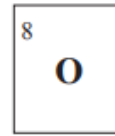
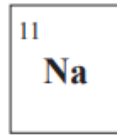


## COLLATED QUESTIONS – ATOMS AND IONS

2020:1

- (a) (i) Sodium and oxygen are elements on the periodic table.



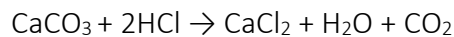
Using the information supplied, draw the electron arrangement of a sodium atom and an oxygen atom.

Sodium ions and oxide ions have the same electron arrangement.

- (ii) State the electron arrangement of the sodium ions and oxide ions. Electron arrangement of both ions:
- (iii) How can sodium ions and oxide ions have the same electron arrangement but different charges? In your answer you should refer to the number of protons, charge, and electron arrangement of the two ions.

2020:2

- (c) Calcium carbonate,  $\text{CaCO}_3$ , reacts with hydrochloric acid,  $\text{HCl}$ , to form calcium chloride,  $\text{CaCl}_2$ .

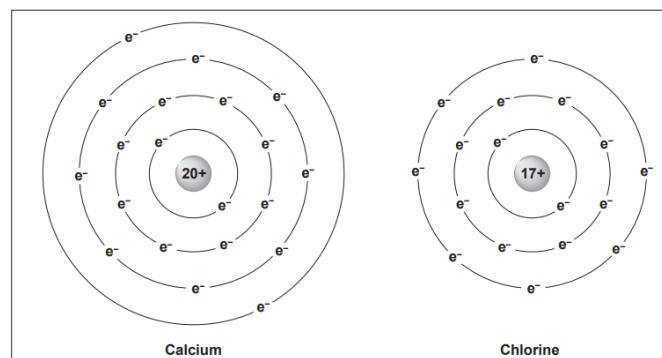


Explain why the ratio of calcium ions to chloride ions in calcium chloride,  $\text{CaCl}_2$ , is different to the ratio of calcium ions and carbonate ions in calcium carbonate,  $\text{CaCO}_3$ .

In your answer you should explain how the ratio is related to the charge on the ions.

2019:2

The diagram shows models of two atoms.



- (a) Write the electronic arrangement of the two atoms.
- (b) Calcium and chlorine atoms both form ions with the same electron arrangement.
- (i) Write the electronic arrangement of the two ions.
- (ii) Explain how each ion,  $\text{Ca}^{2+}$  and  $\text{Cl}^-$ , is formed.

In your answer you should:

- explain why these elements form ions
- explain the charges on both ions in terms of electron arrangement of atoms and ions, number of protons and number of electrons, and charge.

(c) Calcium reacts with chlorine, forming the ionic compound calcium chloride,  $\text{CaCl}_2$ .

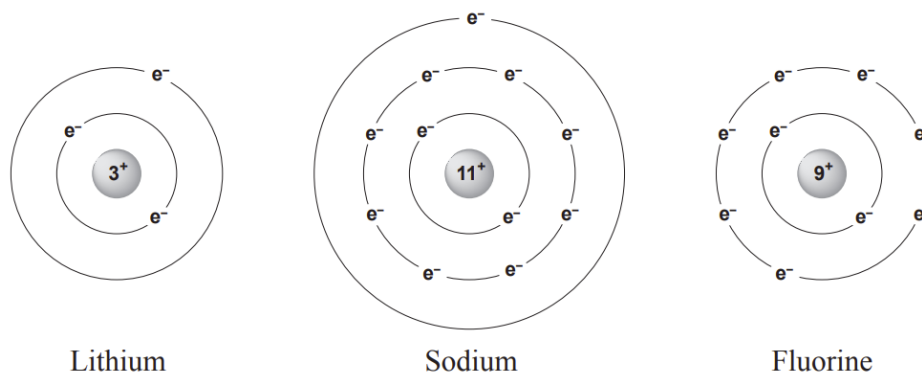
Explain the ratio of calcium ions to chloride ions in  $\text{CaCl}_2$ .

