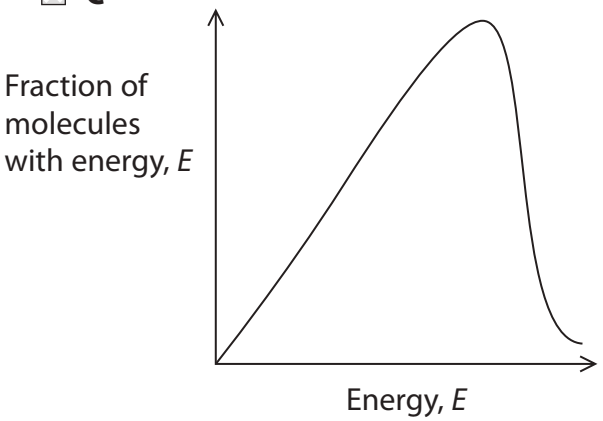
☒ **A**



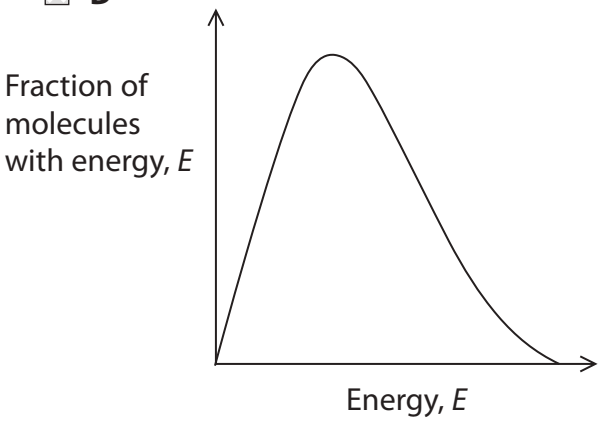
☒ **B**



☒ **C**



☒ **D**



(Total for Question 7 = 1 mark)

8 The rate of the reaction between sodium thiosulfate solution and dilute hydrochloric acid increases as the concentration of sodium thiosulfate increases.

Which of these occurs when the concentration of the sodium thiosulfate solution increases at constant temperature?

	Activation energy	Particles
☒ **A**	decreases	collide more frequently
☒ **B**	decreases	collide with more energy
☒ **C**	stays the same	collide more frequently
☒ **D**	stays the same	collide with more energy

(Total for Question 8 = 1 mark)

9 Consider the following exothermic reaction.

$$A(s) + B(aq) \rightarrow C(aq) + D(g)$$

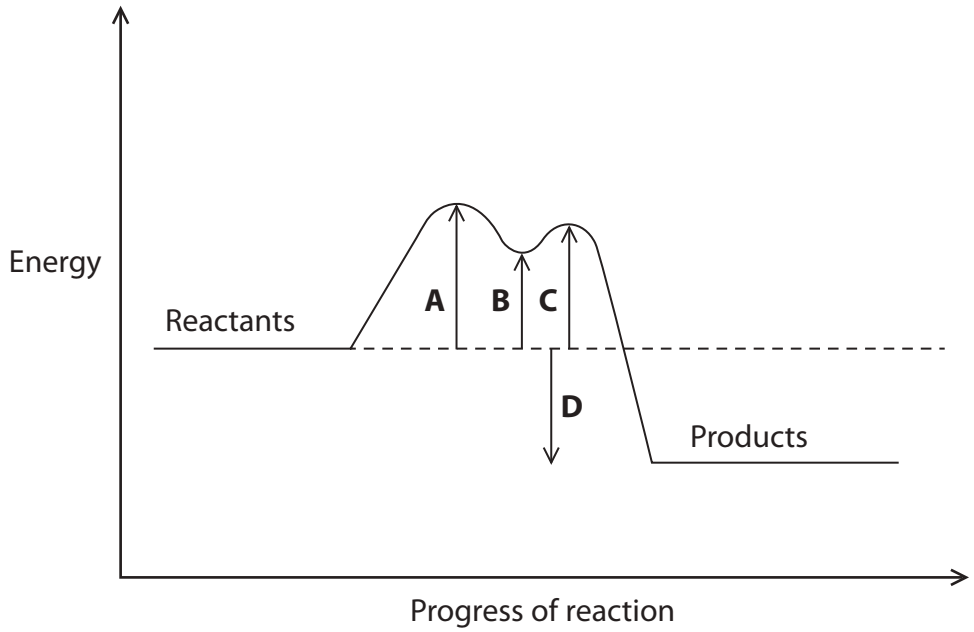
If the mass of A, and the volume and concentration of the solution of B are constant, which of these changes in conditions will result in the fastest initial rate?

