Atomic Structure and the Periodic Table - Questions by Topic

Q1.

This question is about compounds containing chlorine.

(a) A precipitate of silver chloride is formed when silver nitrate solution reacts with sodium chloride solution.

A student wrote an ionic equation for the reaction.

$$Ag^{2+}(l) + 2Cl^{-}(l) \rightarrow AgCl_2(s)$$

Explain why this equation is incorrect, even though it is balanced.

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(b) A sample of a compound is analysed and found to contain **only** 3.09 g carbon, 0.26 g hydrogen and 9.15 g chlorine.

The molar mass of the compound is 97.0 g mol^{-1}.

Calculate the molecular formula of this compound.

You **must** show your working.

(3)

(c) Nitrogen trichloride has the formula NCl_3.

(i) A sample of nitrogen trichloride contained only nitrogen atoms with mass number 14, and chlorine atoms with mass numbers 35 and 37.

Give the formula and mass/charge ratio for each of the **four** ions responsible for the molecular ion peaks in the mass spectrum of nitrogen trichloride.

(2)

(ii) Complete the table to predict the shape and Cl—N—Cl bond angle in nitrogen trichloride.

(3)

Number of bonding pairs of electrons on nitrogen	
Number of lone pairs of electrons on nitrogen	
Shape of molecule	
Cl—N—Cl bond angle	

(Total for question = 10 marks)

Q2.

This question is about nitrogen.

(a) The table shows the successive ionisation energies of nitrogen.

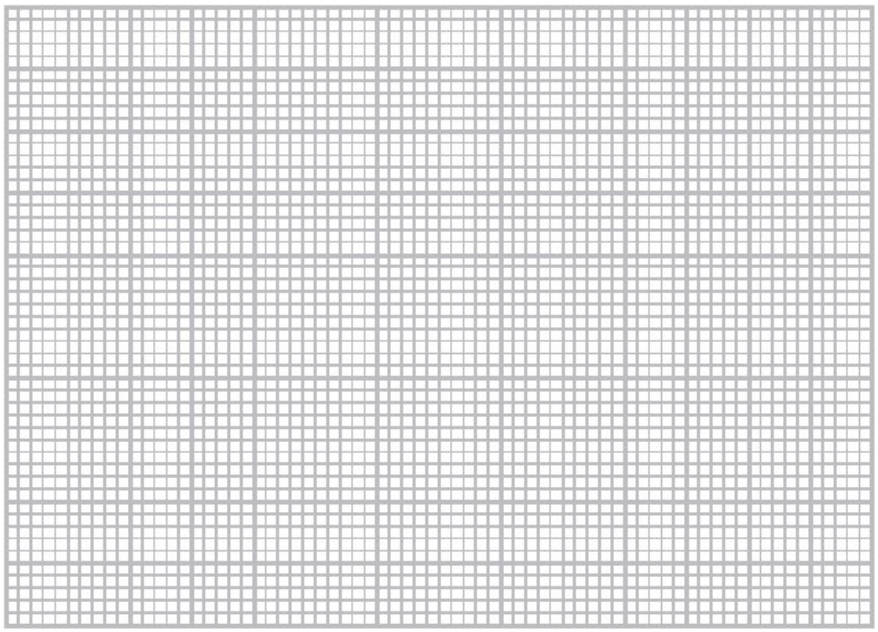
Ionisation number	Ionisation energy / kJ mol^{-1}	log (ionisation energy)
1	1402	3.15
2	2856	3.46
3	4578	3.66
4	7475	3.87
5	9445	3.98
6	53268	
7	64362	

(i) Complete the table.

(1)

(ii) Plot a graph of log (ionisation energy) against ionisation number.

(3)



(iii) Give a reason why the logarithm of the ionisation energy, rather than just the ionisation energy, is used to plot this graph.

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(iv) Explain what can be deduced from the graph about the electronic structure of nitrogen.

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(v) Explain why the first ionisation energy of oxygen is lower than that of nitrogen.

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(b) Nitrogen gas consists of nitrogen molecules.

(i) Draw a dot-and-cross diagram to show the bonding in a molecule of nitrogen.

(1)

(ii) Calculate the number of nitrogen **atoms** in 5.60 g of nitrogen gas.

