F321: Atoms, Bonds and Groups Electron Structure

84 Marks

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

		[Total 3 m
T I I		
The ele	ectron configuration of bromine contains outermost electrons in the 4th sh	ell.
	your knowledge of Group 7 elements, complete the electron configuration	
Using y	your knowledge of Group 7 elements, complete the electron configuration	of

Amm	nonia reacts with hydrogen chloride, HCl, to form ammonium chloride, NH ₄ Cl.	
NH ₄ 0	Cl is an ionic compound containing NH_4^+ and Cl^- ions.	
(i)	Complete the electron configuration of the $C\Gamma$ ion.	
	1s ²	
		[1]
(ii)	Draw a 'dot-and-cross' diagram to show the bonding in NH ₄ ⁺ .	
	Show outer electrons only.	
		[1]
		ניו
(iii)	State the shape of, and bond angle in, an NH_4^+ ion.	
()	shape:	
	bond angle:	
		[2]

3.

(iv) A student investigated the conductivity of ammonium chloride.

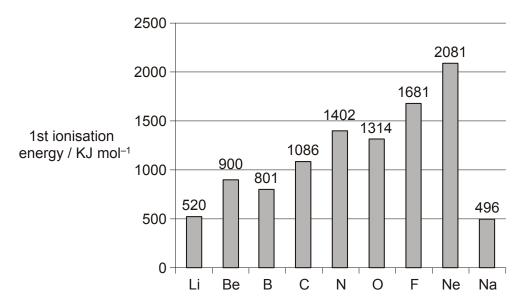
She noticed that when the ammonium chloride was solid it did **not** conduct electricity. However, when ammonium chloride was dissolved in water, the resulting solution did conduct electricity.

Explain these observations.	

[2] [Total 6 marks]

4. Ionisation energies have been used to develop the model of the atom.

The first ionisation energies of the elements Li to Na are shown in the figure below.



Defi	ne the term first ionisation energy.	
		•
		[Total 3 ma
	first ionisation energy of oxygen is 1314 kJ mol ⁻¹ and the second ionisation e	energy
of ox	kygen is 3388 kJ mol ⁻¹ .	
(i)	Write an equation to represent the second ionisation energy of oxygen.	
	Include state symbols.	
(ii)	Suggest why the second ionisation energy of oxygen has a greater value th	an
	the first ionisation energy of oxygen.	
		[Total 2 ma
	Periodic Table is a table of elements arranged in order of atomic number. The nents are classified into blocks.	e
(i)	State what is meant by the term atomic number.	
(ii)	Complete the full electron configuration for a titanium atom.	
` '	1s ²	
	15	••

		State which blo	ock this element is	s in.		
		element		block		
						[1] [Total 3 marks]
7.			nt bromine was dis k <i>bromos</i> meanin		d in 1826. Bromir	ne gets its
	Bron	nine consists of	a mixture of two is	sotopes, ⁷⁹ Br and	⁸¹ Br.	
	(i)	What is meant	by the term isoto	pes?		
						[1]
	(ii)	Complete the t	able below to sho	w the atomic stru	ctures of the bron	
			protons	neutrons	electrons	
		⁷⁹ Br				
		⁸¹ Br				
						[2]
	(iii)	Write the full e	lectronic configura			
			1	s ²		[1]
						[Total 4 marks]
8.	Elect	trons are arrang	ed in energy leve	ls.		
	(a)	An orbital is a	region in which ar	n electron may be	found.	
		Draw diagrams	s to show the shap	pe of an s orbital	and of a p orbital.	

Plymstock School 5

p orbital

[2]

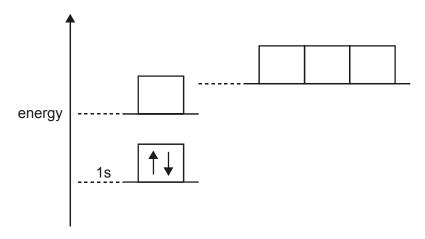
s orbital

(b) Complete the table below to show how many electrons **completely** fill each of the following.

	number of electrons
a d orbital	
a p sub-shell	
the third shell (n = 3)	

[3]

(c) The energy diagram below is for the eight electrons in an oxygen atom. The diagram is incomplete as it only shows the two electrons in the 1s level.



Complete the diagram for the oxygen atom by:

(i) adding labels for the other sub-shell levels,

[1]

(ii) adding arrows to show how the other electrons are arranged.

