

OCR A-LEVEL CHEMISTRY B (SALTERS) • H433

CHEMISTRY



EXAM QUESTION PACK

ELEMENTS OF LIFE (EL): ATOMIC STRUCTURE

SCORE

/34

PERCENTAGE

%

STEMUP

These questions belong to OCR, not to us.

The examination questions, mark schemes and examiner comments in this pack were written and published by OCR. They are past assessment materials, reproduced here so that students can revise from them.

What we do not own

STEMUP is not affiliated with OCR and does not own, and makes no claim to own, any of the question, mark scheme or examiner report material in this pack. OCR has not endorsed, approved or been involved in the production of it. OCR and the qualification titles used here belong to their respective owners and appear for identification only.

Where to find the originals

OCR publishes its past papers, mark schemes and examiner reports free of charge. Always check the current specification at ocr.org.uk before you revise, because content and wording can change between series.

If you hold the rights to any material in this pack and would like it amended or removed, contact admin@stemup.co.uk and we will act on it.

1 Which equation could represent a fusion reaction in the Sun?

- A ${}^1\text{H} + {}^1\text{H} \rightarrow {}^2\text{H}$
- B ${}^2\text{H} + {}^1\text{H} \rightarrow {}^3\text{H}$
- C ${}^3\text{H} + {}^2\text{H} \rightarrow {}^4\text{He} + {}^1\text{H}$
- D ${}^3\text{He} + {}^3\text{He} \rightarrow {}^4\text{He} + 2 {}^1\text{H}$

Your answer

☐

[1]

2 What provided evidence of the atomic nucleus?

- A Thomson's discovery that all elements contain electrons.
- B Geiger and Marsden firing α -particles at gold leaf.
- C The magnitude of successive ionisation energies.
- D The lines on an atomic emission spectrum.

Your answer

☐

[1]

3 A student is investigating the properties of some s-block metals and their compounds.

Complete the electronic configuration, using sub-shells, of an **atom** of sodium and the magnesium **ion** in magnesium carbonate.

sodium **atom** $1s^2$

magnesium **ion** $1s^2$

[2]

4 Please refer to the Article 'Clearing the air around smoke formation' in **Insert for H433/02 June 19**.

In an sp^2 hybrid carbon atom, one s orbital joins with two p orbitals to form three 'hybrid' sp^2 orbitals of the same energy. This leaves one other p orbital of a similar energy containing one electron.

(i) Explain why the remaining p orbital contains one electron.

----- [2]

(ii) State what happens to these single p electrons in the structures of ethene and naphthalene.

ethene -----

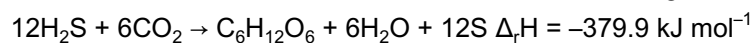
naphthalene -----

[2]

- 5(a) It is possible that developed near hot vents deep under the sea. At these hot vents geothermally heated water rich in minerals emerges from the ocean floor.

Bacteria evolve and synthesise carbohydrates using hydrogen sulfide from the hot vent.

These bacteria then form the basis of food chains for organisms such as tube worms.



Equation 34.1

Use the data in the table to find the enthalpy change of formation of glucose, $\text{C}_6\text{H}_{12}\text{O}_6$.

Substance	$\Delta_f H / \text{kJ mol}^{-1}$
H_2S	-20.6
CO_2	-393.5
H_2O	-285.8
S	0

$$\Delta_f H \text{ C}_6\text{H}_{12}\text{O}_6 = \dots\dots\dots \text{kJ mol}^{-1} \quad [3]$$

- (b) Analysis of water from a hot vent showed a variety of other minerals dissolved from the Earth's crust, such as copper chloride.

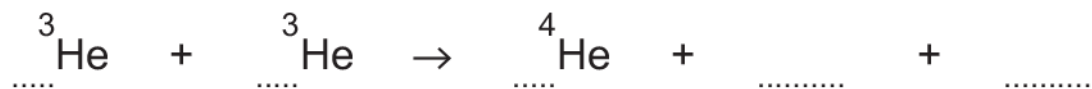
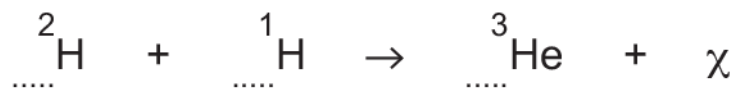
Give the electronic configuration of the chloride ion, using subshells and atomic orbitals.

