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# CHEMISTRY MULTIPLE CHOICE QUESTIONS

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B. Atomic Structure

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2002 -2014

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One of the most important chemical species responsible for the removal of ozone from the stratosphere is a free radical of chlorine,  $^{35}\text{Cl}^{\bullet}$ .

What does  $^{35}\text{Cl}^{\bullet}$  contain?

	protons	neutrons	electrons
A	17	13	16
B	17	13	17
C	13	17	17
D	13	17	18

[2002 O/N (2)]

Unnilpentium is an artificial element. One of its isotopes is  $^{262}_{105}\text{Unp}$ .

Which of the following statements is correct?

- A  $^{262}_{105}\text{Unp}$  has a nucleon number of 105.
- B The atom  $^{260}_{105}\text{X}$  is an isotope of  $^{262}_{105}\text{Unp}$ .
- C There are 262 neutrons in  $^{262}_{105}\text{Unp}$ .
- D The proton number of  $^{262}_{105}\text{Unp}$  is 262.

[2003 O/N (4)]

What is the order of increasing energy of the listed orbitals in the atom of titanium?

- A 3s 3p 3d 4s
- B 3s 3p 4s 3d
- C 3s 4s 3p 3d
- D 4s 3s 3p 3d

[2004 M/J (4)]

Which of the following particles would, on losing an electron, have a half-filled set of p orbitals?

- A  $\text{C}^-$
- B N
- C  $\text{N}^-$
- D  $\text{O}^+$

[2004 M/J (5)]

The isotope cobalt-60 ( $^{60}_{27}\text{Co}$ ) is used to destroy cancer cells in the human body.

Which statements about an atom of cobalt-60 are correct?

- 1 It contains 33 neutrons.
- 2 Its nucleus has a relative charge of 27+.
- 3 It has a different number of neutrons from the atoms of other isotopes of cobalt.

[2004 M/J (31)]

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

It is now thought that where an element exists as several isotopes, the stable ones usually contain a 'magic number' of neutrons. One of these magic numbers is 126.

Which isotope is unstable?

- A  $^{209}\text{Bi}$
- B  $^{208}\text{Pb}$
- C  $^{210}\text{Po}$
- D  $^{208}\text{Tl}$

[2004 O/N (4)]

An atom has eight electrons.

Which diagram shows the electronic configuration of this atom in its lowest energy state?

- A 

↑↓	↑↓	↑↓	↑↓		
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- B 

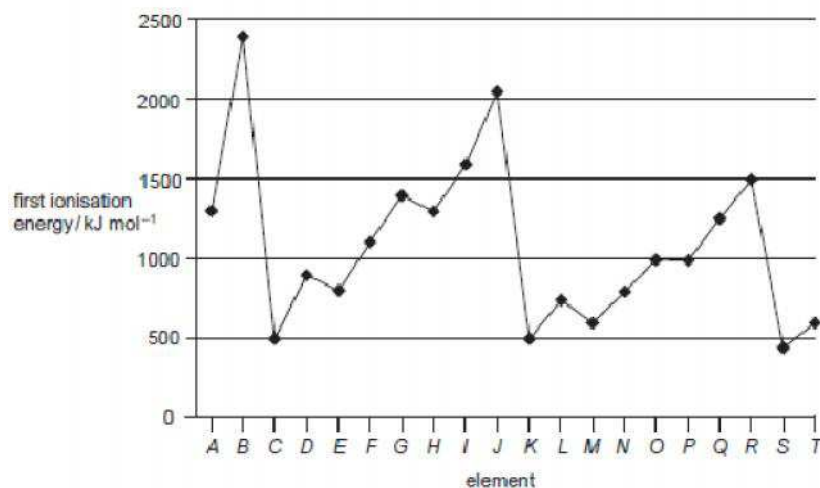
↑↓	↑↓	↑	↓	↑	
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- C 

↑↓	↑↓	↑	↓		↑
----	----	---	---	--	---
- D 

↑↓	↑↓	↑	↑	↑	↑
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[2004 O/N (5)]

The first ionisation energies of successive elements in the Periodic Table are represented in the graph.



Which of these statements about this graph are correct?

- Elements B, J and R are in Group 0 of the Periodic Table.
- Atoms of elements D and L contain 2 electrons in their outer shells.
- Atoms of elements G and O contain half-filled p orbitals.

