F321: Atoms, Bonds and Groups
Periodicity

1. Modern plasma television screens emit light when mixtures of noble gases, such as neon and xenon, are ionised.

The first ionisation energies of neon and xenon are shown in the table below.

element	1st ionisation energy / kJ mol^{-1}
neon	+2081
xenon	+1170

Explain why xenon has a lower first ionisation energy than neon.

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[Total 3 marks]

2. Chemists use the Periodic Table to predict the behaviour of elements.

Early attempts at developing a Periodic Table arranged elements in order of increasing atomic mass.

(i) State which two elements from the **first twenty** elements of the modern Periodic Table are not arranged in order of increasing atomic mass.

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[1]

(ii) Why does the modern Periodic Table **not** arrange some elements, such as those

in (i), in order of increasing atomic mass?

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[1]

[Total 2 marks]

3. The table below shows the melting points and atomic radii of the elements in Period 3, Na to C*l*.

element	Na	Mg	A*l*	Si	P	S	C*l*
melting point / °C	98	639	660	1410	44	113	–101
atomic radius / pm	186	160	143	118	110	102	99

1pm = 1 x 10^{-12} m

(a) (i) Explain the difference in melting point for the elements Na and Mg.

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[3]

(ii) Sulfur exists as S_8 molecules and chlorine as Cl_2 molecules. Use this information to explain the difference in their melting points.

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[2]

(b) Explain the decrease in the atomic radii across the period from Na to C*l*.

In your answer, you should use appropriate technical terms, spelt correctly.

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[3]

[Total 8)

4. (i) Explain why the first ionisation energies show a general increase from Li to Ne.

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[3]

(ii) Explain the difference between the first ionisation energies of Li and Na.

In your answer, you should use appropriate technical terms, spelt correctly.

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[3]

[Total 6 marks]

5. This question refers to the elements in the first four periods of the Periodic Table.

							H										He
Li	Be											B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr

Identify an element from the first four periods that fits each of the following descriptions.

(i) The element that forms a 2– ion with the same electronic configuration as Ar.

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[1]

(ii) The element that forms a 3+ ion with ten electrons.

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[1]

(iii) An element that forms a compound with fluorine with trigonal planar molecules.

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[1]

(iv) The element that forms a chloride XCl_2 with a molar mass of 111.1 g mol^{-1}.

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[1]

(v) The element with the largest atomic radius.

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[1]

(vi) The element with the smallest first ionisation energy.

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[1]

[Total 6 marks]

6. This question refers to the elements in the first four periods of the Periodic Table.

							H										He
Li	Be											B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr

Ionisation energies provide information about the model for the electron structure of elements.

(i) Explain why first ionisation energies show a general increase across Period 3, Na–Ar.

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[3]

(ii) Write an equation, including state symbols, to represent the third ionisation energy of sodium.

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[1]

(iii) Element **X** is in Period 3 of the Periodic Table, Na–Ar.

The first six ionisation energies of an element **X** are shown below.

ionisation number	1st	2nd	3rd	4th	5th	6th
ionisation energy /kJ mol–1	789	1577	3232	4 556	16091	19 785

Predict, with reasons, the identity of element **X**.

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[2]

[Total 6 marks]

7. In a mass spectrometer, gaseous atoms are ionised.

Explain why less energy is needed to ionise gaseous atoms of rubidium than gaseous atoms of sodium.

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[Total 3 marks]

8. Barium, Ba, was discovered by Davy in 1808. The element gets its name from the Greek 'barys' meaning 'heavy'.

The table below compares some properties of barium with caesium.

element	Cs	Ba
group	1	2
atomic number	55	56
atomic radius / pm	531	435

(i) Why do caesium and barium have different atomic numbers?

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[1]

(ii) State the block in the Periodic Table in which caesium and barium are found.

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[1]

(iii) Explain why the atomic radius of barium is **less** than the atomic radius of caesium.

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[3]

(iv) Predict and explain whether a barium **ion** is *larger*, *smaller* or the *same size* as a barium **atom.**

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[2]

[Total 7 marks]

9. In this question, you are provided with information about ionisation energies of elements. You are also provided with some additional information that will help you answer part (b).

