

**Section A**

Q1 The first six ionisation energies of four elements, A to D, are given. Which element is most likely to be in Group IV of the Periodic Table?

ionisation energy/kJ mol <sup>-1</sup>	1st	2nd	3rd	4th	5th	6th
A	494	4560	6940	9540	13400	16600
B	736	1450	7740	10500	13600	18000
C	1090	2350	4610	6220	37800	47000
D	1400	2860	4590	7480	9400	53200

Q2 In which species are the numbers of electrons and neutrons equal?

- A  ${}^9_4\text{Be}$       B  ${}^{19}_9\text{F}$       C  ${}^{23}_{11}\text{Na}^+$       D  ${}^{18}_8\text{O}^{2-}$

Q3 A sample of chlorine containing isotopes of mass numbers 35 and 37 was analysed in a mass-spectrometer. How many peaks corresponding to  $\text{Cl}_2^+$  were recorded?

- A 2      B 3      C 4      D 5

Q4 Gallium nitride, GaN, could revolutionise the design of electric light bulbs because only a small length used as a filament gives excellent light at low cost.

Gallium nitride is an ionic compound containing the  $\text{Ga}^{3+}$  ion.

What is the electron arrangement of the nitrogen ion in gallium nitride?

- A  $1s^2 2s^2$   
 B  $1s^2 2s^2 2p^3$   
 C  $1s^2 2s^2 2p^4$   
 D  $1s^2 2s^2 2p^6$

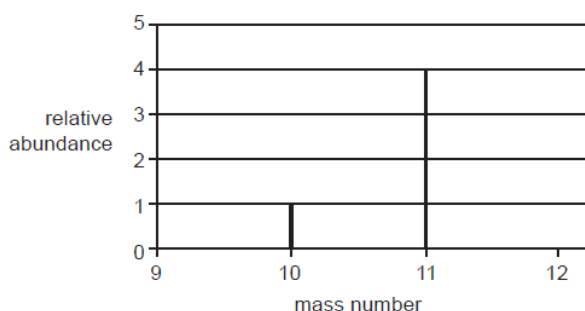
Q5

A radioactive isotope of thallium,  ${}^{201}_{81}\text{Tl}$ , is used to assess damage in heart muscles after a heart attack.

Which statement about  ${}^{201}_{81}\text{Tl}$  is correct?

- A This isotope has a nucleon number of 120.  
 B The number of electrons in one atom of this isotope is 81.  
 C The number of neutrons in one atom of this isotope is 201.  
 D  ${}^{201}_{82}\text{X}$  is an isotope of  ${}^{201}_{81}\text{Tl}$ .

Q6 The isotopic composition of an element is indicated below.



What is the relative atomic mass of the element?

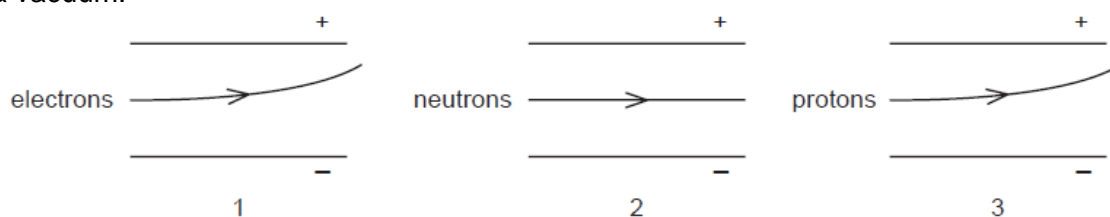
A 10.2

B 10.5

C 10.8

D 11.0

Q7 The diagrams show the possible paths of subatomic particles moving in an electric field in a vacuum.



Which diagrams are correct?

A 1 and 2 only

B 1 and 3 only

C 2 and 3 only

D 1, 2 and 3

Q8

Skin cancer can be treated using a radioactive isotope of phosphorus,  $^{32}_{15}\text{P}$ . A compound containing the phosphide ion  $^{32}_{15}\text{P}^{3-}$ , wrapped in a plastic sheet, is strapped to the affected area.