----- [1]

(c) Over the years, Chemists have investigated the origins of the elements and how life on Earth began.

Helium is formed in the Sun by fusion reactions.

Complete the nuclear equations below to show how helium is formed.



[2]

6 Which row is correct?

	Species	Protons	Neutrons in isotope	Electrons
A	F ⁻	9	10	11
B	Ne	10	10	10
C	Na ⁺	11	10	11
D	Mg ²⁺	14	10	12

Your answer

[1]

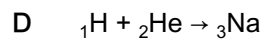
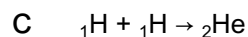
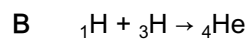
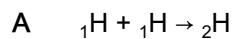
7 Which statement about p-orbitals is correct?

- A A p-orbital is spherical in shape.
- B A p-orbital can contain two electrons.
- C There are six p-orbitals in a p-subshell.
- D An element with outer configuration p² has both electrons in the same p-orbital.

Your answer

[1]

8 Which equation represents a possible fusion reaction?



Your answer

[1]

9 Some models of the structure of the atom are described below.

- 1 Atoms are spheres.
- 2 Atoms have a dense nucleus.
- 3 The electrons are arranged in shells.
- 4 Atoms have protons and electrons embedded in them.

Which row represents the historical sequence of these models, with the earliest first?

A	1	3	2	4
B	2	1	4	3
C	2	1	2	4
D	1	4	2	3

Your answer

[1]

10 An element forms ions with a charge of 3+.

What could be the electron configuration of the atoms of the element?

- A $1s^2 2s^2 2p^3$
- B $1s^2 2s^2 2p^6 3s^2 3p^6 3d^1 4s^2$
- C $1s^2 2s^2 2p^6 3p^1$
- D $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^3$

Your answer

[1]

11 Geiger and Marsden fired α -particles at a gold foil.

Which result did they observe?

- A All the α -particles were deflected slightly.
- B Most α -particles were not deflected but some were deflected slightly.
- C All the α -particles were deflected through large angles.
- D Most α -particles were not deflected but some were deflected through large angles.

Your answer

[1]

12 Which statement is correct about orbitals?

- A s-orbitals are circular.
- B Orbitals always contain two electrons
- C Al has an orbital containing a single electron.
- D A p-orbital can contain up to six electrons.

Your answer

[1]

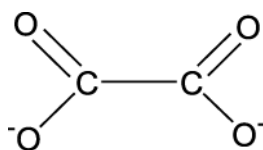
- 13 Which statement is correct about fusion reactions?
- A They occur at room temperature and pressure.
 - B They result in the formation of new elements.
 - C They only occur in stars.
 - D They only occur when a large nucleus collides with a small nucleus.

Your answer

[1]

- 14 *Bar Keeper's Friend* is a powdered cleaning agent invented over 100 years ago and still in use today. It is particularly effective at removing rust stains.

The active ingredients are the ethanedioate ion, shown below, and ethanedioic acid.



Ethanedioate ion

A student decides to investigate how *Bar Keeper's Friend* removes rust stains. The student finds that the ethanedioate ions act as bidentate ligands which form complexes with Fe^{3+} ions.

The student also investigates whether ethanedioic acid $(\text{COOH})_2$ undergoes a redox reaction with Fe^{3+} ions.

Half-reaction	$E^\ominus/V$
$2\text{CO}_2 + 2\text{H}^+ + 2\text{e}^- \rightleftharpoons (\text{COOH})_2$	-0.43
$\text{Fe}^{3+} + \text{e}^- \rightleftharpoons \text{Fe}^{2+}$	+0.77

- (i) Use data from the table to explain why $(\text{COOH})_2$ and Fe^{3+} ions react.

----- [2]

- (ii) Write an ionic equation for the reaction between $(\text{COOH})_2$ and Fe^{3+} in solution.

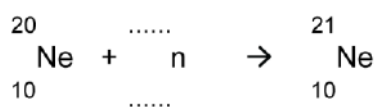
[2]

- (iii) Draw arrows in the appropriate boxes to show the outer electron configurations for Fe^{2+} and Fe^{3+} .