	Size of solid particles of A	Temperature
☒ **A**	doubled	decreased by 10 °C
☒ **B**	doubled	increased by 10 °C
☒ **C**	halved	decreased by 10 °C
☒ **D**	halved	increased by 10 °C

(Total for Question 9 = 1 mark)

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

10 The reaction profile for an exothermic catalysed reaction is shown.



Which arrow represents the activation energy for this reaction?

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(Total for Question 10 = 1 mark)

11 An aqueous solution contains dichromate(VI) ions, $Cr_2O_7^{2-}$, and chromate(VI) ions, CrO_4^{2-}, in equilibrium. This solution is a pale orange colour.

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

orange yellow

What would be seen when a few drops of concentrated sodium hydroxide solution are added to the equilibrium mixture?

☒ **A** No visible change.

☒ **B** The mixture turns green.

☒ **C** The mixture turns a deeper orange.

☒ **D** The mixture turns yellow.

(Total for Question 11 = 1 mark)

12 The following system was allowed to reach equilibrium at 450 °C.

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g) \quad \Delta H = -197 \text{ kJ mol}^{-1}$$

How would a decrease in pressure and an increase in temperature affect the equilibrium position?

	Shift in equilibrium position with a decrease in pressure	Shift in equilibrium position with an increase in temperature
☒ **A**	left	left
☒ **B**	left	right
☒ **C**	right	left
☒ **D**	right	right

(Total for Question 12 = 1 mark)

13 What is the empirical formula of a bromoalkane containing, by mass, 22.0% carbon, 4.6% hydrogen and 73.4% bromine?

(Relative atomic masses: C = 12, H = 1, Br = 80)

☒ **A** C_3H_7Br

☒ **B** C_2H_5Br

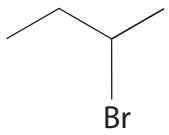
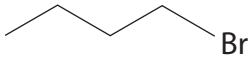
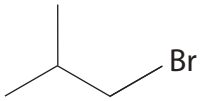
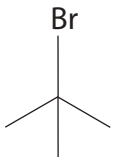
☒ **C** C_2H_3Br

☒ **D** CH_3Br

(Total for Question 13 = 1 mark)

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

14 Four isomers with the formula C_4H_9Br are shown.

P 	**Q** 
R 	**S** 

Which of the isomers are primary halogenoalkanes?

☒ **A** **P** and **R**

☒ **B** **P** and **S**

☒ **C** **Q** and **R**

☒ **D** **Q** only

(Total for Question 14 = 1 mark)

15 How many different alkenes could be formed when 2-iodopentane, $CH_3CHICH_2CH_2CH_3$, reacts with **alcoholic** potassium hydroxide?

☒ **A** 1

☒ **B** 2

☒ **C** 3

☒ **D** 4

(Total for Question 15 = 1 mark)

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

16 1-bromobutane can be made from butan-1-ol.

$$CH_3CH_2CH_2CH_2OH + HBr \rightarrow CH_3CH_2CH_2CH_2Br + H_2O$$

What mass of 1-bromobutane is formed from 3.7 g of butan-1-ol if the yield is 56%?

(Relative molecular masses: butan-1-ol = 74, 1-bromobutane = 137)

☒ **A** 3.84 g

☒ **B** 6.85 g

☒ **C** 12.23 g

☒ **D** 76.72 g

(Total for Question 16 = 1 mark)

17 Which of these molecules does **not** absorb infrared radiation?

☒ **A** carbon monoxide

☒ **B** carbon dioxide

☒ **C** oxygen

☒ **D** water

(Total for Question 17 = 1 mark)

18 Glucose is fermented to produce ethanol.

$$C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2$$

What is the atom economy, by mass, for the production of ethanol in this reaction?

(Relative molecular masses: $C_6H_{12}O_6 = 180$, $C_2H_5OH = 46$, $CO_2 = 44$)