What is the composition of the phosphide ion,  $^{32}_{15}\text{P}^{3-}$ ?

	protons	neutrons	electrons
<b>A</b>	15	17	18
<b>B</b>	15	17	32
<b>C</b>	17	15	17
<b>D</b>	32	17	15

Q9 The first seven ionisation energies of an element between lithium and neon in the Periodic Table are as follows.

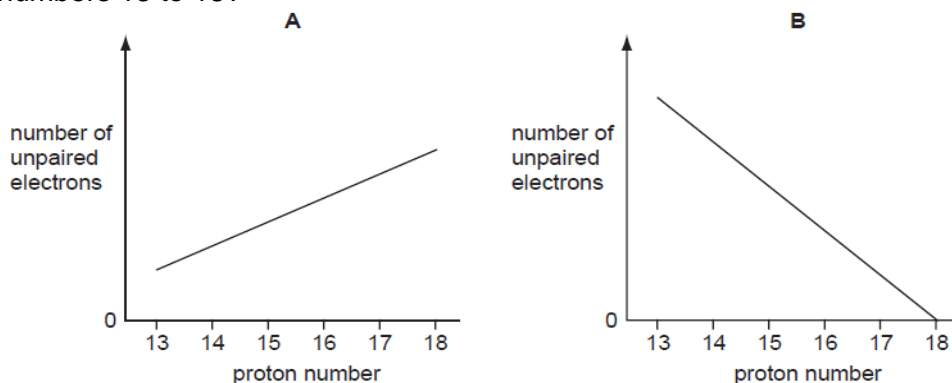
1310 3390 5320 7450 11 000 13 300 71 000 kJ mol<sup>-1</sup>

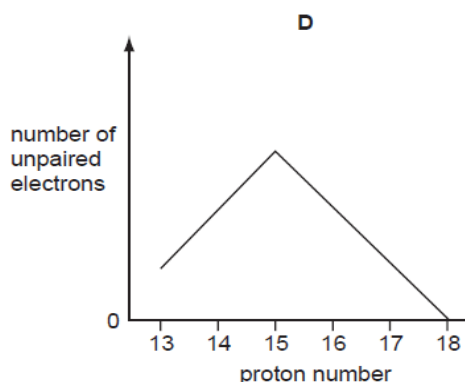
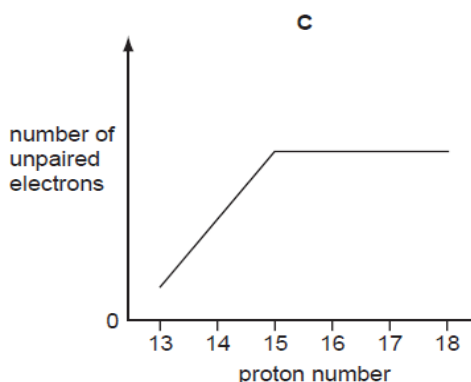
What is the outer electronic configuration of the element?

A 2s<sup>2</sup>B 2s<sup>2</sup>2p<sup>1</sup>C 2s<sup>2</sup>2p<sup>4</sup>D 2s<sup>2</sup>2p<sup>6</sup>

Q10 Use of the Data Booklet is relevant to this question.

Which graph represents the number of unpaired p orbital electrons for atoms with proton numbers 13 to 18?





Q11 Use of the Data Booklet is relevant to this question.

What could be the proton number of an element that has three unpaired electrons in each of its atoms?

- A 5                                      B 13                                      C 15                                      D 21

Q12 Use of the Data Booklet is relevant to this question.

The elements radon (Rn), francium (Fr) and radium (Ra) have consecutive proton numbers in the Periodic Table.

What is the order of their first ionisation energies?

	least endothermic	→	most endothermic
<b>A</b>	Fr		Rn
<b>B</b>	Fr		Ra
<b>C</b>	Ra		Rn
<b>D</b>	Rn		Fr

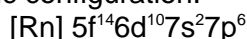
Q13 Helium, He, is the second element in the Periodic Table.