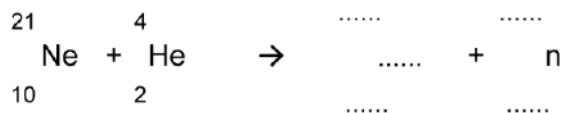
	3d	4s
Fe^{2+}		
Fe^{3+}		

15(a) Elements are formed in stars by fusion processes.

Complete the nuclear equations (by writing on the dotted lines) to show the formation of a new element.



Then



[2]

- (b) In 1869 a green emission line was seen in the Sun during an eclipse. At first this was thought to be caused by a new element. Later it was found to be due to a highly ionised form of iron, Fe^{13+} .

Suggest the electronic configuration of the Fe^{13+} ion in terms of sub-shells and atomic orbitals.

[1]

- 16 In the volcanic crater at Solfatara, near Naples, the air smells of sulfur dioxide. Crystals of sulfur can be seen on the ground, together with orange ammonium sulfide.

Ammonium sulfide crystals, $(\text{NH}_4)_2\text{S}$, are found in the volcanic crater.

- (i) Write the electron configuration (in terms of s and p sub-shells) for a sulfide ion, S^{2-} .

[1]

- (ii) Ammonium sulfide, $(\text{NH}_4)_2\text{S}$, reacts with sodium hydroxide to form sodium sulfide.

Suggest an equation for this reaction.

[2]

END OF QUESTION PAPER

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
1			D	1 (AO1.1)	
			Total	1	
2			B	1 (AO1.1)	
			Total	1	
3			sodium $2s^2 2p^6 3s^1$ ✓ magnesium ion $2s^2 2p^6$ ✓	2 (AO1.1×2)	must be correct order and lower case
			Total	2	
4		i	Carbon atoms contain 4 outer (shell) electrons ✓ sp^2 (orbitals) uses 3 electrons ✓	2(AO2.1 x 2)	<u>Examiner's Comments</u> These two questions assessed candidates' knowledge and understanding of bonding in organic molecules with particular emphasis on double bonds in alkenes and in conjugated systems. In part (i) candidates needed to be able to identify that the electrons involved in bonding in these systems came from the valence shell of the carbon atom. Therefore the first mark was for identifying that there were four electrons in the valence shell. Because there are three sp^2 hybrid orbitals the second mark was for then stating that three of the (valence) electrons would be used in the hybrid orbitals, therefore leaving one electron in an unhybridised p-orbital. In part (ii) candidates needed to state what happens to the unpaired electron in an alkene or a conjugated system i.e. in ethene it forms the π bond, whereas in naphthalene it becomes delocalised (across the conjugated system). Most candidates correctly identified what happens to the p-electron in the naphthalene structure, but often were not precise in their description of what happens in ethene, simply stating that it forms part of the double bond, and so did not score this mark.

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
		ii	ethene: form a π bond ✓ naphthalene: delocalised/conjugated ✓	2(AO1.1 x 2)	
			Total	4	

Mark Scheme

Question		Answer/Indicative content	Marks	Guidance
5	a	FIRST CHECK ANSWER ON ANSWER LINE If answer = $-1273.3 \text{ (kJmol}^{-1}\text{)}$ award 3 marks Correct multiplication of ΔH_f values ✓ $6(-285.8) + x - 6(-393.5) - 12(-20.6) = -379.9$ OR $x = -379.9 + 6(285.8) - 6(393.5) - 12(20.6)$ ✓ Evaluation with sign ✓	3 AO 2.6 x 3	Mp1 $6(-285.8) = -1714.8$ AND $6(-393.5) = -2361$ $12(-20.6) = -247.2$ OR $-2361 + -247.2 = -2608.2$ Mp2 Correct expression of correct ΔH values -893.4 scores 2 (no use of ΔH_f) (+)1273.3 scores 2 (Incorrect sign) (+) 839.4 scores 1 <u>Examiner's Comments</u> Many candidates scored the full 3 marks for this question even though there are many ways to make a mistake. The work was often well set out, so it was easy to give credit for correct parts. The most common sources of error were not using the overall enthalpy change or getting the incorrect sign for some of the terms.
	b	$1s^2 2s^2 2p^6 3s^2 3p^6$ ✓	1 AO 1.1	[Ne]... or [Ar] score 0. e numbers must be superscript and shell designation must be lower case. <u>Examiner's Comments</u> Almost half the candidates did not get this mark, despite a chloride ion being a relatively straightforward configuration. There were some instances of subscripts or upper-case letters, but the most common errors were giving the configuration of the atom, having not read the question carefully, or removing an electron from chlorine rather than adding one.

