12.1 Electrons in Atoms

Question Paper

Course	DP IB Chemistry
Section	12. Atomic Structure (HL only)
Topic	12.1 Electrons in Atoms
Difficulty	Hard

Time allowed: 60

Score: /43

Percentage: /100

Question 1a

a)
Successive ionisation energies provide evidence for the arrangement of electrons in atoms. In the table below the successive ionisation energies of oxygen are given.

Ionisation number	1	2	3	4	5	6	7	8
Ionisation energy ($kJ\ mol^{-1}$)	1314	3388	5301	7469	10989	13327	71337	84080

i)
Give the equation, including state symbols for the **third** ionisation energy of oxygen.

[2]

ii)
Explain how this data shows evidence of two energy shells in oxygen.

[2]

[4 marks]

Question 1b

b)
Amorphous(unorganized solid form) boron is used as a rocket fuel igniter and in pyrotechnic flares.

i)
Write an equation, including state symbols to show the process that occurs for first ionisation of boron, B.

[1]

ii)
Suggest why the ionisation energy of boron is lower than that of beryllium going against the general trend in ionisation energies across the period.

[2]

[3 marks]

Question 1c

c)
Using the table in part (a) and sections 1 and 2 of the data booklet, calculate the wavelength, in nm, of the convergence limit in the spectral lines of an oxygen atom.

[2]

[2 marks]

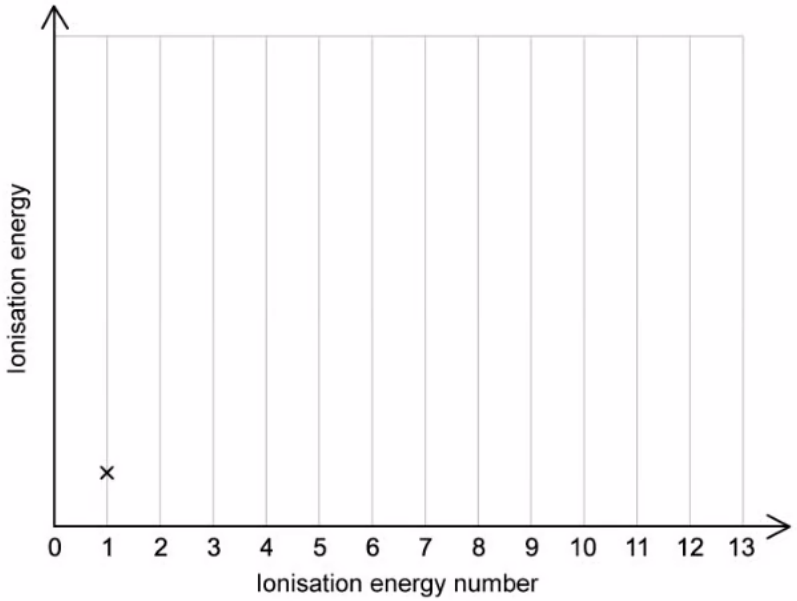
Question 2a

a)

Aluminium has 13 successive ionisation energies.

On the figure below, add crosses to show the 13 successive ionisation energies of aluminium. The value for the first ionisation energy is already completed.

You do not have to join the crosses.



[2]

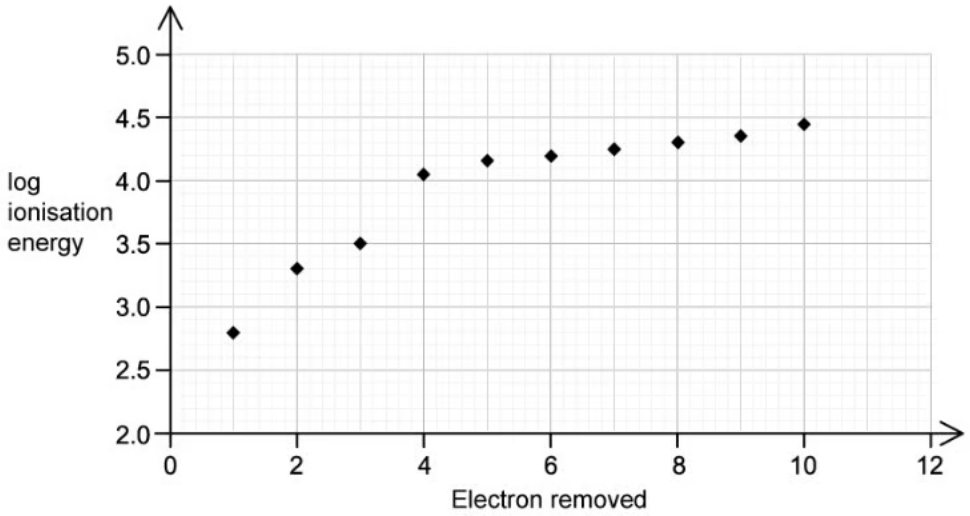
[2 marks]

Question 2b

b)

This question is about ionisation energies of an element, **X**.

The figure below represents the log of the first ten successive ionisation energies of **X** plotted against the number of electrons removed.



State the group of the periodic table where element **X** is found.

[1]

[1 mark]

Question 2c

c)

Element **A** has the following first six ionisation energies in kJ mol^{-1}.

577, 1820, 2740, 11 600, 14 800, 18 400

i)

Explain how you know that element **A** is in group 3 of the periodic table.

[1]

ii)

Two elements **B** and **C** are in the same period as **A**, but **B** is in the group before **A** and **C** is in the group after **A** in the periodic table.

Give approximate first ionisation energies for elements **B** and **C**.

[1]

iii)

Explain, using ideas of electronic structure, the difference in ionisation energy values of element **A** compared to elements **B** and **C**.