In your answer you should explain:

- how the ratio is related to the charge on the ions
- the number of electrons gained or lost by each atom as it forms the ionic compound

### 2018:1

The diagrams show models of three different atoms:



Use the diagrams to answer parts (a), (b), and (c).

- (a) Why are lithium and sodium in the same group (column) of the Periodic Table, but in different periods (rows)?
- (b) Sodium and fluorine form ions that both have the same electron arrangement. How can sodium and fluoride ions have the same electron arrangement but different charges? In your answer you should refer to the number of protons, charge, and electron arrangement of the two atoms and ions.
- (c) Magnesium fluoride has the formula  $\text{MgF}_2$ . Explain how the ratio of ions in the formula is linked to the charge on the ions. In your answer you should include the number of electrons gained or lost by each atom as it forms the ionic compound. A diagram may assist your answer

### 2017:2

Sodium and potassium are both highly reactive metals that react with oxygen gas. However, sodium and potassium do not react with each other.

- (a) Why do sodium and potassium each react with oxygen, but not with each other? In your answer you should:
- refer to the electron arrangements of each of the three atoms and three ions involved
  - explain how the electron arrangement of each of the three atoms relates to its position in the periodic table
  - explain how an ionic bond forms when sodium or potassium reacts with oxygen.

### 2017:3

(a) (i) Explain why silver oxide,  $\text{Ag}_2\text{O}$ , has a 2:1 ratio of ions. In your answer you should:

- relate the ratio of ions to the number of electrons lost or gained by each atom when forming ions
- explain how the ratio of the ions in the compound is related to the charge on the ions.



### 2014:1 ATOMS, IONS AND FORMULAE

(a) Write the formulae for the following ionic compounds.  
Use the Table of Ions in your Resource Booklet to help you.

- (i) Calcium chloride
- (ii) Sodium nitrate
- (iii) Zinc nitrate

(b) Complete the table below for the ions formed by magnesium, aluminium, and oxygen.  
Use the periodic table in your Resource Booklet to help you.

Atom	Atomic number	Electron arrangement of atom	Electron arrangement of ion	Charge on ion
Mg				
Al				
O	8	2,6	2,8	2-

(c) The formula for magnesium oxide is MgO. The formula for aluminium oxide is Al<sub>2</sub>O<sub>3</sub>.  
Explain why the two formulae are different.

In your answer:

- consider the ratio of ions in each formula and explain how the ratio is related to the charge on the ions
- relate the ratio of ions in the formula to the number of electrons lost or gained by each atom

### 2013:1 ATOMIC STRUCTURE

F<sup>-</sup>, Ne, and Mg<sup>2+</sup> have the **same** electron arrangement.

(a) Complete the table below.

Use the periodic table in your Resource Booklet.

Atomic number	Number of protons	Number of electrons	Electron arrangement
F <sup>-</sup>			
Ne			
Mg <sup>2+</sup>			

(b) Compare the atomic structure of F<sup>-</sup>, Ne, and Mg<sup>2+</sup>.

In your answer you should:

- describe the difference between an atom and an ion
- explain the charges on F<sup>-</sup>, Ne, and Mg<sup>2+</sup> in terms of electron arrangement and number of protons
- relate the position of F<sup>-</sup>, Ne, and Mg<sup>2+</sup> on the periodic table to the charges and electron arrangement
- explain why all three have the same electron arrangement.

## 2012:1 ATOMS AND IONS

(a) Complete the table below for ions formed by Ca, F, and Cl.

Atom	Atomic number	Electron arrangement of atom	Electron arrangement of ion	Ion symbol
Ca	20			
F	9			
Cl	17			

- (b) Explain the charges on ALL three ions, in terms of electron arrangement and number of protons.  
 (c) Use their positions on the periodic table to explain why two of the atoms form ions with the same charge, AND two of the atoms form ions with the **same electron arrangement**.

