Please check the examination details below before entering your candidate information

Candidate surname	Other names

Centre Number | Candidate Number

Pearson Edexcel International Advanced Level

Wednesday 10 May 2023

Morning (Time: 1 hour 30 minutes)

Paper reference **WCH11/01**

Chemistry

International Advanced Subsidiary/Advanced Level
UNIT 1: Structure, Bonding and Introduction to Organic Chemistry

You must have:
Scientific calculator

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- If pencil is used for diagrams/sketches/graphs it must be dark (HB or B).
- **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.*
- You will be assessed on your ability to organise and present information, ideas, descriptions and arguments clearly and logically, including your use of grammar, punctuation and spelling.
- A Periodic Table is printed on the back cover of this paper.

Advice

- Read each question carefully before you start to answer it.
- Show all your working in calculations and include units where appropriate.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

P71860A

P 7 1 8 6 0 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 Which compound has the greatest covalent character?

☒ **A** $MgBr_2$

☒ **B** MgF_2

☒ **C** NaBr

☒ **D** NaF

(Total for Question 1 = 1 mark)

2 Which has the smallest ionic radius?

☒ **A** F^-

☒ **B** Mg^{2+}

☒ **C** Na^+

☒ **D** O^{2-}

(Total for Question 2 = 1 mark)

3 The first seven ionisation energies, in kJ mol^{-1}, of an element are shown.

1010, 1900, 2910, 4960, 6270, 21 300, 25 400

In which group of the Periodic Table is this element located?

☒ **A** Group 3

☒ **B** Group 4

☒ **C** Group 5

☒ **D** Group 6

(Total for Question 3 = 1 mark)

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

4 What is the electronic configuration of an oxygen atom in its ground state?

		1s	2s	$2p_x$	$2p_y$	$2p_z$	3s
☒	**A**	↑↓	↑↓	↑↓	↑↓		
☒	**B**	↑↓	↑↓	↑↑	↑	↑	
☒	**C**	↑↓	↑↓	↑	↑	↑	↑
☒	**D**	↑↓	↑↓	↑↓	↑	↑	

(Total for Question 4 = 1 mark)

5 Which property shows a **general decrease** across the Periodic Table from sodium to chlorine?

☒ **A** atomic radius

☒ **B** electronegativity

☒ **C** first ionisation energy

☒ **D** melting temperature

(Total for Question 5 = 1 mark)

6 The first ionisation energy of sulfur is lower than that of phosphorus.

Which is the best explanation for this?

☒ **A** the atomic radius of sulfur is greater than that of phosphorus

☒ **B** the electronegativity of sulfur is greater than that of phosphorus

☒ **C** the repulsion between the outer electrons of sulfur is greater than that of phosphorus

☒ **D** the shielding by the inner shell electrons of sulfur is greater than that of phosphorus

(Total for Question 6 = 1 mark)

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

7 1 kg of seawater contains 64 mg of bromide ions.

[A_r of Br = 80 Avogadro constant, $L = 6.0 \times 10^{23}$ mol^{-1}]

(a) What is the concentration of bromide ions in parts per million (ppm) by mass?

(1)

- ☒ **A** 0.80
- ☒ **B** 64
- ☒ **C** 800
- ☒ **D** 64 000

(b) How many bromide ions are in 500 g of the sample?

(1)

- ☒ **A** 2.4×10^{20}
- ☒ **B** 4.8×10^{20}
- ☒ **C** 1.9×10^{22}
- ☒ **D** 3.8×10^{22}

(Total for Question 7 = 2 marks)

8 0.15 mol of aluminium is added to 120 cm^3 of 1.50 mol dm^{-3} hydrochloric acid.

$$2Al(s) + 6H^+(aq) \rightarrow 2Al^{3+}(aq) + 3H_2(g)$$

The amount of **unused** reactant is

- ☒ **A** 0.06 mol aluminium
- ☒ **B** 0.09 mol aluminium
- ☒ **C** 0.03 mol hydrochloric acid
- ☒ **D** 0.13 mol hydrochloric acid

(Total for Question 8 = 1 mark)

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

9 An organic compound contains 24.2 % carbon, 4.00 % hydrogen and 71.8 % chlorine by mass.

[A_r values: H = 1.0 C = 12.0 Cl = 35.5]

What is the empirical formula of the compound?