[Avogadro constant = $6.02 \times 10_{23}$ mol^{-1}]

(2)

(iii) A sample of nitrogen gas occupied 108 cm^3 at a temperature of 25 °C and a pressure of 1.36×10^5 Pa.

Using the ideal gas equation, calculate the number of moles of nitrogen gas in this sample.

[$pV = nRT$ $R = 8.31$ J mol^{-1} K^{-1}]

(4)

(Total for question = 18 marks)

Q3.

This question is about bromine.

(a) Complete the electronic configuration for a bromine atom, using the s, p, d notation.

(1)

[Ar] .....

(b) Bromine exists as two isotopes with mass numbers 79 and 81.

(i) Complete the table to show the numbers of subatomic particles in a ^{79}Br atom and a $^{81}Br^-$ ion.

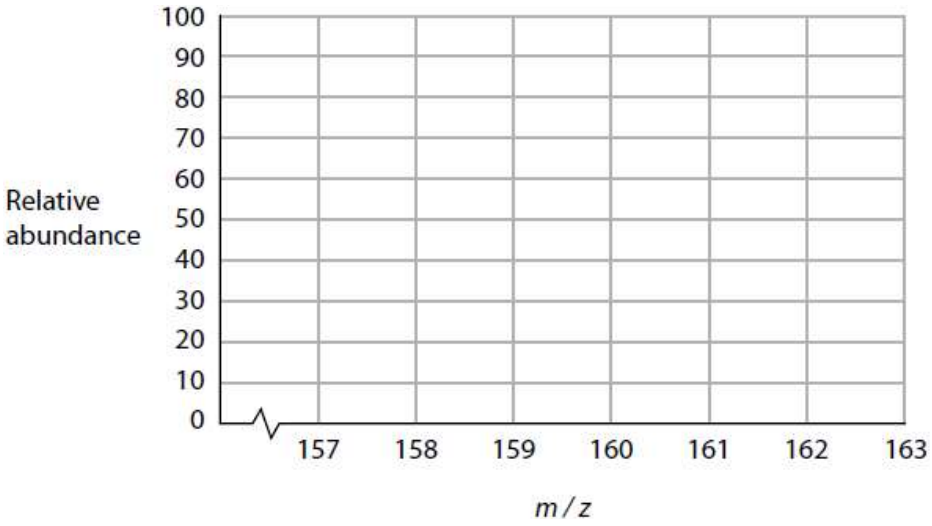
(2)

Species	Protons	Neutrons	Electrons
^{79}Br			
$^{81}Br^-$			

(ii) A sample of bromine contained equal amounts of the two isotopes.

Complete the mass spectrum to show the peaks you would expect for Br_2^+ from this sample of bromine gas.

(2)



(iii) Calculate the number of bromine molecules in 2.00 g of Br_2.

[Avogadro constant = 6.02×10^{23} mol^{-1}]

(2)

Number of molecules = ...

(c) A sample of bromine gas occupied 200 cm^3 at a temperature of 77 °C and a pressure of 1.51×10^5 Pa.

Calculate, using the ideal gas equation, the amount in moles of bromine molecules in this sample.

[$pV = nRT$ $R = 8.31$ J mol^{-1} K^{-1}]

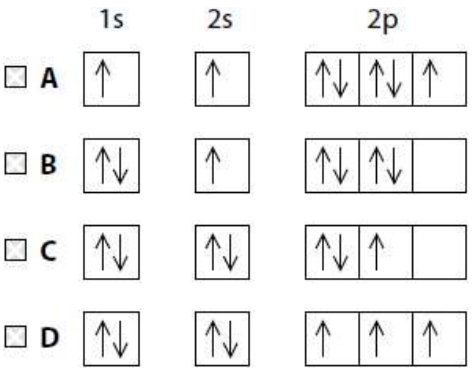
(4)

Amount of bromine molecules = ... mol

(Total for question = 11 marks)

Q4.

Which is the electronic configuration of nitrogen?



(Total for question = 1 mark)

Q5.