## 2011:1 IONS AND IONIC FORMULAE

- (a) Explain why the ions formed by sodium and oxygen both have the same electron arrangement. In your answer you should:
- describe an ion
  - describe the atomic structures of a sodium ion and an oxide ion
  - state the charge on the sodium ion and the oxide ion
  - explain the charges on both ions in terms of electron arrangement and number of protons.
- (b) Element X is between numbers 11 and 18 on the Periodic Table. An atom of element X forms an ion. This ion combines with the hydroxide ion to form a neutral compound,  $X(OH)_3$ .

Determine what element X is and justify your answer. In your answer you should:

- consider the ratio of X ions to hydroxide ions
- use the formula  $X(OH)_3$  to determine the charge of the X ion
- explain how you would use the Periodic Table in your Resource Booklet to find out which group element X is in
- name element X.

## 2011:1 IONIC COMPOUNDS (SAMPLE)

- (a) Magnesium and calcium atoms both form ions with a charge of +2. Magnesium atoms form  $Mg^{2+}$  ions, and calcium atoms form  $Ca^{2+}$  ions. Explain why magnesium and calcium atoms form ions with the same charge of +2. In your answer, you should:
- define an ion
- explain why atoms form ions
- identify the group on the periodic table where the two atoms are found
  - explain why both magnesium and calcium ions have a charge of +2.

- (b) Sodium and beryllium atoms form ions with different charges. Complete the table below.

Element	Periodic table group number	Electron arrangement of atom	Charge on the ion that the atom forms
Sodium			
Beryllium			

- (c) Explain why the ions in sodium hydroxide combine to give the formula NaOH but the ions in beryllium hydroxide combine to give the formula Be(OH)<sub>2</sub>.

In your answer, you should:

- compare the charges on the individual ions found in the compounds sodium hydroxide and beryllium hydroxide
- explain why the ions combine in the ratios the way they do to form the compounds NaOH and Be(OH)<sub>2</sub>.

*NOTE: Isotopes has been removed from AS90944 v2. However, you might still be asked to describe differences and similarities between two atoms, given their atomic and mass numbers.*

### 2011:2 ISOTOPES AND IONS (SAMPLE)

- (a) Lithium atoms can exist in different forms (called isotopes). Two of these are Lithium-6 ( ${}^6_3\text{Li}$ ) and Lithium-7 ( ${}^7_3\text{Li}$ ).

Explain why  ${}^6_3\text{Li}$  and  ${}^7_3\text{Li}$  are both neutral atoms. In your answer, you should fully describe their atomic structure and state their electron configuration.

- (b) Beryllium can exist as an isotope in the form of beryllium-7 ( ${}^7_4\text{Be}$ ).

Discuss how the mass of  ${}^7_4\text{Be}$  compares with  ${}^6_3\text{Li}$  and  ${}^7_3\text{Li}$ . In your answer, you should:

- consider the atomic structure of each atom
- consider the meaning of the numbers '6' and '7' in terms of the atomic structures
- explain how the particles within an atom contribute to its overall mass.

You may draw labelled diagrams in the box below to support your answer.

### 2010:2 ALUMINIUM OXIDE (expired AS90189)

Aluminium reacts with oxygen to form aluminium oxide. The formula of aluminium oxide contains two aluminium ions and three oxide ions.

Discuss why the formula has two aluminium ions and three oxide ions.

In your answer you should:

- State the formula for aluminium oxide.
- State the electron configuration of the aluminium atom, the oxygen atom, the aluminium ion, and the oxide ion.
- Use the electron configurations and numbers of electrons lost or gained when forming ions to justify the formula of aluminium oxide.

*You may support your answer with diagrams.*

### 2009:1 ATOMIC STRUCTURE (expired AS90189)

Some elements have isotopes. Isotopes of an element have the same number of protons, but different numbers of neutrons. Carbon-12 ( ${}^{12}_6\text{C}$ ) and carbon-13 ( ${}^{13}_6\text{C}$ ) are isotopes of carbon.