[1]

[Total 7 marks]

9. Successive ionisation energies provide evidence for the arrangement of electrons in atoms. The table below shows the eight successive ionisation energies of oxygen.

ionisation number	1st	2nd	3rd	4th	5th	6th	7th	8th
ionisation energy / kJ mol ⁻¹	1 314	3 388	5 301	7 469	10 989	13 327	71 337	84 080

oxygen. [2]	(i)	Define the term <i>first</i> ionisation energy.	
(ii) Write an equation, with state symbols, to represent the third ionisation energy of oxygen. [2] (iii) Explain how the information in the table above provides evidence for two electron shells in oxygen.			
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(iii) Explain how the information in the table above provides evidence for two electron shells in oxygen.	(ii)		
(iii) Explain how the information in the table above provides evidence for two electron shells in oxygen.			[2]
shells in oxygen.			[4]
[2]	(iii)		
[2]			
[2]			
[2]			
			[2]
		ITotal 7 m	

10. Magnesium exists naturally as a mixture of its isotopes, ²⁴Mg, ²⁵Mg and ²⁶Mg.

The isotopes in magnesium can be separated by mass spectrometry. The diagram below shows a mass spectrometer.

(i) Complete the table below to show the composition of the $^{25}{\rm Mg}$ and $^{26}{\rm Mg}$ isotopes.

	protons	neutrons	electrons
²⁵ Mg			
²⁶ Mg			

[2]

(ii) Complete the electronic configuration of an atom of ²

. 🤈	
104	
1.5	

[1]

(iii) Results from the mass spectrum of a sample of magnesium are shown below.

isotope	²⁴ Mg	²⁵ Mg	²⁶ Mg
relative isotopic mass	24.00	25.00	26.00
% abundance	78.60	10.11	11.29

Calculate the relative atomic mass of the sample of magnesium. Give your answer to two decimal places.

anawar												
answer			 	٠.			 				 	

[2]

[Total 5 marks]

11.	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.

(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]

[3]

element	Li	Ве	В	С	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		ic	onisation ene	ergy / kJ mol ⁻	-1	
	1st	2nd	3rd	4th	5th	6th
X	578	1817	2745	11 578	14 831	18 378

Table 2

[Total 13 marks]

12. In their reactions, calcium and strontium each lose electrons to form ions with a 2+ charge. The first and second ionisation energies of calcium and strontium are shown below.

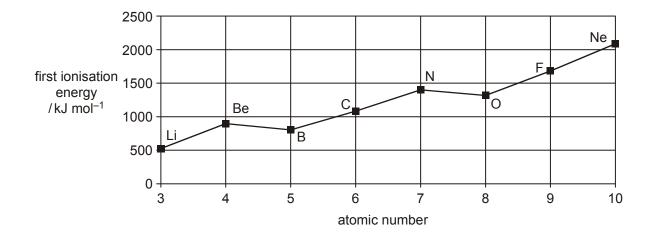
	1st ionisation energy / kJ mol ⁻¹	2nd ionisation energy / kJ mol ⁻¹
calcium	590	1145
strontium	550	1064

(i)	Write an equation, with state symbols, to represent the second ionisation energy of calcium.	
		[2]
(ii)	Why are the second ionisation energies of calcium and strontium greater than their first ionisation energies?	
		[1]
(iii)	Explain why the first and second ionisation energies of strontium are less than those of calcium.	
	[Total 6	[3] narks]
Com	plete the electronic configuration of carbon.	
1s ²		
	[Total 1	mark]

Plymstock School 10

13.

14. 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

	 	 	• • • • • • • • • • • • • • • • • • • •	• • • • • • • • • • • • • • • • • • • •	• • • • • • • • • • • • • • • • • • • •	
• • • • • •	 	 				

[3]

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

[2]

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

[2]

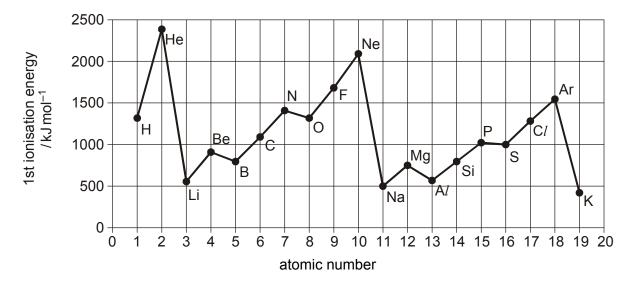
[Total 7 marks]

15.	Complete the electronic configuration of a titanium atom.				
	1s ² 2	2s ² 2p ⁶			
		•	[Total 1 mark]		
40	Daa	officers of the Oracus Oractala involve represent of alcohoma. The alcohoma are			
16.	remo	ctions of the Group 2 metals involve removal of electrons. The electrons are oved more easily as the group is descended and this helps to explain the easing trend in reactivity.			
	(i)	The removal of one electron from each atom in 1 mole of gaseous radium a	toms		
		is called the			
			[2]		
		The equation for this process in radium is:			
			[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 radium atom than from a calcium atom.	ı a		
			[3]		
			ادا [Total 7 marks]		
17.	The	electronic configuration of a bromine atom can be written in terms of sub-she	lls.		
	(i)	Complete the electronic configuration of a bromine atom.			
		1s ² 2s ² 2p ⁶ 3s ² 3p ⁶			
			[2]		
	(ii)	Why is bromine classified as a p-block element?			
			[1]		

Plymstock School 12

[Total 3 marks]

18. 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 ion	isation	energy.
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 	•••••	

[3]

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

 	•••••	

[2]

[Total 5 marks]