01 Atomic Structure

Set B **Exam practice**

Name	Time 1 hour	Total 34 marks	Score ____ / 34

A Data Booklet may be used.

Marks by notes section For the marker: total each row. A score below the target means that section of the notes needs revising.

Notes section	Questions	Marks	Target	Score
1 Sub-atomic Particles	3, 4(a), 5	7	5	
2 Relative Masses of Atoms	12	5	3	
3 Shells, Subshells and Orbitals	2, 11	2	2	
4 Electronic Configuration	1, 7(a), 8(a)	4	3	
5 Ionisation Energy	4(b), 6, 7(b), 7(c), 8(b), 9, 10	16	10	

A Multiple choice

3 MARKS

(1) An element can be a semiconductor if

- one of its electronic levels is fully occupied (such as an s subshell), and
- the level just above it is only slightly higher in energy, and is empty or partly filled (such as a p subshell).

On this basis, which elements are expected to be semiconductors?

1 $_{31}Ga$
2 $_{34}Se$
3 $_{55}Cs$

A 1 only **B** 1 and 2 only **C** 2 and 3 only **D** 1, 2 and 3

Answer ☐ [1]

/1

Source: 2018 HCI J1 Promo P1 Q2

2 Which statement about the orbitals in a krypton atom is correct?

A The 1s and 2s orbitals have the same energy but are different in size.

B All 3d orbitals have the same shape.

C The 3d subshell has five orbitals of the same energy in an isolated atom.

D The second principal quantum shell (n = 2) has two subshells and three orbitals.

Answer [ ] [1]

/1

Source: CJC 2017 Promo, via EJC 2022 Atomic Structure Topical Revision, Q6

3 Nuclear theories predict that nuclei with these numbers of protons, or of neutrons, are especially stable: 2, 8, 20, 28, 50, 82, 126. The most stable nuclei have one of these numbers of protons and one of these numbers of neutrons.

Which isotope is the most stable?

A ^{2}He **B** ^{8}Be **C** ^{40}Ca **D** ^{210}Pb

Answer [ ] [1]

/1

Source: 2022 HCI J1 Promo P1 Q1

B Structured questions

31 MARKS

4 The deuteron is the nucleus of deuterium, $^{2}_{1}D$.

(a) Compare and account for the behaviour of protons, hydrogen atoms and deuterons in an electric field.

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..... [2]

(b) Suggest a value for the enthalpy change to form 1 mol of deuterons from deuterium atoms. Explain your answer.

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..... [2]

/4

Source: 2024 RVHS J2 Prelim P2 Q1(a)

5 COMMON Particles travelling at the same speed through an electric field of constant strength are deflected through an angle proportional to their charge to mass ratio. In one set-up, protons are deflected through +15°.

(a) Calculate the angle of deflection of $^{4}He^{2+}$ under the same conditions.

[1]

(b) A beam of particles A, each with 12 times the mass of a proton, is deflected through +5° under the same conditions. Suggest the overall charge on a particle of A.

[1]

(c) A particle of A contains 6 protons. Deduce the number of neutrons and of electrons in a particle of A.

[2]

/4

Source: 2022 JPJC J1 Year End P2 Q1(a)(iii) to (v)

6 COMMON Element A is in Period 4. Its first eight ionisation energies, in kJ mol^{-1}, are

947 1798 2735 4837 6043 12 310 14 300 16 800

(a) Identify element A and explain your answer.

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[2]

(b) Explain the difference between the first ionisation energy of A and that of the element to its right in the Periodic Table.

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[2]

/4

Source: 2024 NJC J2 Prelim P2 Q1(a)

7 **(a)** Write the full electronic configuration of an aluminium atom.

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[1]

(b) Write an equation to show the third ionisation energy of aluminium.

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[1]

(c) COMMON Explain why the third ionisation energy of aluminium is greater than the first ionisation energy of sodium.

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[2]

/4

Source: 2024 VJC J2 Prelim P2 Q1(b)

8 Iron, copper and zinc are in Period 4 of the Periodic Table.

(a) Complete the electronic configurations of Cu^+ and Zn^+.

Cu^+: $1s^2\ 2s^2\ 2p^6$ .....

Zn^+: $1s^2\ 2s^2\ 2p^6$ ..... [2]

(b) With reference to your answer to (a), suggest why the second ionisation energy of copper is higher than that of zinc.

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[2]

/4

Source: 2022 HCI J1 Promo P2 Q1(b)

9 **(a)** COMMON Explain what is meant by the term first ionisation energy.

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[1]

(b) Use your knowledge of the first ionisation energies of the Period 3 elements to predict and explain how the first ionisation energies of bromine and krypton compare.

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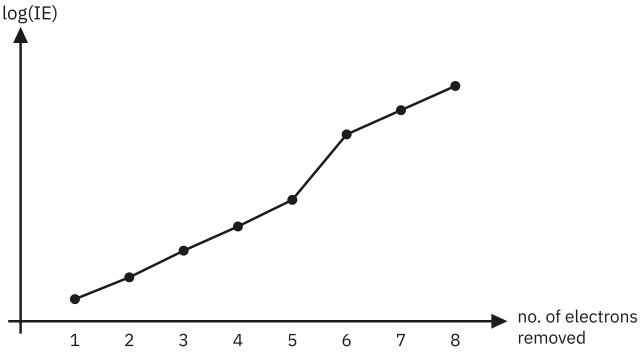
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[2]

/3

Source: 2024 HCI J2 Prelim P2 Q1(b), adapted

10 The graph below shows a sketch of the logarithm of the first eight ionisation energies, log(IE), of element A in Period 3. Deduce the identity of element A.



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[2]

/2

Source: 2021 RVHS J1 Common Test P2 Section A Q1(c)

11 Draw labelled diagrams of the d_{xy} and $d_{x^2-y^2}$ orbitals on separate axes.

[1]

/1

Source: 2023 RI J2 Prelim P3 QA2(c)(i)

12 CHALLENGE Sulfur in volcanic gases is mainly a mixture of the isotopes ^{32}S and ^{34}S. A sample enriched in ^{32}S comes from deep mantle degassing (gas released from magma deep in the Earth's mantle), while a sample enriched in ^{34}S comes from recycled hydrothermal sources.

(a) 1.994 g of SO_2 collected at a volcano gave 1.00 g of sulfur, a mixture of ^{32}S and ^{34}S. Calculate the percentage by mass of ^{32}S in the sulfur. Use relative isotopic masses of 32 and 34, and $A_r(O) = 16$.

[3]

(b) Hence suggest the likely origin of the sulfur sample.

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[1]

(c) Naturally occurring sulfur has the isotopic composition below. Calculate the A_r of sulfur to two decimal places.

isotope	^{32}S	^{33}S	^{34}S	^{36}S
relative isotopic mass	31.972	32.971	33.968	35.967
abundance / %	95.02	0.75	4.21	0.02

[1]

/5

Source: 2025 EJC J2 Prelim P2 Q1(b)