Atomic Structure

(Past Year Topical Questions 2010-2015)

May/June 2010 (21)

1 In the 19th and 20th centuries, experimental results showed scientists that atoms consist of a positive, heavy nucleus which is surrounded by electrons.

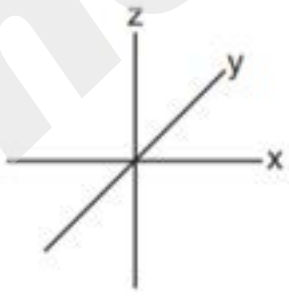
Then in the 20th century, theoretical scientists explained how electrons are arranged in orbitals around atoms.

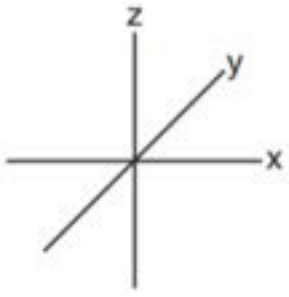
(a) The diagram below represents the energy levels of the orbitals present in atoms of the second period (Li to Ne).

(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

[6]

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

N ..... kJ mol^{-1} O ..... 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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[3]

Oct/Nov 2011 (23)

1 Sulfur, S, and polonium, Po, are both elements in Group VI of the Periodic Table.

Sulfur has three isotopes.

(a) Explain the meaning of the term *isotope*.

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..... [2]

(b) A sample of sulfur has the following isotopic composition by mass.

isotope mass	32	33	34
% by mass	95.00	0.77	4.23

Calculate the relative atomic mass, A_r, of sulfur to **two** decimal places.

A_r = ...

[2]

(c) Isotopes of polonium, proton number 84, are produced by the radioactive decay of several elements including thorium, Th, proton number 90.

The isotope ^{213}Po is produced from the thorium isotope ^{232}Th.

Complete the table below to show the atomic structures of the isotopes ^{213}Po and ^{232}Th.

	number of		
isotope	protons	neutrons	electrons
^{213}Po			
^{232}Th			

[3]

Radiochemical reactions, such as nuclear fission and radioactive decay of isotopes, can be represented by equations in which the nucleon (mass) numbers must balance and the proton numbers must also balance.

For example, the nuclear fission of uranium-235, $^{235}_{92}U$, by collision with a neutron, $^{1}_{0}n$, produces strontium-90, xenon-143 and three neutrons.

$$^{235}_{92}U + {}^{1}_{0}n \rightarrow {}^{90}_{38}Sr + {}^{143}_{54}Xe + 3\,{}^{1}_{0}n$$

In this equation, the nucleon (mass) numbers balance because: 235 + 1 = 90 + 143 + (3x1).

The proton numbers also balance because: 92 + 0 = 38 + 54 + (3x0).

(d) In the first stage of the radioactive decay of $^{232}_{90}Th$, the products are an isotope of element *E* and an alpha-particle, $^{4}_{2}He$.

(i) By considering nucleon and proton numbers only, construct a balanced equation for the formation of the isotope of *E* in this reaction.

$$^{232}_{90}Th \rightarrow \text{.....} + {}^{4}_{2}He$$

Show clearly the nucleon number and proton number of the isotope of *E*.

nucleon number of the isotope of *E* .....

proton number of the isotope of *E* .....

(ii) Hence state the symbol of the element *E*.

.....

[3]

Oct/Nov 2013 (23)/Q3

(b) The halogens form many interhalogen compounds in which two different halogens are combined. One such compound is bromine monochloride, BrC*l*.

(i) Complete the electronic configurations of chlorine and bromine.

chlorine	$1s^2 2s^2 2p^6$
bromine	$1s^2 2s^2 2p^6$

(ii) Draw a 'dot-and-cross' diagram of the BrC*l* molecule.
Show outermost electrons only.

[2]

May/June 2014 (21)

1 **(a)** Explain what is meant by the term *ionisation energy*.

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..... [3]

(b) The first seven ionisation energies of an element, **A**, in kJ mol^{-1}, are

1012 1903 2912 4957 6274 21269 25398.

(i) State the group of the Periodic Table to which **A** is most likely to belong. Explain your answer.

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..... [2]

(ii) Complete the electronic configuration of the element in Period 2 that is in the same group as **A**.