☒ **A** 25.6%

☒ **B** 48.9%

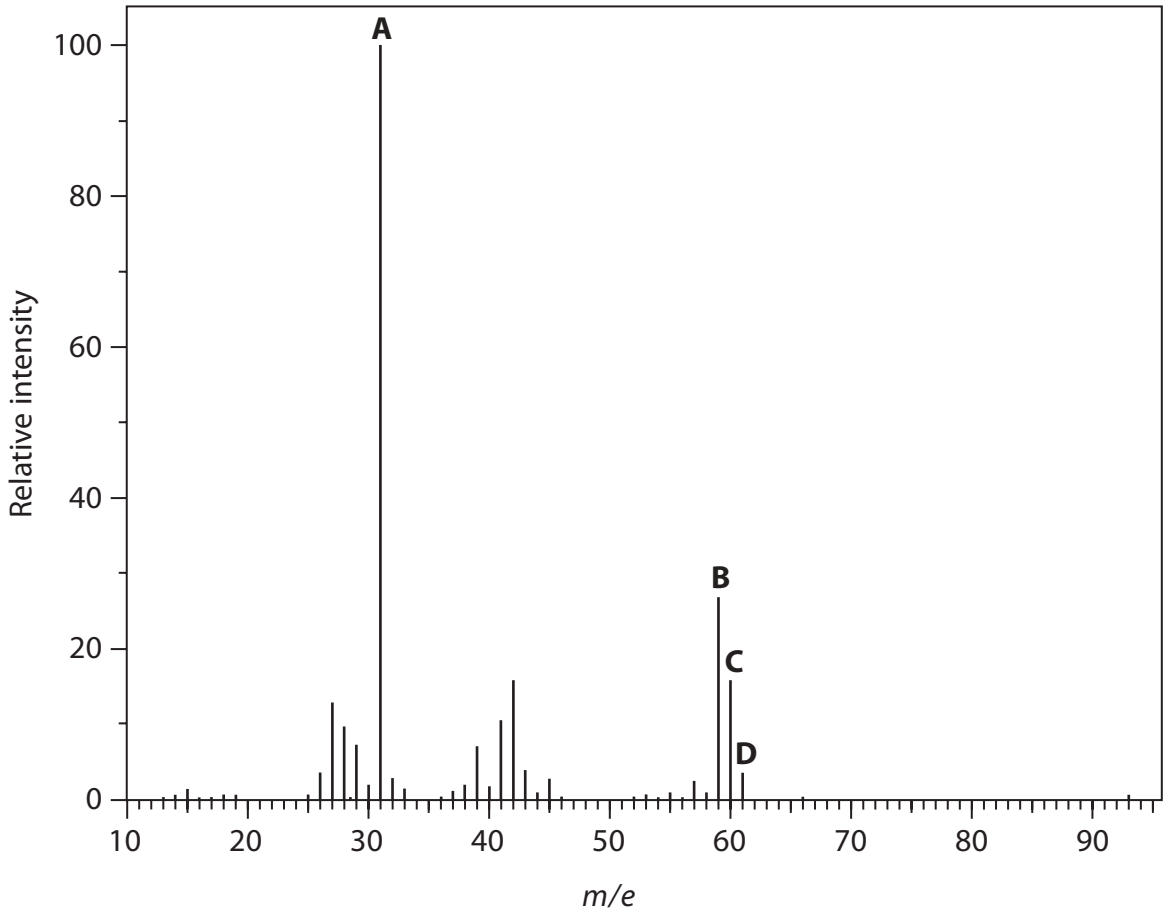
☒ **C** 50.0%

☒ **D** 51.1%

(Total for Question 18 = 1 mark)

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

19 The mass spectrum of propan-1-ol is shown.



Which peak represents the molecular ion for propan-1-ol containing a carbon-13 isotope?

- ☒ **A**
- ☒ **B**
- ☒ **C**
- ☒ **D**

(Total for Question 19 = 1 mark)

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

20 Compounds containing oxygen are sometimes added to hydrocarbon fuels to reduce incomplete combustion and improve engine performance.

Which contains the greatest number of oxygen atoms?

(Relative molecular masses: $CH_3OH = 32$, $C_2H_5OH = 46$, $CH_2OHCH_2OH = 62$, $C_4H_9OH = 74$)

☒ **A** 8.0 g of methanol, CH_3OH

☒ **B** 9.2 g of ethanol, C_2H_5OH

☒ **C** 6.2 g of ethane-1,2-diol, CH_2OHCH_2OH

☒ **D** 7.4 g of butan-1-ol, C_4H_9OH

(Total for Question 20 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS

SECTION B

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

21 This question is about the carbonates and nitrates of elements in Group 1 and Group 2 of the Periodic Table.

(a) Many of the metal ions of Group 1 and Group 2 can be identified using flame tests.

(i) State the colour given to a flame by barium nitrate.

(1)

.....

(ii) Explain the origin of the flame colour.

(3)

.....

.....

.....

.....

.....

.....

(b) Sodium nitrate and magnesium nitrate decompose when they are heated.

Write equations to show the thermal decomposition of each of these nitrates. State symbols are not required.