(a) Define the term *first ionisation energy.*

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[3]

(b) In this question, one mark is available for the quality of use and organisation of scientific terms.

Table 1 provides data on elements in **Period 2** of the Periodic Table.

Table 2 shows the first 6 successive ionisation energies of an element **X**, which is in **Period 3** of the Periodic Table.

- Using Table 1, describe and explain the trend in first ionisation energies shown by the Period 2 elements, Li–N.
- Using Table 2, identify element **X**. Explain how you decided on your answer.

[10]

element	Li	Be	B	C	N
number of protons	3	4	5	6	7
electron configuration	$1s^2\,2s^1$	$1s^2\,2s^2$	$1s^2\,2s^2\,2p^1$	$1s^2\,2s^2\,2p^2$	$1s^2\,2s^2\,2p^3$
1st ionisation energy / kJ mol^{-1}	520	900	801	1086	1402

Table 1

element	ionisation energy / kJ mol^{-1}					
	1st	2nd	3rd	4th	5th	6th
X	578	1817	2745	11 578	14 831	18 378

Table 2

[Total 13 marks]

10. In this question, one mark is available for the quality of spelling, punctuation and grammar.

Many physical properties can be explained in terms of bonding and structure. The table below show some properties of elements in Period 2 of the Periodic Table.

element	Li	C (graphite)	N
electrical conductivity of solid	good	good	poor
boiling point / °C	1342	4000	–196

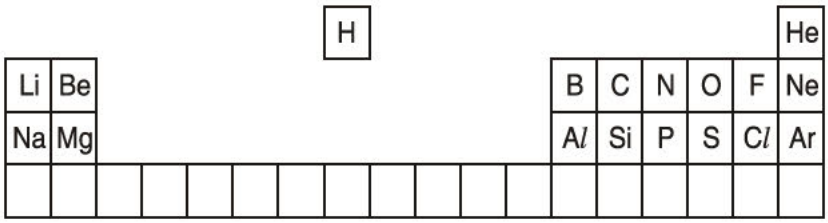
Explain these properties in terms of bonding and structure.

[11]

Quality of Written Communication [1]

[Total 12 marks]

11. This question refers to the elements in the first three periods of the Periodic Table:



Identify an element from the first three periods that fits each of the following descriptions.

(i) The element that forms a 2– ion with the same electronic configuration as Ne.

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[1]

(ii) The element that forms a 3+ ion with the same electronic configuration as Ne.

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[1]

(iii) The element that has the electronic configuration $1s^2 2s^2 2p^6 3s^2 3p^3$.

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[1]

(iv) An element that forms a compound with hydrogen with tetrahedral molecules.

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[1]

(v) An element that forms a compound with hydrogen with pyramidal molecules.

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[1]

(vi) The element that forms a chloride XCl_2 with a molar mass of 95.3 g mol^{-1}.

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[1]

(vii) The element with the largest atomic radius.

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[1]

(viii) The element in Period 3 with the highest boiling point.

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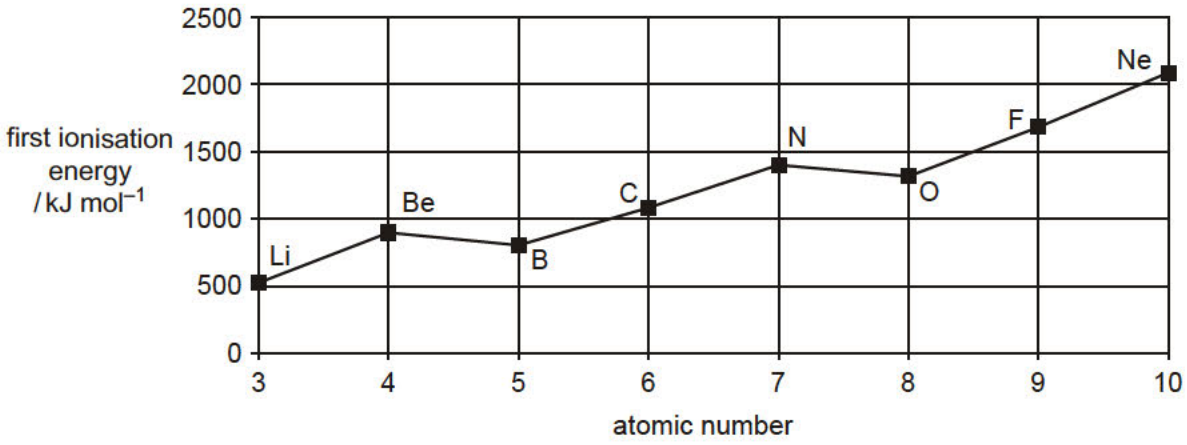
[1]