[2004 O/N (34)]

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
<b>A</b>	494	4560	6940	9540	13400	16600
<b>B</b>	736	1450	7740	10500	13600	18000
<b>C</b>	1090	2350	4610	6220	37800	47000
<b>D</b>	1400	2860	4590	7480	9400	53200

[2005 M/J (3)]

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**  ${}^{18}_8\text{O}^{2-}$

[2005 M/J (4)]

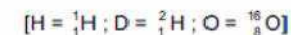
The following species contain the same number of electrons.

In which order do their radii increase?

	smallest radius	→	largest radius
<b>A</b>	Ar		Ca <sup>2+</sup>
<b>B</b>	Ca <sup>2+</sup>		K <sup>+</sup>
<b>C</b>	Ca <sup>2+</sup>		Ar
<b>D</b>	K <sup>+</sup>		Ca <sup>2+</sup>

[2005 M/J (12)]

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



- A** D      **B** H<sub>3</sub>O<sup>+</sup>      **C** OD      **D** OH

[2005 O/N (2)]

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 Ga<sup>3+</sup> ion.

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

- A** 1s<sup>2</sup> 2s<sup>2</sup>  
**B** 1s<sup>2</sup> 2s<sup>2</sup> 2p<sup>3</sup>  
**C** 1s<sup>2</sup> 2s<sup>2</sup> 2p<sup>4</sup>  
**D** 1s<sup>2</sup> 2s<sup>2</sup> 2p<sup>6</sup>

[2006 M/J (3)]

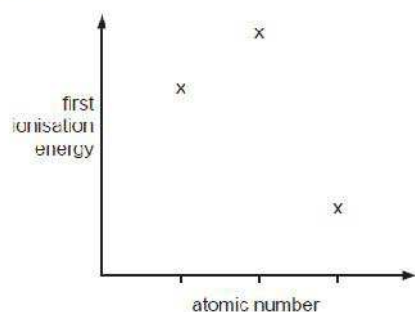
A radioactive isotope of thallium,  $^{201}_{81}\text{Tl}$ , is used to assess damage in heart muscles after a heart attack.

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  $^{201}_{81}\text{Tl}$ .

[2006 M/J (4)]

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

[2006 O/N (2)]

*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  $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6$

[2006 O/N (3)]

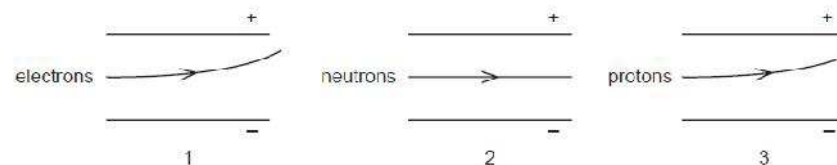
John Dalton's atomic theory, published in 1808, contained four predictions about atoms.

Which of his predictions is still considered to be correct?

- A Atoms are very small in size.
- B No atom can be split into simpler parts.
- C All the atoms of a particular element have the same mass.
- D All the atoms of one element are different in mass from all the atoms of other elements.

[2007 M/J (3)]

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

[2007 M/J (4)]

*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.

[2007 M/J (31)]

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<sup>+</sup>                      C Sn<sup>2+</sup>                      D Sr<sup>2+</sup>

[2007 O/N (2)]

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
A	15	17	18
B	15	17	32
C	17	15	17
D	32	17	15

[2008 M/J (3)]

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

[2008 O/N (3)]

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    kJmol<sup>-1</sup>

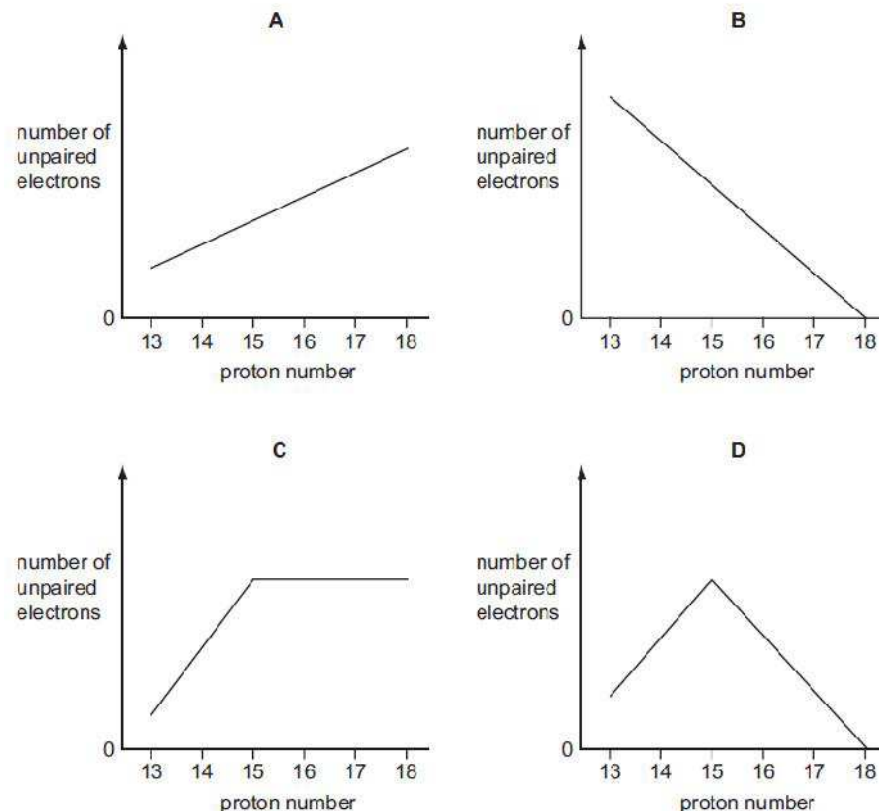
What is the outer electronic configuration of the element?

