Please check the examination details below before entering your candidate information

Candidate surname	Other names

Centre Number | Candidate Number

Pearson Edexcel International Advanced Level

Thursday 9 October 2025

Afternoon (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 ▶

P84360A

M:1/1/1/1/

P 8 4 3 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 Atomic numbers and mass numbers are used to identify isotopes.

(a) What is the mass number of the isotope $^{84}_{36}Kr$?

(1)

☒ **A** 36

☒ **B** 48

☒ **C** 84

☒ **D** 120

(b) Which element has the atomic number 15 and mass number 31?

(1)

☒ **A** Ga

☒ **B** P

☒ **C** Pd

☒ **D** S

(c) What is the number of electrons in the selenide ion $^{80}_{34}Se^{2-}$?

(1)

☒ **A** 34

☒ **B** 36

☒ **C** 80

☒ **D** 82

(Total for Question 1 = 3 marks)

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

2 Mass spectrometry is used to analyse samples of elements and molecules.

(a) What is used to accelerate ions in a mass spectrometer?

(1)

- ☒ **A** beam of electrons
- ☒ **B** electric field
- ☒ **C** magnetic field
- ☒ **D** vaporisation

(b) A sample of boron contains 20.6% ^{10}B and 79.4% ^{11}B.

What is the relative atomic mass of this sample of boron?

(1)

- ☒ **A** 10.21
- ☒ **B** 10.50
- ☒ **C** 10.79
- ☒ **D** 10.80

(c) Bromine only has the two isotopes, ^{79}Br and ^{81}Br.

A pure sample of elemental bromine, Br_2, was analysed in a mass spectrometer.

Why did the mass spectrum have a small peak with $m/z = 80$?

(1)

- ☒ **A** an isotope with a mass of 80 was formed in the spectrometer
- ☒ **B** there was contamination in the spectrometer
- ☒ **C** ions can form with a 2+ charge
- ☒ **D** this is the mean value of the two isotopic masses

(Total for Question 2 = 3 marks)

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

3 An organic compound contains 53.3% carbon, 11.1% hydrogen and 35.6% oxygen by mass. The molar mass of this compound is 90.0 g mol^{-1}.

[Data: A_r H = 1.0 C = 12.0 O = 16.0]

What is the **empirical** formula of the compound?

☒ **A** $C_4H_{10}O$

☒ **B** $C_4H_{10}O_2$

☒ **C** $C_4H_5O_2$

☒ **D** C_2H_5O

(Total for Question 3 = 1 mark)

4 Strontium nitrate, $Sr(NO_3)_2$, can be prepared by the reaction of strontium carbonate with dilute nitric acid. The equation is shown.

$$SrCO_3(s) + 2HNO_3(aq) \rightarrow Sr(NO_3)_2(aq) + CO_2(g) + H_2O(l)$$

(a) Which is the **ionic** equation for this reaction?

(1)

☒ **A** $Sr^{2+}(s) + 2NO_3^-(aq) \rightarrow Sr(NO_3)_2(aq)$

☒ **B** $CO_3^{2-}(s) + 2H^+(aq) \rightarrow CO_2(g) + H_2O(l)$

☒ **C** $SrCO_3(s) + 2H^+(aq) \rightarrow Sr^{2+}(aq) + CO_2(g) + H_2O(l)$

☒ **D** $SrCO_3(s) + 2HNO_3(aq) \rightarrow Sr^{2+}(aq) + 2NO_3^- + CO_2(g) + H_2O(l)$

(b) What is the percentage atom economy, by mass, for this preparation of strontium nitrate?

[Data: A_r H = 1.0 C = 12.0 N = 14.0 O = 16.0 Sr = 87.6]

(1)

☒ **A** 22.7

☒ **B** 70.7

☒ **C** 77.3

☒ **D** 82.8

(Total for Question 4 = 2 marks)

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

5 Which isoelectronic ion has the largest radius?

- ☒ **A** Ca^{2+}
- ☒ **B** Cl^-
- ☒ **C** K^+
- ☒ **D** S^{2-}

(Total for Question 5 = 1 mark)

6 0.100 mol of sodium nitrate dissolves in deionised water to form 250 cm^3 of solution.

What is the solution concentration, in **g dm^{-3}**?