[Total 8 marks]

12. The diagram below shows the variation in the first ionisation energies of elements across Period 2 of the Periodic Table.



(i) Define the term *first ionisation energy*.

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[3]

(ii) Explain why the first ionisation energies show a **general** increase across Period 2.

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[2]

(iii) Explain why the first ionisation energy of B is **less** than that of Be.

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[2]

[Total 7 marks]

13. Reactions of the Group 2 metals involve removal of electrons. The electrons are removed more easily as the group is descended and this helps to explain the increasing trend in reactivity.

(i) The removal of one electron from each atom in 1 mole of gaseous radium atoms

is called the .....

[2]

The equation for this process in radium is:

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[2]

(ii) Atoms of radium have a greater nuclear charge than atoms of calcium.

Explain why, despite this, **less** energy is needed to remove an electron from a radium atom than from a calcium atom.

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[3]

[Total 7 marks]

14. The atomic radii of nitrogen and oxygen are shown below.

element	nitrogen	oxygen
atomic radius/nm	0.075	0.073

Explain why a nitrogen atom is larger than an oxygen atom.

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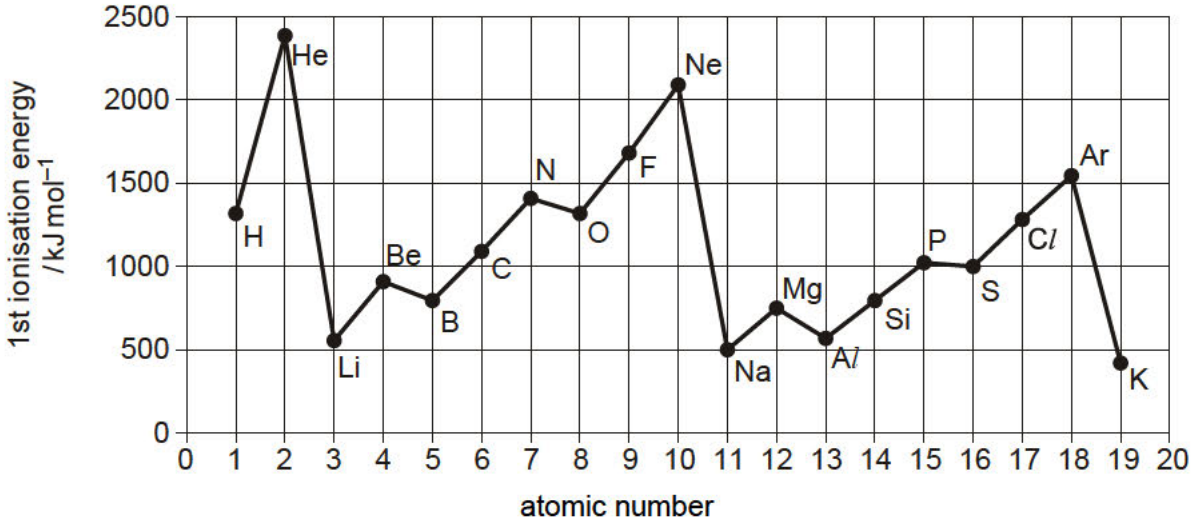
[Total 4 marks]

15. The first ionisation energies of the elements H to K are shown below. Use this diagram to help with your answers to this question.



(a) Define the term *first ionisation energy*.

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[3]

(b) Explain why the first ionisation energies show a **general** increase across Period 2 (Li to Ne).

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[2]

[Total 5 marks]

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

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[Total 4 marks]