Tritium is the isotope of hydrogen  $^3\text{H}$ .

What is the same in an atom of  $^4\text{He}$  and an atom of  $^3\text{H}$ ?

- A the number of electrons  
B the number of neutrons  
C the number of protons  
D the relative atomic mass

Q14 In 1999, researchers working in the USA believed that they had made a new element and that it had the following electronic configuration.



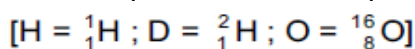
In which Group of the Periodic Table would you expect to find this element?

- A II                                      B IV                                      C VI                                      D 0

Q15 In which species are the numbers of protons, neutrons and electrons all different?

- A**  $^{11}_5\text{B}$                                       **B**  $^{19}_9\text{F}^-$                                       **C**  $^{23}_{11}\text{Na}^+$                                       **D**  $^{24}_{12}\text{Mg}^{2+}$

Q16 Which ion has more electrons than protons and more protons than neutrons?

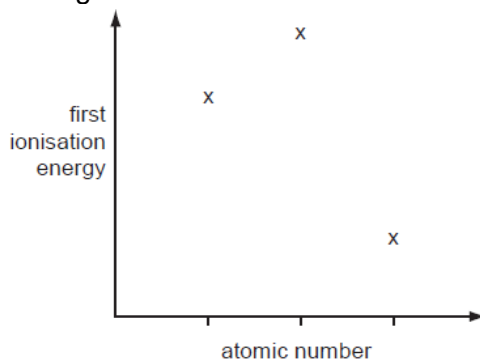


- A  $\text{D}^-$                                       B  $\text{H}_3\text{O}^+$                                       C  $\text{OD}^-$                                       D  $\text{OH}^-$

Q17 What is the electronic configuration of an element with a second ionisation energy higher than that of each of its neighbours in the Periodic Table?

- A  $1s^2 2s^2 2p^6 3s^2$   
 B  $1s^2 2s^2 2p^6 3s^2 3p^1$   
 C  $1s^2 2s^2 2p^6 3s^2 3p^2$   
 D  $1s^2 2s^2 2p^6 3s^2 3p^3$

Q18 Three successive elements in the Periodic Table have first ionisation energies which have the pattern shown in the diagram.



What could be the first element of this sequence?

- A C                                      B N                                      C F                                      D Na

Q19 Use of the Data Booklet is relevant to this question.

The electronic structures of calcium, krypton, phosphorus and an element X are shown. Which electronic structure is that of element X?

- A  $1s^2 2s^2 2p^6 3s^2 3p^3$   
 B  $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2$   
 C  $1s^2 2s^2 2p^6 3s^2 3p^6 3d^6 4s^2$   
 D  $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6$

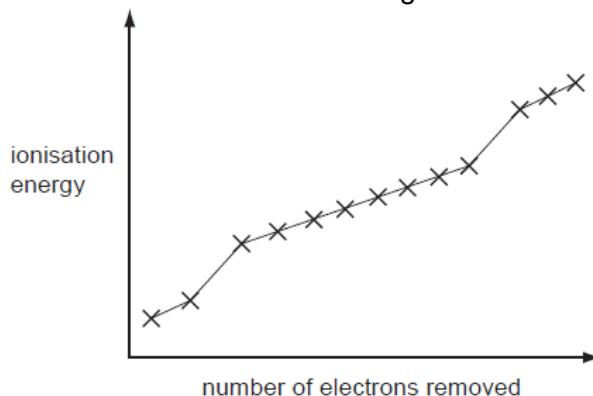
Q20 Use of the Data Booklet is relevant to this question.

In forming ionic compounds, elements generally form an ion with the electronic structure of a noble gas.

Which ion does not have a noble gas electronic structure?

- A  $I^-$                                       B  $Rb^+$                                       C  $Sn^{2+}$                                       D  $Sr^{2+}$

Q21 The graph shows the first thirteen ionisation energies for element X.



What can be deduced about element X from the graph?

A It is in the second period (Li to Ne) of the Periodic Table.