- 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>

[2009 M/J (3)]

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?



[2009 M/J (4)]

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

[2010 M/J – 11(1)]



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

[2010 M/J - 11(2)]

A simple ion  $X^+$  contains eight protons.

What is the electronic configuration of  $X^+$ ?

- A**  $1s^2 2s^1 2p^6$
- B**  $1s^2 2s^2 2p^3$
- C**  $1s^2 2s^2 2p^5$
- D**  $1s^2 2s^2 2p^7$

[2010 O/N - 13(1)]

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

$[H = {}^1_1H ; D = {}^2_1H ; O = {}^{16}_8O]$

- A**  $D^-$
- B**  $H_3O^+$
- C**  $OD^-$
- D**  $OH^-$

[2010 O/N - 13(3)]

Which equation represents the second ionisation energy of an element X?

- A**  $X(g) \rightarrow X^{2+}(g) + 2e^-$
- B**  $X^+(g) \rightarrow X^{2+}(g) + e^-$
- C**  $X(g) + 2e^- \rightarrow X^{2-}(g)$
- D**  $X^-(g) + e^- \rightarrow X^{2-}(g)$

[2011 M/J - 11(1)]

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

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

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

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

[2011 M/J - 12(1)]

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

[2011 M/J - 12(13)]

Which element has an equal number of electron pairs and of unpaired electrons within orbitals of principal quantum number 2?

- A** beryllium
- B** carbon
- C** nitrogen
- D** oxygen

[2011 O/N - 11(1)]

Use of the Data Booklet is relevant to this question.

[2012 O/N – 11(2)]

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

[2011 O/N – 12(3)]

In which species does the underlined atom have an incomplete outer shell?

- A  $\underline{\text{B}}\text{F}_3$       B  $\underline{\text{C}}\text{H}_3^-$       C  $\text{F}_2\underline{\text{O}}$       D  $\text{H}_3\underline{\text{O}}^+$

[2012 M/J – 11(1)]

Use of the Data Booklet is relevant to this question.

In which pairs do both species have the same number of unpaired p electrons?

- O and  $\text{Cl}^+$
- $\text{F}^+$  and  $\text{Ga}^-$
- P and  $\text{Ne}^+$

[2012 M/J – 11(32)]

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

- A  ${}_{5}^{11}\text{B}$       B  ${}_{9}^{19}\text{F}^-$       C  ${}_{11}^{23}\text{Na}^+$       D  ${}_{12}^{24}\text{Mg}^{2+}$

[2012 M/J – 12(2)]

In which species does the underlined atom have an incomplete outer shell?

- A  $\underline{\text{Al}}_2\text{Cl}_6$       B  $\underline{\text{C}}\text{H}_3^+$       C  $\text{Cl}_2\underline{\text{O}}$       D  $\text{H}_2\underline{\text{C}}\text{Cl}\cdot$

[2012 M/J – 12(4)]

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?

- It has 4 electrons in its outer p subshell.
- It has 13 electrons in its outer shell.
- It has 37 neutrons.
- Its proton number is 32.

John Dalton's atomic theory, published in 1808, contained four predictions about atoms.

Which of his predictions is still considered to be correct?

- All atoms are very small in size.
- All the atoms of a particular element have the same mass.
- All the atoms of one element are different in mass from all the atoms of other elements.
- No atom can be split into simpler parts.