[Data: $NaNO_3$ molar mass = 85.0 g mol^{-1}]

- ☒ **A** 0.034
- ☒ **B** 0.400
- ☒ **C** 8.50
- ☒ **D** 34.0

(Total for Question 6 = 1 mark)

7 Which of the giant lattices of carbon atoms contain flat hexagonal rings?

- ☒ **A** diamond only
- ☒ **B** graphene only
- ☒ **C** graphite only
- ☒ **D** graphene and graphite only

(Total for Question 7 = 1 mark)

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

8 The first ionisation energy for hydrogen is 1312 kJ mol^{-1}.

What is the ionisation energy, in **joules**, that is needed per atom of hydrogen?

[Data: Avogadro constant, $L = 6.02 \times 10^{23}$ mol^{-1}]

- ☒ **A** 1.09×10^{-18}
- ☒ **B** 2.18×10^{-18}
- ☒ **C** 1.09×10^{-21}
- ☒ **D** 2.18×10^{-21}

(Total for Question 8 = 1 mark)

9 Which molecule is polar?

- ☒ **A** $BeCl_2$
- ☒ **B** NCl_3
- ☒ **C** CCl_4
- ☒ **D** PCl_5

(Total for Question 9 = 1 mark)

10 Zinc has electrons in s, p and d orbitals.

How many electrons **in total** does zinc have in p orbitals?

- ☒ **A** 12
- ☒ **B** 10
- ☒ **C** 8
- ☒ **D** 6

(Total for Question 10 = 1 mark)

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

11 A sample of 6.300 g of cerium reacted completely with 1.439 g of oxygen gas.

What is the formula of the oxide formed in this reaction?

[Data: A_r Ce = 140.1 O = 16.0]

☒ **A** CeO_4

☒ **B** Ce_2O_3

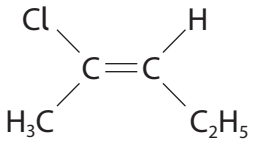
☒ **C** CeO_2

☒ **D** Ce_3O_4

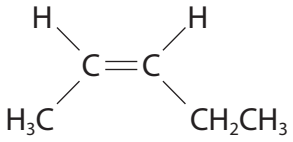
(Total for Question 11 = 1 mark)

12 Which compound can only be named using the *E-Z* naming system and **not** using the *cis-* and *trans-* naming system?

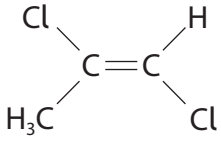
☒ **A**



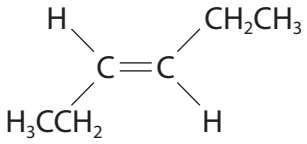
☒ **B**



☒ **C**



☒ **D**



(Total for Question 12 = 1 mark)

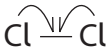
Use this space for any rough working. Anything you write in this space will gain no credit.

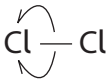
13 Free radical substitution is the mechanism of the reaction between methane and chlorine.

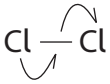
(a) Which drawing of curly half-arrows shows initiation?

(1)

☒ **A** 

☒ **B** 

☒ **C** 

☒ **D** 

(b) Which equation is **not** a possible propagation step in the reaction?

(1)

☒ **A** $CH_4 + Cl\bullet \rightarrow CH_3Cl + H\bullet$

☒ **B** $CH_4 + Cl\bullet \rightarrow CH_3\bullet + HCl$

☒ **C** $CH_3\bullet + Cl_2 \rightarrow CH_3Cl + Cl\bullet$

☒ **D** $CH_3Cl + Cl\bullet \rightarrow CH_2Cl\bullet + HCl$

(c) What differentiates a termination step from a propagation step?

(1)

☒ **A** covalent bonds are formed

☒ **B** heterolytic fission occurs

☒ **C** no free radicals are formed

☒ **D** ultraviolet radiation is not needed

(Total for Question 13 = 3 marks)

TOTAL FOR SECTION A = 20 MARKS

SECTION B

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

14 Ionisation energies provide information about the orbitals in the electronic structures of atoms.

(a) State what is meant by the term 'orbital'.

(2)

(b) Explain the trend in first ionisation energies down Group 1.

(4)

(c) Explain how the changes in the first four successive ionisation energies of calcium indicate the group to which it belongs.

(2)

(d) Write the equation for the **second** ionisation energy of fluorine.
Include state symbols.

(2)

(e) The **first** ionisation energy of nitrogen is +1402 kJ mol^{-1}.

Predict an approximate value for the first ionisation energy of oxygen.
Justify your answer.

(3)

Value ..... kJ mol^{-1}

Justification

(f) The first ionisation energy of magnesium and of aluminium are shown.