- ☒ **A** CHCl
- ☒ **B** CH_2Cl
- ☒ **C** $C_2H_4Cl_2$
- ☒ **D** $C_4H_4Cl_4$

(Total for Question 9 = 1 mark)

10 Which solution contains the **smallest** number of ions?

- ☒ **A** 500 cm^3 of 0.06 mol dm^{-3} $Ca(NO_3)_2(aq)$
- ☒ **B** 500 cm^3 of 0.09 mol dm^{-3} KI(aq)
- ☒ **C** 250 cm^3 of 0.12 mol dm^{-3} $BaCl_2(aq)$
- ☒ **D** 250 cm^3 of 0.09 mol dm^{-3} $(NH_4)_2SO_4(aq)$

(Total for Question 10 = 1 mark)

11 A piece of filter paper is soaked in water and attached to a microscope slide.

A few crystals of green copper(II) chromate(VI) are placed in the centre of the filter paper.

The filter paper is connected to a DC supply of 20 V.

What colours are observed on the paper after a few minutes?

positive electrode | negative electrode

☒	**A**	blue	yellow
☒	**B**	green	blue
☒	**C**	yellow	green
☒	**D**	yellow	blue

(Total for Question 11 = 1 mark)

12 The melting temperature of beryllium is greater than that of barium.

What is the best explanation for this statement?

- ☒ **A** beryllium ions are smaller than barium ions
- ☒ **B** beryllium atoms have fewer outer shell electrons than barium atoms
- ☒ **C** beryllium ions have a smaller charge density than barium ions
- ☒ **D** beryllium atoms have a higher electronegativity than barium atoms

(Total for Question 12 = 1 mark)

13 Which molecule has the largest bond angle?

- ☒ **A** BF_3
- ☒ **B** CF_4
- ☒ **C** H_2O
- ☒ **D** NH_3

(Total for Question 13 = 1 mark)

14 Which molecule is polar?

- ☒ **A** CO_2
- ☒ **B** SF_6
- ☒ **C** SO_2
- ☒ **D** $SiCl_4$

(Total for Question 14 = 1 mark)

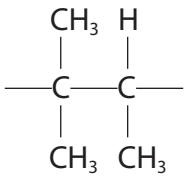
15 The reaction of methane with chlorine is a free radical substitution.

Which termination step does **not** occur?

- ☒ **A** $CH_3\bullet + CH_3\bullet \rightarrow C_2H_6$
- ☒ **B** $CH_3\bullet + Cl\bullet \rightarrow CH_3Cl$
- ☒ **C** $CH_3\bullet + H\bullet \rightarrow CH_4$
- ☒ **D** $Cl\bullet + Cl\bullet \rightarrow Cl_2$

(Total for Question 15 = 1 mark)

16 The repeat unit of a polymer is shown.

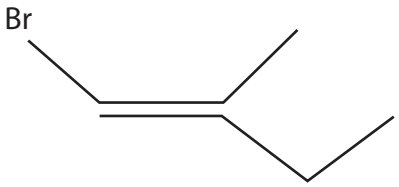


Which is the name of the monomer that forms this polymer?

- ☒ **A** 1,1,2-trimethylethene
- ☒ **B** 1,1-dimethylpropene
- ☒ **C** 2-methylbut-2-ene
- ☒ **D** 3-methylbut-2-ene

(Total for Question 16 = 1 mark)

17 What is the IUPAC name for the compound shown?

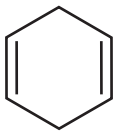


- ☒ **A** *E*-1-bromo-2-methylbut-1-ene
- ☒ **B** *Z*-1-bromo-2-methylbut-1-ene
- ☒ **C** *E*-1-bromo-2-ethyl-2-methylethene
- ☒ **D** *Z*-1-bromo-2-ethylpropene

(Total for Question 17 = 1 mark)

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

18 The skeletal formula of cyclohexa-1,4-diene is shown.



(a) The total number of σ (sigma) bonds in this molecule is

(1)

- ☒ **A** 4
- ☒ **B** 6
- ☒ **C** 12
- ☒ **D** 14

(b) 1.60 g of cyclohexa-1,4-diene is reduced to cyclohexane by reacting it with hydrogen gas.

[The molar volume of a gas is 24.0 dm^3 mol^{-1} at room temperature and pressure (r.t.p.)

M_r of cyclohexa-1,4-diene = 80]

What is the minimum volume, in dm^3, of hydrogen needed at r.t.p.?

(1)

- ☒ **A** 0.0400
- ☒ **B** 0.480
- ☒ **C** 0.960
- ☒ **D** 1.92

(Total for Question 18 = 2 marks)

TOTAL FOR SECTION A = 20 MARKS

SECTION B

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

19 This question is about mass spectrometry and the shapes of molecules.

(a) In a mass spectrometer vaporised atoms are ionised, and the ions formed are accelerated, deflected and detected.

(i) State how atoms are ionised in the mass spectrometer.

(1)

(ii) State how the ions formed are accelerated.

(1)

(iii) Explain why isotopes of an element have the same chemical reactions but their ions are deflected differently in a mass spectrometer.