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
	c		${}^1_1\text{H} + {}^1_1\text{H} \rightarrow {}^2_2\text{He} + \gamma$ ${}^3_2\text{He} + {}^3_2\text{He} \rightarrow {}^4_2\text{He} + {}^1_1\text{H} + {}^1_1\text{H}$ The 2 product hydrogen atoms (correct numbers must be on the left) ✓ The rest correct ✓	2 AO 2.5 x 2	Mark each point separately Ignore γ but any other radiation is CON Use of 'p' instead of H is acceptable in the product NOT P <u>Examiner's Comments</u> Most candidates did not have difficulties filling the atomic numbers but some found working out the 2 hydrogen atoms more problematic.
			Total	6	
6			B	1	<u>Examiner's Comments</u> This question was very well done.
			Total	1	
7			B	1	
			Total	1	
8			C	1	<u>Examiner's Comments</u> This was generally well done, but B was a common incorrect response.
			Total	1	
9			D	1	
			Total	1	
10			B	1	
			Total	1	
11			D	1	
			Total	1	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
12			C	1	
			Total	1	
13			B	1	
			Total	1	
14		i	The $E^\ominus$ of $\text{CO}_2/(\text{COOH})_2$ half cell is more negative / less positive than that of the $\text{Fe}^{3+}/\text{Fe}^{2+}$ half cell ($\text{COOH})_2$ will release electrons / reduce Fe^{3+} OR Fe^{3+} will gain electrons / oxidise ($\text{COOH})_2$ ✓	2	ALLOW abbreviated descriptions of half cells as ' Fe^{3+} ' etc (since there are only two of them) IGNORE 'greater than', 'less than'
		ii	$2\text{Fe}^{3+} + (\text{COOH})_2 \rightarrow 2\text{Fe}^{2+} + 2\text{CO}_2 + 2\text{H}^+$ species ✓ balancing with correct species ✓	2	
		iii	Fe^{2+} double arrow in one 3d box, single arrows (same direction) in the other 3d boxes. 4s box empty ✓ Fe^{3+} single arrows in all 3d boxes (same direction). 4s box empty ✓	2	
			Total	6	
15	a		1 n in both equations ✓ 0 24 Mg ✓ 12	2	
	b		$\text{Fe}^{13+} 1s^2 2s^2 2p^6 3s^2 3p^1$ ✓	1	ALLOW capital letters but numbers must be superscript.
			Total	3	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
16		i	$1s^2 2s^2 2p^6 3s^2 3p^6$ / [Ne] $3s^2 3p^6$ ✓	1	ALLOW capital letters but electron numbers must be superscripts Examiner's Comments Only half the candidates scored here. Most of the others wrote the configuration of the S^{2+} ion, while some gave the configuration of a sulfur atom.
		ii	$(NH_4)_2S + 2NaOH \rightarrow 2NH_3 + Na_2S + 2H_2O$ Na_2S as a product ✓ completely correct ✓	2	ALLOW $(NH_4)_2S + 2NaOH \rightarrow 2NH_4OH + Na_2S$ IGNORE state symbols NOT formulae or equation containing ions formulae must be represented in conventional way but... ALLOW otherwise correct balanced equation forming $(Na)_2S$ for 1 mark Examiner's Comments Many candidates could write the correct formula for sodium sulfide and then could go on to write and balance an equation forming the sulfide and 'ammonium hydroxide' or ammonia and water. Candidates must be aware that chemists have definite conventions for writing formulae and that use of extraneous brackets, such as $(Na)_2S$ and $(NH_4)OH$ are not acceptable.
			Total	3	