(i) Sodium nitrate

(1)

(ii) Magnesium nitrate

(1)

(c) Magnesium carbonate decomposes readily when heated but sodium carbonate does not.

Explain this observation by including reference to the charge and size of the cations.

(4)

(d) Hydrated sodium carbonate has the formula $Na_2CO_3.xH_2O$.

A student determined the value of x in the formula of a sample of hydrated sodium carbonate. The following procedure was used.

- Use 2.50 g of hydrated sodium carbonate to prepare 250 cm^3 of solution.
- Use a pipette to transfer 25.0 cm^3 of the sodium carbonate solution to a conical flask.
- Add a few drops of methyl orange indicator to the conical flask.
- Titrate the solution with 0.105 mol dm^{-3} hydrochloric acid until concordant results are obtained.

The student's mean titre was 16.65 cm^3.

The equation for the reaction is

$$Na_2CO_3 + 2HCl \rightarrow 2NaCl + H_2O + CO_2$$

*(i) Calculate the amount, in moles, of sodium carbonate, Na_2CO_3, in the 250 cm^3 of solution in the volumetric flask.

(3)

amount Na_2CO_3 in 250 cm^3 = ... mol

(ii) Calculate the molar mass of $Na_2CO_3.xH_2O$ and hence the value of x.

(2)

(iii) Another student carried out the same experiment but obtained a different answer. The method this student used for preparing the sodium carbonate solution is shown.

> I weighed 2.50 g of hydrated sodium carbonate in a weighing bottle and then tipped the solid into a 250 cm^3 volumetric flask.
>
> I dissolved the solid in a small amount of distilled water and then added distilled water up to the mark.
>
> I then carried out a series of titrations.

Identify **two** errors that the student made in preparing this solution and explain the effect these errors will have on the titration volumes.

(4)

Error 1.....

.....

Effect on the titration volumes.....

.....

.....

Error 2.....

.....

Effect on the titration volumes.....

.....

.....

(Total for Question 21 = 19 marks)

22 This question concerns the halogens and some of their compounds.

(a) A halogen dissolves in water to form a yellow solution, and in cyclohexane to form a purple solution.

Name the halogen.

(1)

.....

(b) Oxygen difluoride, OF_2, is produced in the reaction between fluorine and cold, dilute sodium hydroxide solution.

$$2F_2 + 2OH^- \rightarrow OF_2 + 2F^- + H_2O$$

....

Give the oxidation numbers of fluorine and oxygen in all of the species in the equation above and use them to explain why this is a redox reaction.

(3)

.....

.....

.....

.....

.....

.....

(c) Chlorine oxidises thiosulfate ions, $S_2O_3^{2-}$, to sulfate(VI) ions.

The ionic half-equations for the reaction are

$$Cl_2 + 2e^- \rightarrow 2Cl^-$$

$$S_2O_3^{2-} + 5H_2O \rightarrow 2SO_4^{2-} + 10H^+ + 8e^-$$

Write the overall equation for the reaction.

(1)

(d) The boiling temperatures of the hydrogen halides are shown.

Hydrogen halide	Boiling temperature / K
HF	293
HCl	188
HBr	206
HI	238

*(i) London forces are present in **all** of these compounds.

Describe how these forces arise.

(2)

(ii) State why the London forces are greater in hydrogen iodide than in hydrogen bromide.

(1)

.....

.....

(iii) Explain why the boiling temperature of hydrogen fluoride is higher than that of hydrogen chloride.

(2)

.....

.....

.....

.....

.....

(e) In the solid state, phosphorus(V) chloride exists as $[PCl_4]^+$ and $[PCl_6]^-$ ions.

Predict the shapes of these ions. Fully justify your answers.

(4)

Shape $[PCl_4]^+$ .....

Shape $[PCl_6]^-$ .....

Justification

.....

.....

.....

.....

.....

.....

.....

.....

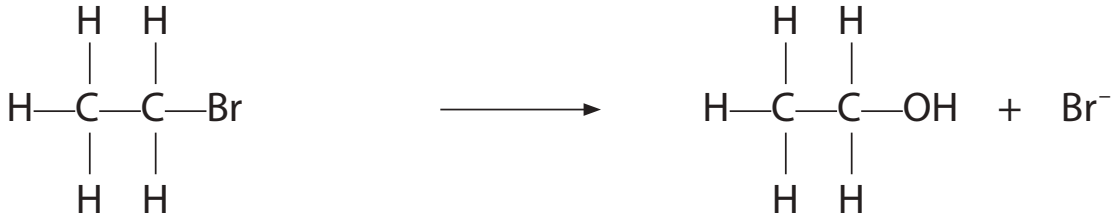
(Total for Question 22 = 14 marks)

23 This question is about mechanisms involving halogenoalkanes.

(a) Bromoethane reacts with dilute aqueous potassium hydroxide in a nucleophilic substitution reaction to form ethanol.