(2)

(b) Data from mass spectra may be used to determine the relative atomic masses of elements.

(i) State what is meant by relative atomic mass.

(2)

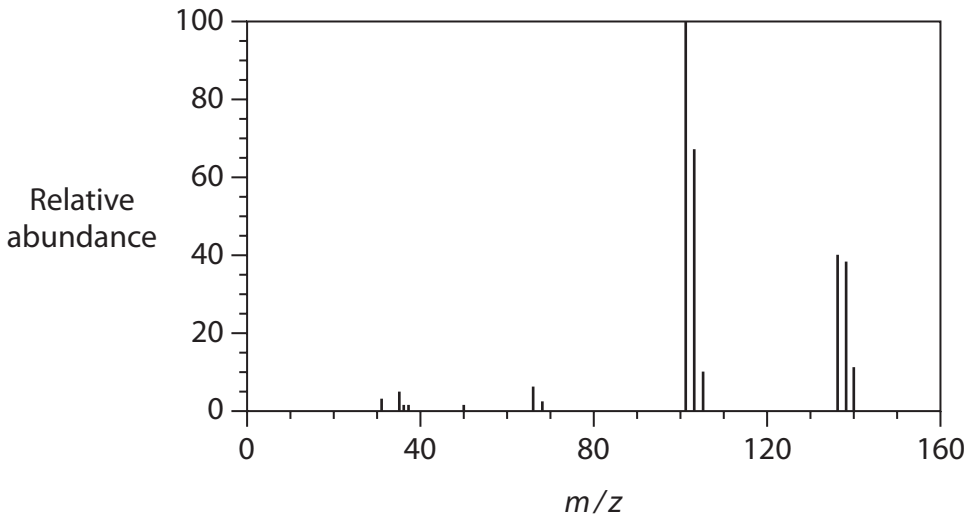
(ii) A sample of chlorine contains 75.53 % of ^{35}Cl and 24.47 % of ^{37}Cl.

Calculate the relative atomic mass of this sample of chlorine, giving your answer to **four** significant figures.

(2)

(c) The mass spectrum of phosphorus trichloride, PCl_3, is shown.

Phosphorus has only one isotope, ^{31}P.



(i) There are three peaks in the region of $m/z = 101–105$.

Complete the table to show the ions responsible for these peaks.

(2)

m/z	Formula of ion	Relative peak height
101		9
103		6
105		1

(ii) Show that the relative peak heights given in the table are consistent with the isotopic ratio of ^{35}Cl to ^{37}Cl being 3 : 1.

(2)

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(d) (i) Draw a dot-and-cross diagram of a PCl_3 molecule.
Show outer electrons only.

(2)

(ii) Explain the shape of a PCl_3 molecule.

(3)

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(Total for Question 19 = 17 marks)

20 (a) Barium chloride, $BaCl_2$, can be prepared by the reaction of barium carbonate with hydrochloric acid.

$$BaCO_3(s) + 2HCl(aq) \rightarrow BaCl_2(aq) + CO_2(g) + H_2O(l)$$

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

(1)

(ii) Calculate the atom economy by mass for this preparation of barium chloride.

[A_r values: H = 1.0 C = 12.0 O = 16.0 Cl = 35.5 Ba = 137.3]

(2)

(iii) Barium chloride has a melting temperature of 962 °C.
Caesium chloride has a melting temperature of 646 °C.

Explain, by considering the ions involved, the difference between the melting temperatures of these Period 6 chlorides.

(4)

(iv) Covalent and ionic bonding are the extremes of a continuum of bonding type.

Explain the difference in bonding between barium chloride and beryllium chloride, using the electronegativity values shown.

Element	Electronegativity
Ba	0.9
Be	1.5
Cl	3.0

(2)

(b) Barium chloride reacts with Group 1 sulfates, M_2SO_4.

$$M_2SO_4(aq) + BaCl_2(aq) \rightarrow BaSO_4(s) + 2MCl(aq)$$

A solution is made by dissolving 7.98 g of a Group 1 sulfate in deionised water.

Excess aqueous barium chloride is added to this solution and the precipitate is filtered, dried and weighed.

The mass of the barium sulfate precipitate is 10.72 g.

Identify the Group 1 element.

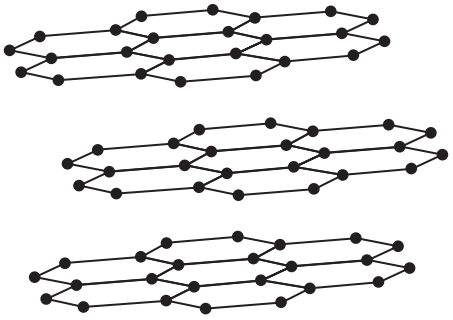
[A_r values: Ba = 137.3 S = 32.1 O = 16.0]

(4)

(Total for Question 20 = 13 marks)

21 Graphite electrodes are used in the extraction of aluminium by the electrolysis of aluminium oxide, Al_2O_3, dissolved in a solvent (molten cryolite) at a temperature of 950 °C.