B It is a d-block element.

C It is in Group II of the Periodic Table.

D It is in Group III of the Periodic Table.

Q22 In which pair do both atoms have one electron only in an s orbital in their ground states?

A Ca, Sc

B Cu, Be

C H, He

D Li, Cr

Q23 Use of the Data Booklet is relevant to this question.

Hard water contains calcium ions and hydrogencarbonate ions arising from dissolved calcium hydrogencarbonate,  $\text{Ca}(\text{HCO}_3)_2$ .

How many electrons are present in the hydrogencarbonate anion?

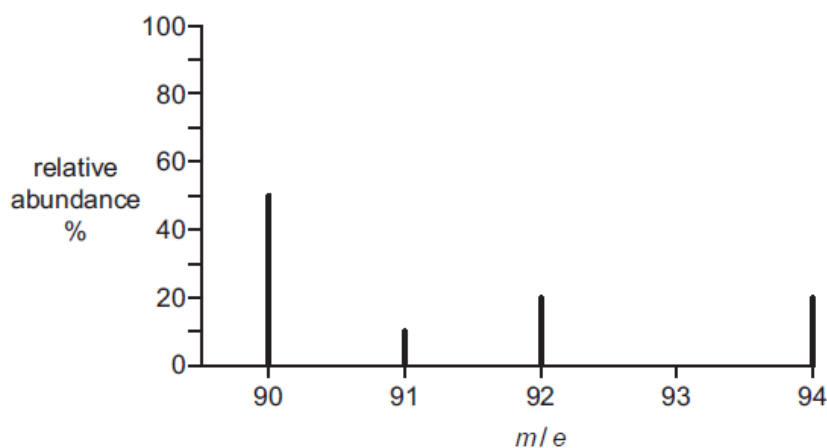
A 30

B 31

C 32

D 33

Q24 An element X consists of four isotopes. The mass spectrum of X is shown in the diagram.



What is the relative atomic mass of X?

A 91.00

B 91.30

C 91.75

D 92.00

Q25 Use of the Data Booklet is relevant to this question.

From which particle is the removal of an electron the most difficult?

A  $\text{Cl}^-(\text{g})$

B  $\text{F}^-(\text{g})$

C  $\text{K}^+(\text{g})$

D  $\text{Na}^+(\text{g})$

Q26 Use of the Data Booklet is relevant to this question.

The  ${}^{68}\text{Ge}$  isotope is medically useful because it undergoes a natural radioactive process to give a gallium isotope,  ${}^{68}\text{Ga}$ , which can be used to detect tumours. This transformation of  ${}^{68}\text{Ge}$  occurs when an electron enters the nucleus, changing a proton into a neutron.

Which statement about the composition of an atom of the  ${}^{68}\text{Ga}$  isotope is correct?

A It has 4 electrons in its outer p subshell.

B It has 13 electrons in its outer shell.

C It has 37 neutrons.

D Its proton number is 32.

**Section B**

<b>A</b>	<b>B</b>	<b>C</b>	<b>D</b>
<b>1, 2 and 3</b> are correct	<b>1 and 2</b> only are correct	<b>2 and 3</b> only are correct	<b>1 only</b> is correct

Q27 Use of the Data Booklet is relevant to this question.

The technetium-99 isotope ( $^{99}\text{Tc}$ ) is radioactive and has been found in lobsters and seaweed adjacent to nuclear fuel reprocessing plants.

Which statements are correct about an atom of  $^{99}\text{Tc}$ ?

- 1 It has 13 more neutrons than protons.
- 2 It has 43 protons.
- 3 It has 99 nucleons.

Q28 On a scale in which the mass of a  $^{12}\text{C}$  atom is 12 the relative molecular mass of a particular sample of chlorine is 72.

Which properties of the atoms in this sample are always the same?

- 1 radius
- 2 nucleon number
- 3 isotopic mass

Q29 The relative molecular mass of a molecule of chlorine is 72.

Which properties of the atoms in this molecule are the same?