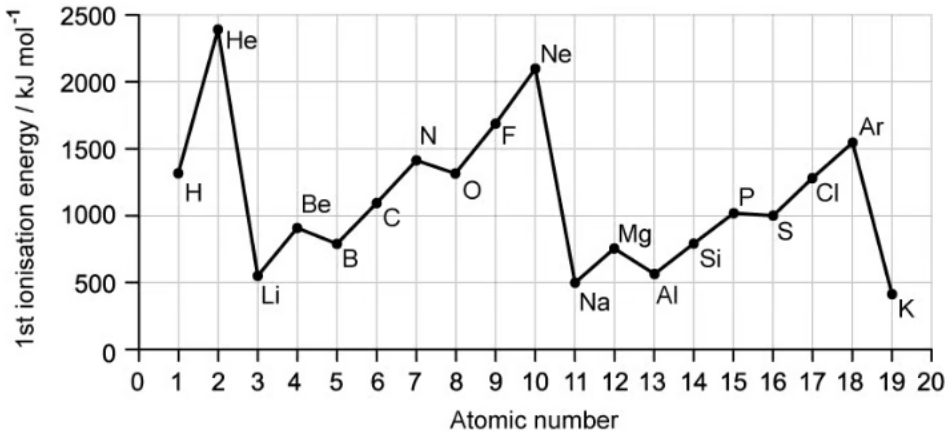
[2]

[4 marks]

Question 3a

a)

The first ionisation energies of the elements H to K are shown below in the figure below



State and explain the trend in first ionisation energies shown by the elements with the atomic numbers 2, 10 and 18.

[4]

[4 marks]

Question 3b

b)

Compound **J** reacts with chlorine. The first five successive ionisation energies for an element **J**, are shown in the table below.

Energy number	1st	2nd	3rd	4th	5th
Ionisation energy value / kJ mol^{-1}	738	1450	7733	10543	13630

State the formula of the compound when element **J** reacts with chlorine.

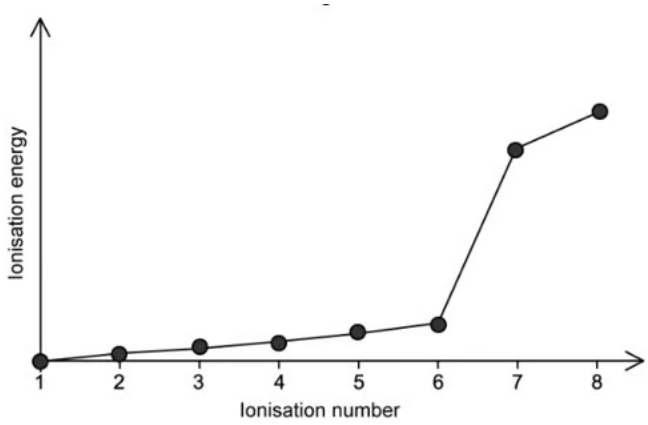
[1]

[1 mark]

Question 3c

c)

The figure below shows the successive ionisation energies for a period 2 element.



With reference to electronic structures, state the identity of this element and explain your answer.

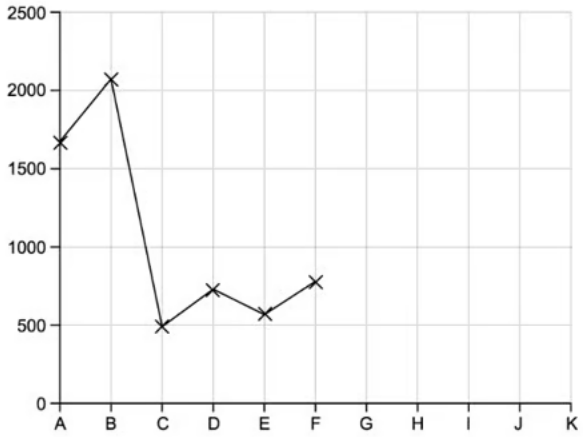
[2]

[2 marks]

Question 4a

a)

Electrons in atoms occupy orbitals. The figure below shows the first ionisation energies for six consecutive elements labelled **A**–**F** in kJ mol^{-1}.



i)

Complete the graph of the first ionisation energies for the next five elements.

[3]

ii)

Explain why the value of the first ionisation energy for D is greater than for C.

[2]

[5 marks]

Question 4b

b)
The sequence of the first three elements in the Periodic Table is hydrogen, helium and then lithium.

Explain why the first ionisation energy of hydrogen is less than that of helium but greater than that of lithium.

[4]

[4 marks]

Question 4c

c)
Using the figure in part (a) and sections 1 and 2 of the data booklet, calculate the frequency, in THz, of the convergence limit of a single atom of element C.
The prefix Tera, T, corresponds to a power of 10^{12}.

[1]

[1 mark]

Question 5a

a)
The table below shows the successive ionisation energies of an unknown element, **X**.

Ionisation number	Ionisation energy / kJ mol^{-1}
1st	578
2nd	1817
3rd	2745
4th	11577
5th	14842
6th	18379

Deduce the group number and identity of element **X** and explain your answer with reference to its electron configuration.

[3]

[3 marks]

Question 5b

b)
First ionisation energies decrease down groups in the Periodic Table.

Explain this trend and the effect on the reactivity of groups containing metals.

[3]

[3 marks]

Question 5c

c)
The ionisation energy values show a general increase across period 4 from gallium to krypton.

i)
State and explain how selenium deviates from this trend.

[3]

ii)
Give one other element from period 2 or 3 which also deviates from this general trend, similar to selenium.

[1]

[4 marks]