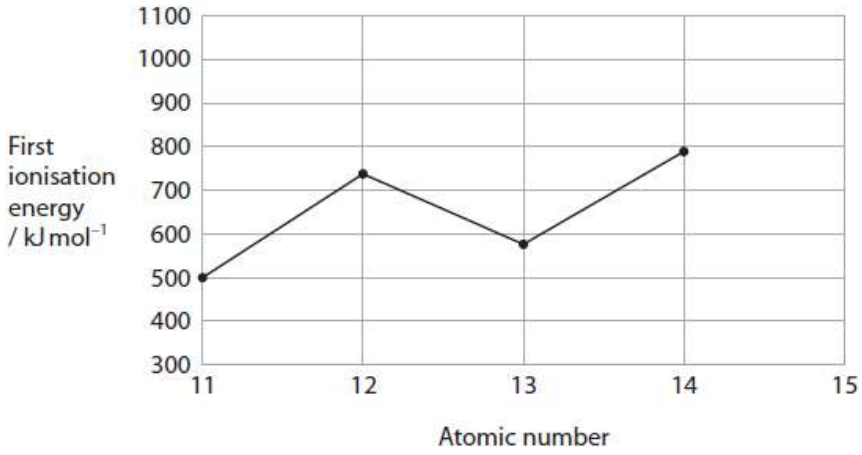
What are the maximum numbers of electrons in a 2p orbital and in the third quantum shell?

	Maximum number of electrons in a 2p orbital	Maximum number of electrons in the third quantum shell
☐ A	2	8
☐ B	2	18
☐ C	6	8
☐ D	6	18

(Total for question = 1 mark)

Q6.

The diagram shows the first ionisation energy for the elements from sodium to silicon.



What is the approximate first ionisation energy, in kJ mol^{-1}, of phosphorus (atomic number 15)?

☒ **A** 400

☒ **B** 500

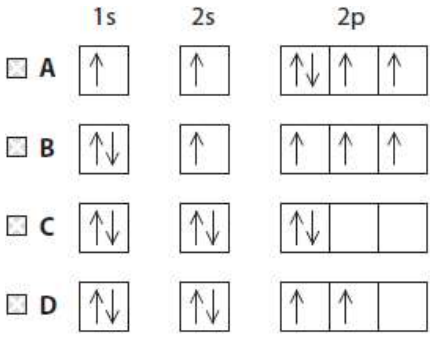
☒ **C** 700

☒ **D** 1000

(Total for question = 1 mark)

Q7.

Which is the electronic configuration of a carbon atom in its ground state?



(Total for question = 1 mark)

Q8.

The first six ionisation energies of an element, in kJ mol^{-1}, are shown.

578 1817 2745 11578 14831 18378

Which group of the Periodic Table includes this element?

☐ **A** Group 2

☐ **B** Group 3

☐ **C** Group 4

☐ **D** Group 5

(Total for question = 1 mark)

Q9.

What is the maximum number of electrons in the 3p subshell, and in the third quantum shell of an atom?

	Maximum number of electrons in the 3p subshell	Maximum number of electrons in the third quantum shell
☐ **A**	2	8
☐ **B**	2	18
☐ **C**	6	8
☐ **D**	6	18

(Total for question = 1 mark)

Q10.

The hydroxide ion, OH^-, has a total of 9 protons.

How many neutrons and electrons are there in this ion?

	Number of neutrons	Number of electrons
☐ **A**	8	8
☐ **B**	8	10
☐ **C**	9	8
☐ **D**	9	9

(Total for question = 1 mark)

Q11.

A sample of silicon contains the following isotopes.

Isotope	Percentage abundance
^{28}Si	81.21
^{29}Si	14.10
^{30}Si	4.69

What is the relative atomic mass of silicon, to one decimal place, in this sample?