- 1 radius
- 2 nucleon number
- 3 relative isotopic mass

1. C
2. D
3. B
4. D
5. B
6. C
7. A
8. A
9. C
10. D
11. C
12. A
13. B
14. D
15. C
16. D
17. B
18. C
19. C
20. C
21. C
22. D
23. C
24. B
25. D
26. C
27. A
28. D
29. D

Q1 Use the *Data Booklet* to complete the table below to show the atomic structure of  $^{56}\text{Fe}$  and of  $^{59}\text{Co}$ .

isotope	number of		
	protons	neutrons	electrons
$^{56}\text{Fe}$			
$^{59}\text{Co}$			

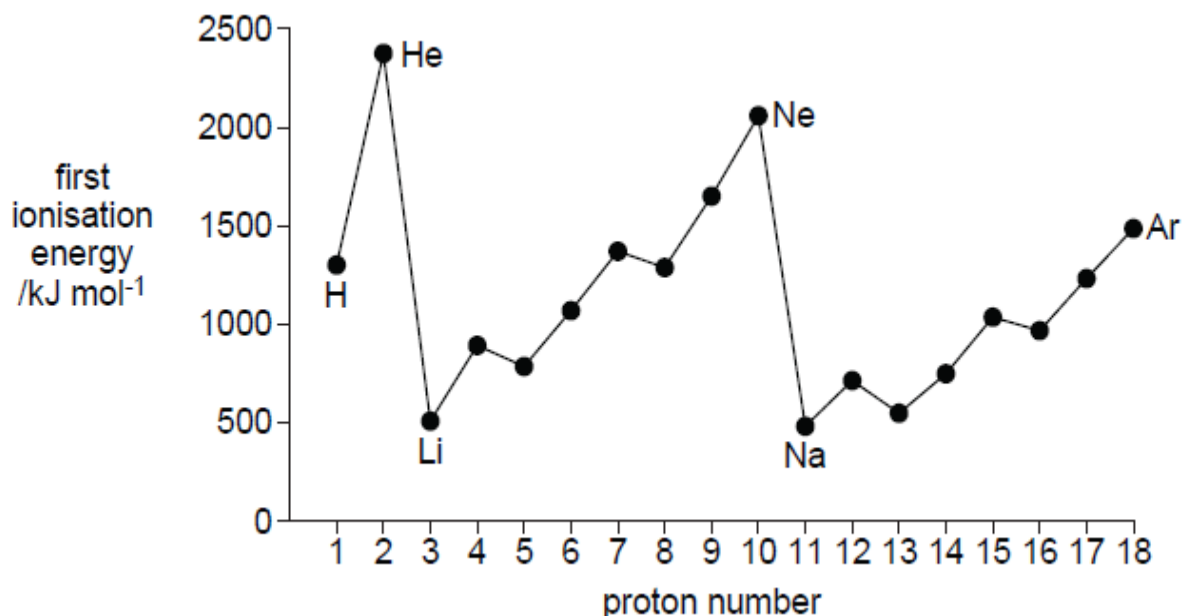
(June 2005)

Q2 Complete the table below to show the electronic configuration of calcium atoms and of strontium ions,  $\text{Sr}^{2+}$ .

	1s	2s	2p	3s	3p	3d	4s	4p	4d
Ca	2	2	6						
$\text{Sr}^{2+}$	2	2	6						

(JUNE 2007)

Q3 The diagram below shows the first ionisation energies of the first 18 elements of the Periodic Table as we know it today.



(a) Give the equation, including state symbols, for the first ionisation energy of fluorine.

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(b) Explain why there is a general increase in first ionisation energies from sodium to argon.

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(c)(i) Explain why the first ionisation energy of aluminium is less than that of magnesium.

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(ii) Explain why the first ionisation energy of sulphur is less than that of phosphorus.