Element	First ionisation energy / kJ mol^{-1}
Magnesium	+738
Aluminium	+578

Explain why the first ionisation energy of aluminium is less than that of magnesium.

(2)

.....

.....

.....

.....

(Total for Question 14 = 15 marks)

15 Propane and butane are used as fuels in portable heaters. They are stored under pressure in cylinders as liquids. When the cylinder valve is opened, the decrease in pressure causes the liquid fuel to change into a gas.

(a) A gas cylinder contains 18.4 dm^3 of liquid propane, C_3H_8.

Calculate the volume of propane gas that would be produced from this quantity of liquid propane at 101 kPa and 25°C.
Include units in your answer. You **must** show your working.

Use the ideal gas equation, $pV = nRT$.

[Data: $R = 8.31\ J\ mol^{-1}\ K^{-1}$ Density of liquid propane = $0.585\ g\ cm^{-3}$]

(4)

(b) Gas cylinders are made of metal.

Explain, with reference to structure and bonding, why these gas cylinders can withstand the high pressures.

(2)

(c) Complete combustion of butane produces more carbon dioxide than the complete combustion of propane, per mole of fuel.

(i) Write an equation for the complete combustion of propane.
State symbols are not required.

(1)

(ii) Determine the increase in volume, in **dm^3**, of carbon dioxide gas produced per mole of butane compared to per mole of propane on complete combustion.

Use 24 $dm^3 mol^{-1}$ for the molar volume of carbon dioxide gas.

(1)

(iii) State an environmental problem which arises from the use of propane and butane as fuels.

(1)

.....

.....

(d) Incomplete combustion of propane produces carbon monoxide, which is a serious health hazard. The UK's Health and Safety Executive has imposed a maximum workplace exposure limit.
This limit is 20 ppm of carbon monoxide, by volume, during an 8-hour period.

(i) A small workroom has a volume of 50.2 m^3.

Calculate the **maximum** number of carbon monoxide molecules allowed in the workroom if a person is present for 8 hours.

[Data: Avogadro constant, $L = 6.02 \times 10^{23}$ mol^{-1}
Molar gas volume = 24 dm^3 mol^{-1}]

(3)

(ii) Suggest **two** steps a person could take to reduce the risk associated with the hazardous carbon monoxide whilst working in this room.

(2)

.....

.....

.....

.....

.....

.....

(Total for Question 15 = 14 marks)

16 This question is about organic compounds with the molecular formula C_5H_{10}.

(a) Pent-1-ene and pent-2-ene are structural isomers, but only pent-2-ene has geometric isomers.

(i) State why pent-1-ene and pent-2-ene are structural isomers.

(1)

.....

.....

(ii) Explain why pent-2-ene has geometric isomers.

(2)

.....

.....

.....

.....

(b) Pent-1-ene can be converted into pentane.

Add a catalyst for this conversion on the dotted line.

(1)

$$CH_2CHCH_2CH_2CH_3 + H_2 \xrightarrow{\text{.....}} CH_3CH_2CH_2CH_2CH_3$$

(c) Pent-2-ene reacts with hydrogen bromide to form two different products.

Draw the **displayed** formula of each product.

(2)

Product 1	Product 2

(d) Both pent-1-ene and pent-2-ene react with steam in the presence of an acid catalyst to produce alcohols.

Explain, by referring to the addition of steam, how both alkenes can produce the same alcohol but can also produce different alcohols.
Include names and structures of all three alcohols.

(5)

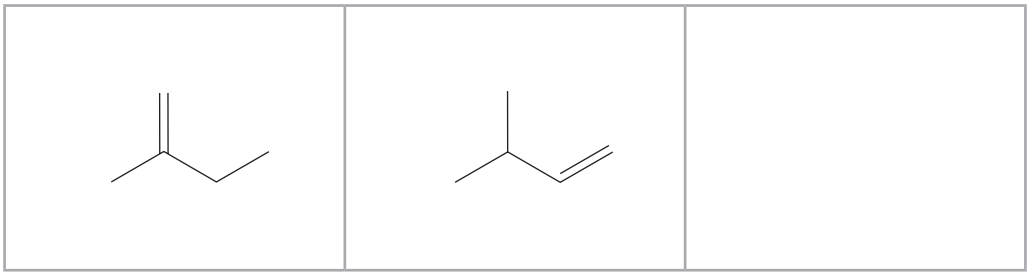
(e) Draw **two** repeat units of poly(pent-2-ene).