(a) Explain how the structure and bonding in graphite make it suitable for this application.
Refer to the diagram in your answer.



graphite

(3)

(b) The half-equations for the electrolysis reactions are shown.

Negative electrode $2Al^{3+} + 6e^- \rightarrow 2Al$

Positive electrode $3O^{2-} \rightarrow 1½O_2 + 6e^-$

The oxygen produced reacts with the graphite electrode.

$$C(s) + O_2(g) \rightarrow CO_2(g)$$

(i) Calculate the maximum volume, in dm^3, of CO_2, measured at r.t.p. which could be produced when 1.00 kg aluminium is extracted using this process.

[The molar volume of a gas is 24.0 dm^3 mol^{-1} at r.t.p.]

(4)

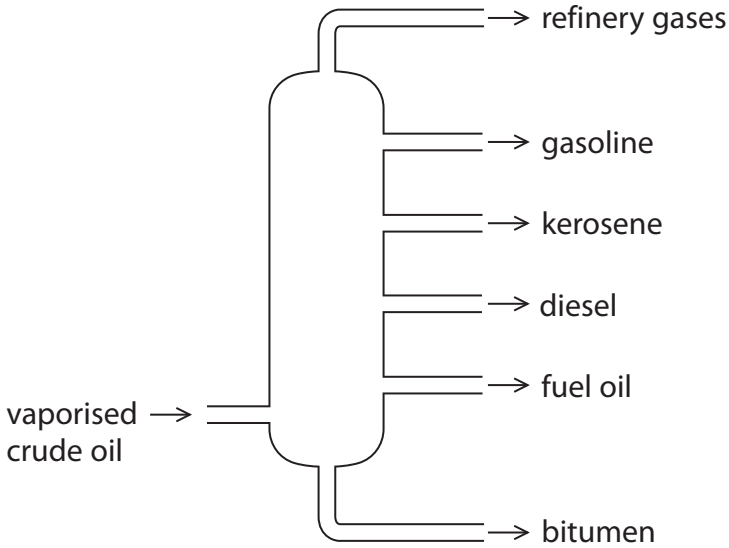
(ii) Every year in the United Kingdom, about 7.2 billion aluminium cans are recycled.

Suggest three ways this recycling reduces energy consumption.

(3)

(Total for Question 21 = 10 marks)

22 Crude oil is mainly a mixture of saturated hydrocarbons that can be separated by fractional distillation.
The diagram shows, in a simplified form, the products of fractional distillation.



(a) (i) State what is meant by a saturated hydrocarbon.

(2)

(ii) Describe how the fractions in crude oil are separated during fractional distillation.

(2)

(b) Butane, C_4H_{10}, is found in the refinery gases fraction of crude oil.
It is used as a propellant in pharmaceutical inhalers.
An inhaler that provides a total of 120 doses contains 1.55 g of butane.

Calculate the volume, in cm^3, of propellant used for each dose at 25 °C and 100 kPa.

Use the ideal gas equation and give your answer to an appropriate number of significant figures.

[$pV = nRT$ $R = 8.31\ J\ K^{-1}\ mol^{-1}$]

(5)

(c) Octane, C_8H_{18}, is found in the gasoline fraction of crude oil.

(i) Write an equation for the complete combustion of octane.
Include state symbols.

(2)

(ii) Give **two** reasons why alternative fuels, such as bioethanol, are being developed to replace those produced from crude oil.

(2)

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(iii) Straight-chain alkanes, such as octane, are converted into branched-chain alkanes to improve the performance of petrol in car engines.

Name this conversion process.

(1)

.....

(iv) Give an equation using skeletal formulae for the conversion of octane into 2,5-dimethylhexane.
State symbols are not required.

(1)

(d) In steam cracking, a mixture of hydrocarbons and steam is heated to 850 °C for a very short time in the absence of oxygen.

(i) Give a reason why oxygen should be excluded during steam cracking.

(1)

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(ii) Ethene is the major product.

State one use of ethene.

(1)

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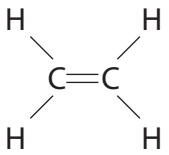
(e) Ethene reacts with hydrogen bromide to form bromoethane.

Draw the mechanism for this reaction.
Include curly arrows, and relevant lone pairs and dipoles.

(3)



(Total for Question 22 = 20 marks)

TOTAL FOR SECTION B = 60 MARKS
TOTAL FOR PAPER = 80 MARKS

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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

* 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