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(June 2008)

**Q4 (a)(i)** Write an equation, with state symbols, for the **second** ionisation energy of magnesium.

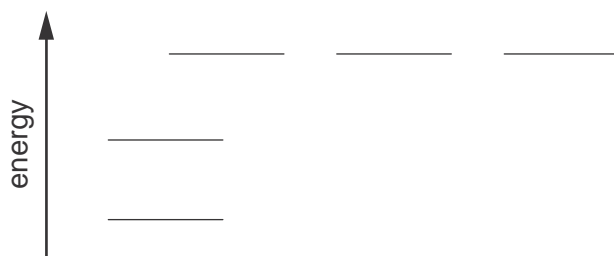
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(ii) Use the *Data Booklet* to calculate the enthalpy change that occurs when one mole of gaseous magnesium ions,  $\text{Mg}^{2+}$ , is formed from one mole of gaseous magnesium atoms. Include a sign in your answer.

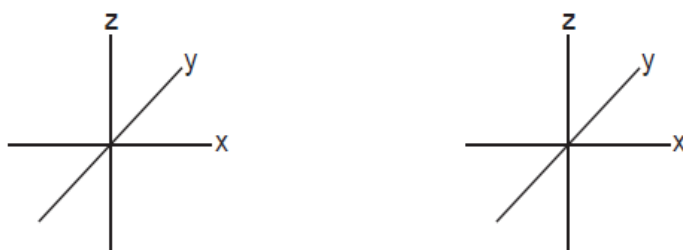
(June 2009 P21)

Q5(a) The diagram below represents the energy levels of the orbitals present in atoms of the second period (Li to Ne).

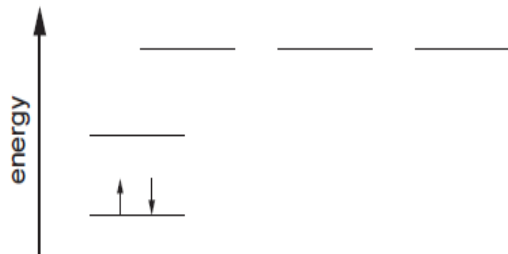
(i) Label the energy levels to indicate the principal quantum number **and** the type of orbital at each energy level.



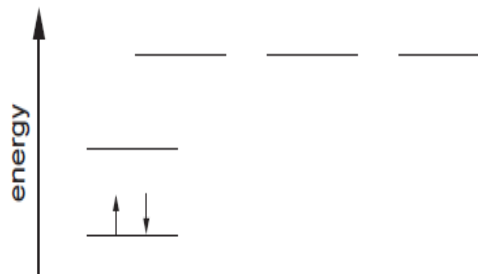
(ii) On the axes below, draw a sketch diagram of **one** of each **different type (shape)** of orbital that is occupied by the electrons in a second-period element. Label each type.



iii) Complete the electronic configurations of nitrogen atoms and oxygen atoms on the energy level diagrams below. Use arrows to represent electrons.



nitrogen



oxygen

(b)(i) Use the *Data Booklet* to state the value of the first ionisation energy of nitrogen and of oxygen.

N .....  $\text{kJ mol}^{-1}$

O .....  $\text{kJ mol}^{-1}$

(ii) Explain, with reference to your answer to (a)(iii), the relative values of these two ionisation energies.

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(JUNE 2010 P22)

Q6 The first six ionisation energies of an element **X** are given below.

ionisation energy / $\text{kJ mol}^{-1}$					
first	second	third	fourth	fifth	sixth
950	1800	2700	4800	6000	12300

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

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(b) Write an equation, with state symbols, for the **second** ionisation energy of element **X**.

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(c) Use the data given above to deduce in which Group of the Periodic Table element **X** is placed. Explain your answer.

Group.....

explanation.....

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The first ionisation energies (I.E.) for the elements of Group IV are given below.

element	C	Si	Ge	Sn	Pb
1st I.E. / $\text{kJ mol}^{-1}$	1090	786	762	707	716

(d) Explain the trend shown by these values in terms of the atomic structure of the elements.

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(NOV 2005)

Q7 Radium, proton number 88, and uranium, proton number 92, are radioactive elements.

The isotope  $^{226}\text{Ra}$  is produced by the radioactive decay of the uranium isotope  $^{238}\text{U}$ .