$1s^2$ ..... [1]

Oct/Nov 2014 (21)

1 **(a)** Successive ionisation energies for the elements magnesium to barium are given in the table.

element	1st ionisation energy / kJ mol^{-1}	2nd ionisation energy / kJ mol^{-1}	3rd ionisation energy / kJ mol^{-1}
Mg	736	1450	7740
Ca	590	1150	4940
Sr	548	1060	4120
Ba	502	966	3390

(i) Explain why the first ionisation energies decrease down the group.

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(ii) Explain why, for each element, there is a large increase between the 2nd and 3rd ionisation energies.

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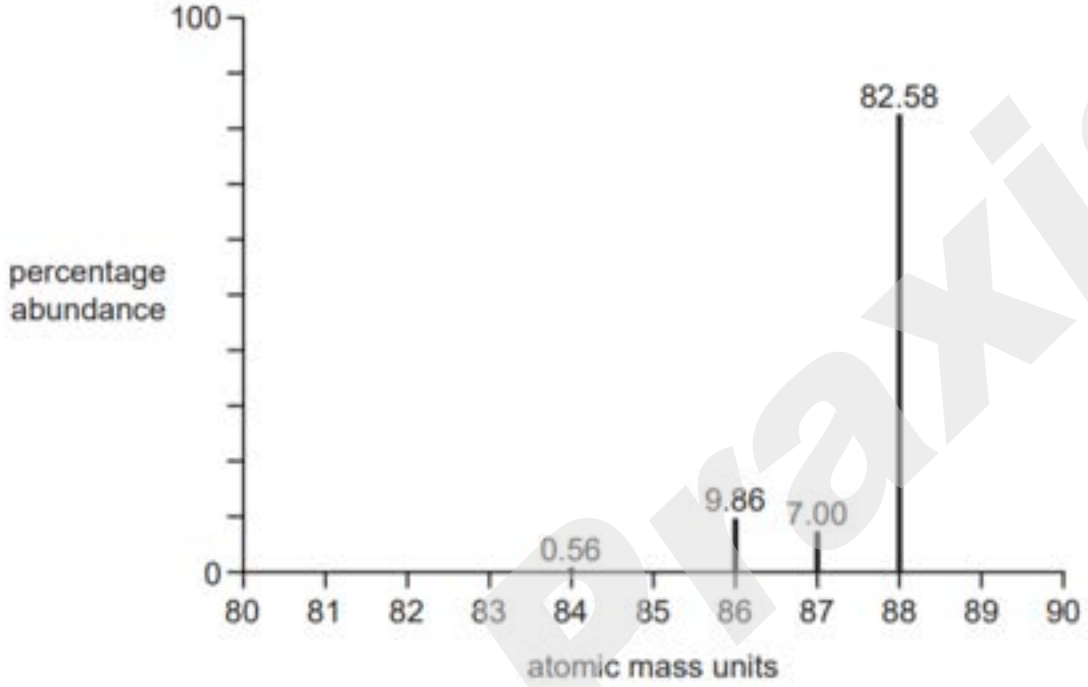
..... [2]

(b) A sample of strontium, atomic number 38, gave the mass spectrum shown. The percentage abundances are given above each peak.



(i) Complete the full electronic configuration of strontium.

$1s^2\ 2s^2\ 2p^6$ ..... [1]

(ii) Explain why there are four different peaks in the mass spectrum of strontium.

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..... [1]

May/June 2015 (23)

1 Neon is a noble gas.

(a) Complete the full electronic configuration of neon.

$1s^2$ ..... [1]

(b) **(i)** Explain what is meant by the term *first ionisation energy*.

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..... [3]

(ii) Explain why the first ionisation energy of neon is greater than that of fluorine.

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..... [2]

Oct/Nov 2015 (22)

1 (a) Fill the gaps in the table for each of the given particles.

name of isotope	type of particle	charge	symbol	electron configuration
carbon-13				$1s^2 2s^2 2p^2$
		–1	$^{37}_{17}Cl^-$	
sulfur-34	atom	0		
iron-54	cation			$1s^2 2s^2 2p^6 3s^2 3p^6 3d^6$

[5]