(1)

(f) There are three branched alkenes with the molecular formula C_5H_{10}.
The skeletal formulae of two of these are shown.

Draw the **skeletal** formula of the other branched alkene of C_5H_{10}.

(1)



(g) Five cycloalkane molecules have the molecular formula C_5H_{10}.

(i) Describe the result when bromine is added to cyclopentane in the dark.

(1)

(ii) Draw the structure of **three** of the other cycloalkane isomers of C_5H_{10}.
Do **not** draw cyclopentane.

(2)

(Total for Question 16 = 16 marks)

17 This question is about the salts ammonium sulfate and copper(II) sulfate.

(a) Ammonium sulfate has the formula $(NH_4)_2SO_4$.

Ammonium salts contain the ammonium ion NH_4^+. This ion is formed when ammonia forms a dative covalent bond with a proton.

Explain, using electron-pair repulsion theory, how the ammonia molecule and the ammonium ion have different bond angles and shapes.

(4)

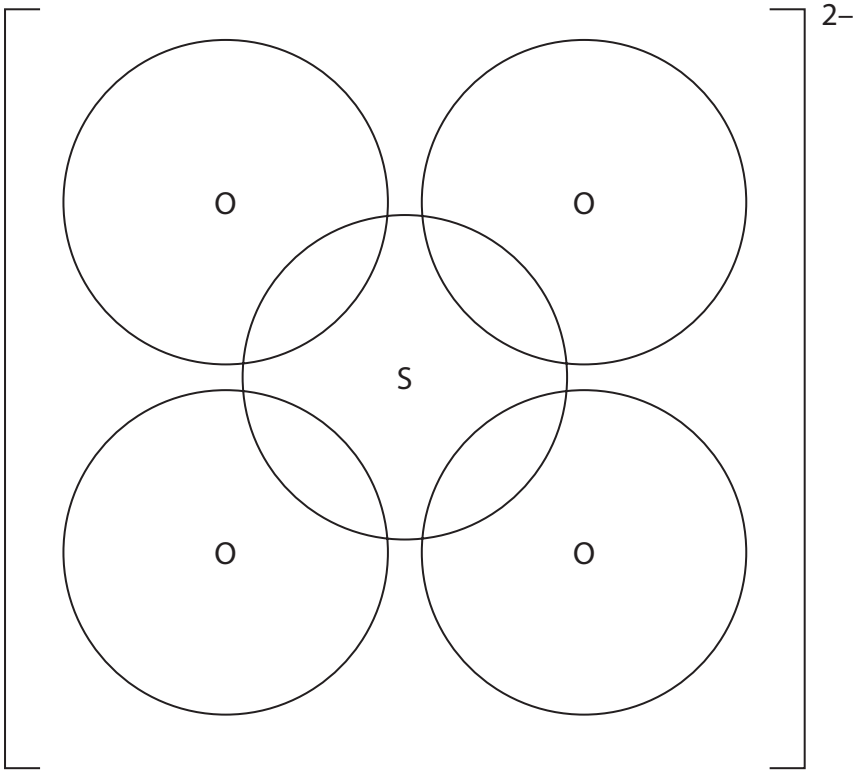
(b) Copper(II) sulfate is an ionic compound.

(i) Describe an experiment which would demonstrate the movement of the copper(II) ions in an aqueous solution of this salt.

(3)

(ii) Complete the dot-and-cross diagram of the sulfate ion.
Use dots (●) for the sulfur electrons, crosses (✖) for the oxygen electrons and triangles (▲) for the extra electrons.

(2)



(c) The double salt, $(NH_4)_2Cu(SO_4)_2$, can be made by adding ammonium sulfate solution to aqueous copper(II) sulfate. The equation for this preparation is shown.

$$(NH_4)_2SO_4 + CuSO_4 \rightarrow (NH_4)_2Cu(SO_4)_2$$

The double salt was prepared by:

- dissolving 3.35 g of ammonium sulfate in 25 cm^3 of deionised water
- dissolving 3.96 g of copper(II) sulfate in 25 cm^3 of deionised water
- adding the two solutions together, heating and then leaving to crystallise

(i) Calculate which of the salts was in excess.

(3)

(ii) The crystalline salt prepared is hydrated and has the formula $(NH_4)_2Cu(SO_4)_2 \cdot 6H_2O$. The mass collected was 9.52 g.

Calculate the percentage yield of the double salt from this preparation.

(3)

(Total for Question 17 = 15 marks)

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

BLANK PAGE

BLANK PAGE

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