[2012 O/N – 11(9)]

Use of the Data Booklet is relevant to this question.

The 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  ${}^{99}\text{Tc}$ ?

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

[2012 O/N – 11(32)]

The phosphide ion  ${}_{15}^{31}\text{P}^{3-}$  and sulfide ion  ${}_{16}^{32}\text{S}^{2-}$  have the same number of which sub-atomic particles?

- neutrons
- electrons
- protons

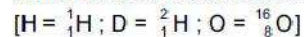
[2012 O/N – 13(32)]

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

- A  ${}_{13}^{27}\text{Al}$       B  ${}_{17}^{35}\text{Cl}^-$       C  ${}_{16}^{32}\text{S}^{2-}$       D  ${}_{19}^{39}\text{K}^+$

[2013 M/J – 11(5)]

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  $\text{OH}^-$

[2013 M/J – 12(3)]

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

In which pairs do both species have the same number of unpaired p electrons?

- 1  $\text{Al}^{2-}$  and  $\text{O}^+$
- 2 N and  $\text{Cl}^{2+}$
- 3 C and  $\text{Cl}^+$

[2013 M/J – 12(31)]

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

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

- A  ${}^{19}_9\text{F}^-$             B  ${}^{23}_{11}\text{Na}^+$             C  ${}^{31}_{15}\text{P}$             D  ${}^{32}_{16}\text{S}^{2-}$

[2013 M/J – 13(2)]

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

Which statements are correct when referring to the atoms  ${}^{23}\text{Na}$  and  ${}^{24}\text{Mg}$ ?

- 1 They have the same number of full electron orbitals.
- 2 They have the same number of neutrons.
- 3 They are both reducing agents.

[2013 M/J – 13(32)]

X is a particle with 18 electrons and 20 neutrons.

What could be the symbol of X?

- 1  ${}^{38}_{18}\text{Ar}$
- 2  ${}^{40}_{20}\text{Ca}^{2+}$
- 3  ${}^{39}_{19}\text{K}^+$

[2013 O/N – 11(31)]

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

In which set do all species contain the same number of electrons?

- A  $\text{Co}^{2+}$ ,  $\text{Co}^{3+}$ ,  $\text{Co}^{4+}$   
B  $\text{F}^-$ ,  $\text{Br}^-$ ,  $\text{Cl}^-$   
C  $\text{Na}^+$ ,  $\text{Mg}^{2+}$ ,  $\text{Al}^{3+}$   
D  $\text{K}_2\text{SO}_4$ ,  $\text{K}_2\text{SeO}_4$ ,  $\text{K}_2\text{TeO}_4$

[2013 O/N – 12(4)]

X is a particle with 18 electrons and 20 neutrons.

What could be the symbol of X?

- 1  ${}^{38}_{18}\text{Ar}$
- 2  ${}^{40}_{20}\text{Ca}^{2+}$
- 3  ${}^{39}_{19}\text{K}^+$

[2013 O/N – 12(31)]

The  ${}^1\text{H}_3^+$  ion was first characterised by J. J. Thomson over a century ago.  ${}^6\text{Li}$  is a rare isotope of lithium which forms the  ${}^6\text{Li}^+$  ion.

Which statements are correct?

- 1 Both ions contain the same number of protons.
- 2 Both ions contain the same number of electrons.
- 3 Both ions contain the same number of neutrons.

[2013 O/N – 13(31)]

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

Atoms of element X have six unpaired electrons.

What could be element X?

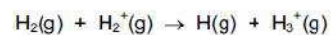
- A carbon  
B chromium  
C iron  
D selenium

[2014 M/J – 11(1)]



Use of the Data Booklet is relevant to this question.

The most common ion-molecule reaction in gas clouds of the Universe is as shown.



What could be the composition of an  $\text{H}_3^+$  ion?

	protons	neutrons	electrons
A	2	1	1
B	2	1	2
C	3	0	1
D	3	0	2

[2014 M/J – 13(4)]

In 2011 an international group of scientists agreed to add two new elements to the Periodic Table. Both elements had been made artificially and were called ununquadium (Uuq) and ununhexium (Uuh).

	Uuq	Uuh
proton number	114	116
nucleon number	289	292

Which statements about these elements are correct?

- 1 One atom of Uuh has one more neutron than one atom of Uuq.
- 2 One  $\text{Uuq}^{2-}$  ion has the same number of electrons as one atom of Uuh.
- 3 One  $\text{Uuh}^+$  ion has the same number of electrons as one  $\text{Uuq}^-$  ion.

[2014 M/J – 13(31)]