(i) Complete the mechanism for the reaction by adding curly arrows and the relevant dipole.

(3)



:OH^-

(ii) Explain the meaning of the term **nucleophilic substitution** in this mechanism.

(2)

.....

.....

.....

.....

(b) Chlorofluorocarbons, CFCs, were used for refrigerants, solvents and aerosol propellants because they are unreactive and neither flammable nor toxic.

However, in the stratosphere, ultraviolet radiation breaks CFCs into free radicals and these react with ozone.

Write the equation for the formation of two free radicals from a molecule of chlorotrifluoromethane, CF_3Cl. Curly arrows are not required.

(1)

(Total for Question 23 = 6 marks)

TOTAL FOR SECTION B = 39 MARKS

SECTION C

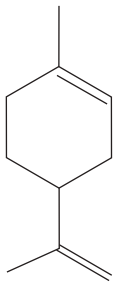
Answer ALL the questions. Write your answers in the spaces provided.

24

Many organic compounds have characteristic odours.

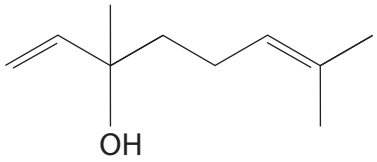
Some of these odours are pleasant, and the organic compounds are used in perfumes, soaps, deodorants, shampoos and other cosmetics.

Limonene is a colourless liquid which is present in the rind of lemons.



limonene

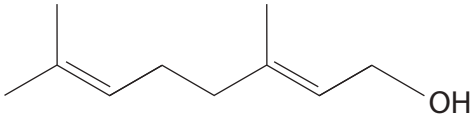
Linalool occurs in lavender oil.



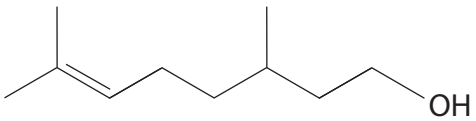
linalool

Geraniol and citronellol occur in lemon grass.

They have rose-like odours.



geraniol



citronellol

(a) (i) Give the **molecular** formula for linalool.

(1)

(ii) Give the **empirical** formula for limonene.

(1)

(iii) Which of these four compounds are structural isomers?

(1)

(iv) Which of these four compounds show(s) geometric isomerism?

(1)

(b) Describe simple test tube reactions to identify the two functional groups present in linalool.

Give the reagents required and the observations you would make.

(4)

*(c) (i) Explain whether it is possible to distinguish between limonene, linalool, geraniol and citronellol using **only** infrared spectroscopy.

(2)

(ii) Describe a chemical test that could be used to distinguish between samples of linalool and geraniol. Give the result of the test for both compounds.

(2)

(d) The four organic compounds react with hydrogen gas, in the presence of a suitable catalyst.

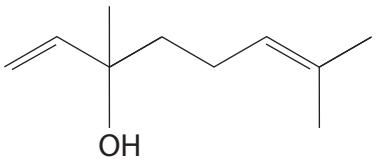
(i) Name a suitable catalyst for the reaction with hydrogen.

(1)

.....

(ii) Complete the balanced equation for the reaction of linalool with excess hydrogen.

(1)



(iii) A sample of lavender oil contained 70.0% by mass of linalool and no other unsaturated compounds. Calculate the minimum volume of hydrogen gas, measured at room temperature and pressure, needed to completely reduce 2.55 g of this lavender oil.

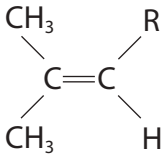
(The molar volume of hydrogen at room temperature and pressure is 24.0 dm^3 mol^{-1}. The molar mass of linalool is 154 g mol^{-1})

(3)

(e) Hydrogen bromide reacts with C═C bonds such as those in citronellol.

Draw the mechanism for the reaction of hydrogen bromide with citronellol.

You should use the formula



to represent a molecule of citronellol.

Include the dipole on the hydrogen bromide molecule.

(4)

(Total for Question 24 = 21 marks)

TOTAL FOR SECTION C = 21 MARKS
TOTAL FOR PAPER = 80 MARKS

The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8)
							1.0 H hydrogen 1										(18) 4.0 He helium 2
(1)	(2)		Key: relative atomic mass / atomic symbol / name / atomic (proton) number									(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							

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