☐ **A** 28.0

☐ **B** 28.2

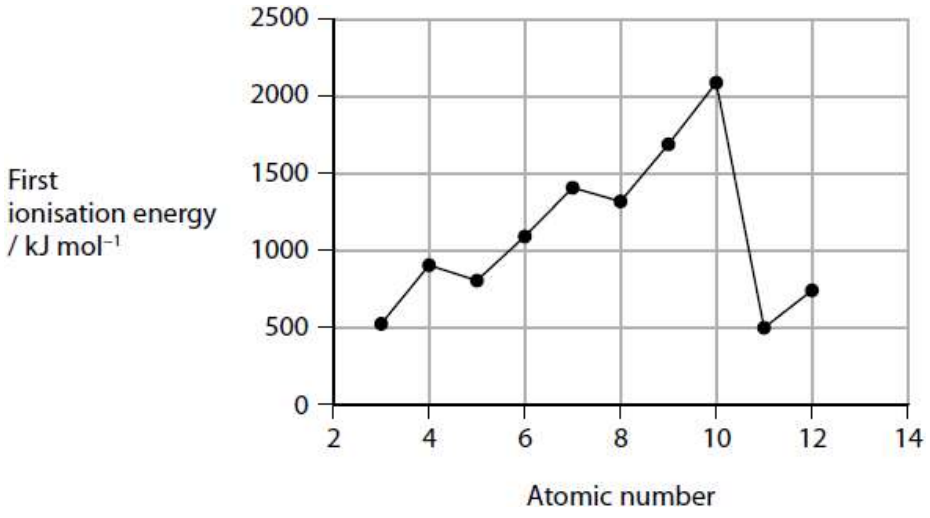
☐ **C** 29.0

☐ **D** 29.8

(Total for question = 1 mark)

Q12.

The graph shows the first ionisation energies for the elements with atomic numbers from 3 to 12.



(a) Write the equation for the first ionisation energy of nitrogen. Include state symbols.

(2)

(b) Explain the changes in first ionisation energy for the elements with atomic numbers from 3 to 10.

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(c) Explain why the first ionisation energy of element 11 is lower than that of element 3.

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(Total for question = 8 marks)

Q13.

Data from the mass spectrum of a sample of pure iron is given in the table.

m / *z*	Relative peak height
28	0.1
54	6.3
56	100.0
57	2.4
58	0.3

Which species is most likely to cause the peak at $m/z = 28$?

(1)

☐ **A** $^{28}Fe^{+}$

☐ **B** $^{56}Fe^{2+}$

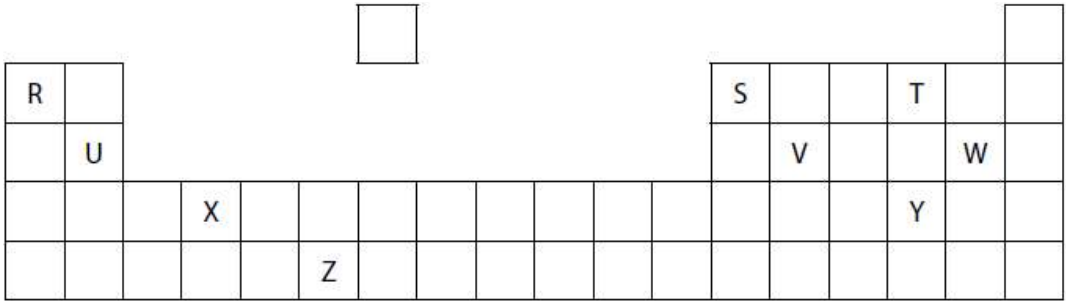
☐ **C** $^{28}Si^{+}$

☐ **D** $^{84}Sr^{3+}$

(Total for question = 1 mark)

Q14.

An outline of part of the Periodic Table is shown.
The letters are not the usual symbols of the elements.



(a) Which elements are in the s-block of the Periodic Table?

(1)

☒ **A** R and U

☒ **B** T and Y

☒ **C** V and W

☒ **D** X and Z

(b) Which element has four occupied quantum shells, with six electrons in the outermost shell?

(1)

☒ **A** V

☒ **B** X

☒ **C** Y

☒ **D** Z

(c) In which pair do the ions have the same electronic configuration?

(1)

☒ **A** R^{+} and T^{2-}

☒ **B** T^{2-} and Y^{2-}

☒ **C** U^{2+} and T^{2-}

☒ **D** U^{2+} and W^{-}

(Total for question = 3 marks)

Q15.

This question is about phosphorus and sulfur.

Which species contains 15 protons, 16 neutrons and 18 electrons?

(1)

- ☐ **A** P^{3-}
- ☐ **B** P^{3+}
- ☐ **C** S^{2-}
- ☐ **D** S^{2+}

(Total for question = 1 mark)

Q16.

A sample of neon contains the following isotopes.

Isotope	Percentage abundance
^{20}Ne	90.92
^{21}Ne	0.26
^{22}Ne	8.82

What is the relative atomic mass of neon to two decimal places?

(1)

- ☒ **A** 20.00
- ☒ **B** 20.09
- ☒ **C** 20.18
- ☒ **D** 21.00

(Total for question = 1 mark)