(a) Complete the table below to show the atomic structures of the isotopes  $^{226}\text{Ra}$  and  $^{238}\text{U}$ .

isotopes	number of		
	protons	neutrons	electrons
$^{226}\text{Ra}$			
$^{238}\text{U}$			

(b) Radium, like other Group II elements, forms a number of ionic compounds.

(i) What is the formula of the radium cation? .....

(ii) Use the *Data Booklet* to suggest a value for the energy required to form one mole of the gaseous radium cation you have given in (i) from one mole of gaseous radium atoms.

Explain your answer

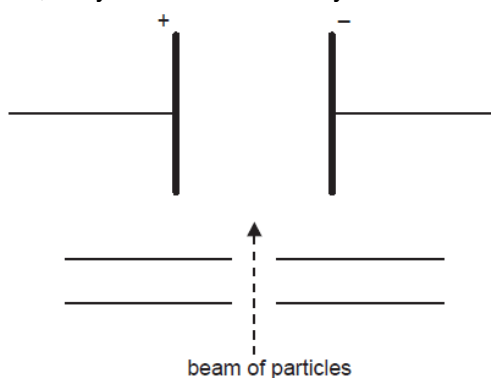
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(NOV 2009)

Q8 When separate beams of electrons, neutrons or protons are passed through an electric field in the apparatus below, they behave differently.



(a)(i) Which of these three particles will be deflected the most by the electric field?

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(ii) In which direction will this particle be deflected?

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(iii) Explain your answer.

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(b)(i) Define the term *proton number*

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(ii) Why is the proton number of an atom of an element usually different from the nucleon number of an atom of the element?

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(c) Protons and neutrons have been used in nuclear reactions which result in the formation of artificial elements. In such processes, protons or neutrons are accelerated to high speeds and then fired like 'bullets' at the nucleus of an atom of an element.

Suggest why neutrons are more effective than protons as 'nuclear bullets'.

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(d) In some cases, when neutrons are fired at atoms of an element, the neutrons become part of the nucleus of those atoms. What effect does the presence of an extra neutron have on the chemical properties of the new atoms formed? Explain your answer.

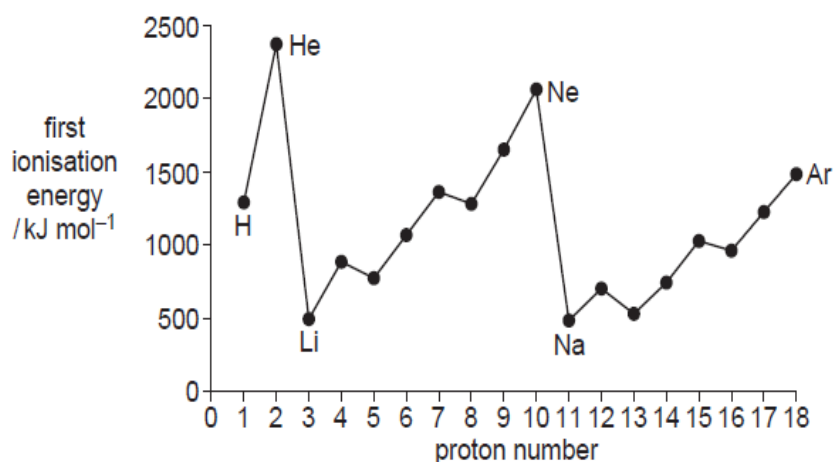
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(NOV 2006)

Q9 The diagram below shows the first ionisation energies of the first 18 elements of the Periodic Table.



(a) Give the equation, including state symbols, for the first ionisation energy of carbon.

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(b)(i) Explain why sodium has a lower first ionisation energy than magnesium.

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(ii) Explain why magnesium has a higher first ionisation energy than aluminium.

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(iii) Explain why helium, He, and neon, Ne, occupy the two highest positions on the diagram.

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(iv) Explain why the first ionisation energy of argon, Ar, is lower than that of neon, which is lower than that of helium.

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(NOV 2011 P23)