- Explain why  ${}^{12}_6\text{C}$  and  ${}^{13}_6\text{C}$  are neutral atoms. You should describe their atomic structure, and state their electron configuration.
- Explain how the particles within an atom contribute to its overall mass.
- Nitrogen can exist as an isotope in the form of nitrogen-13 ( ${}^{13}_7\text{N}$ ).

Discuss how the **mass** of  ${}^{13}_7\text{N}$  compares with  ${}^{12}_6\text{C}$  and  ${}^{13}_6\text{C}$ .

In your answer consider:

- the atomic structure of each atom
- the relevance of the numbers “12” and “13” in terms of atomic structure.

Diagram(s) may be used to support your discussion.

### 2008 :1 (expired AS90189)

Oxygen atoms are made of protons, neutrons, and electrons.

One type of oxygen atom can be represented as  ${}^{18}_8\text{O}$ .

- Draw a diagram to show the arrangement of the electrons, protons, and neutrons within the above oxygen atom.
  - Explain, with reference to the diagram, why the atom is neutral.
- Use the table of ions in the Resource Booklet to fill in the missing name or formula for each of the compounds below.

Scientific name	Formula
(i)	$\text{FeSO}_4$
Ammonium nitrate	(ii)
(iii)	$\text{KNO}_3$
Calcium hydrogen carbonate	(iv)

- Both potassium and magnesium form compounds with hydroxide ions.
  - Complete the table below for potassium and magnesium:

Element	Periodic Table Group Number	Electron arrangement of atom	Charge on ion that forms
Potassium			
Magnesium			

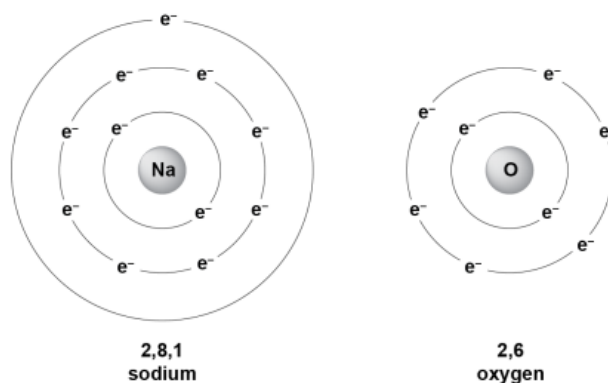
- Discuss why potassium hydroxide has the formula  $\text{KOH}$ , while magnesium hydroxide has the formula  $\text{Mg(OH)}_2$ . Refer to:
  - the information in part (i)
  - the changes in the electron arrangements of potassium and magnesium when they react.



ANSWERS TO RECENT QUESTIONS

2020:1

(a) (i)



(ii) Both ions. 2, 8

(iii) Na needs to lose an electron to have a full outer shell and become stable. Na forms a  $\text{Na}^+$  ion, which has a charge of +1, as it now has 10 negative electrons and 11 positive protons. O needs to gain two electrons to have a full outer shell and become stable. O gains 2 electrons to form  $\text{O}^{2-}$  ion, which has a charge of -2, as it now has 10 negative electrons and 8 positive protons. Therefore,  $\text{Na}^+$  and  $\text{O}^{2-}$  ions now both have the same electron arrangement of 2,8

2020:2

(c) Calcium forms an ion with a charge of +2. It requires two negative charges to form a neutral compound. The chloride ion has a charge of -1, so two chloride ions, with a combined charge of -2 are required to cancel out the charge on the calcium ion. The carbonate ion has a charge of -2, so only one carbonate ion is required to cancel out the charge on the calcium ion.

2019:2

(a) Ca: 2,8,8,2 Cl: 2,8,7

(b) (i) Both ions have the electron arrangement 2,8,8

(ii)  $\text{Ca}^{2+}$  because it has 20 + protons (+ charges) and only 18- electrons (- charges). It has only 18 electrons, as its electron arrangement as an atom was 2,8,8,2, and when it forms an ion, it loses two electrons to form an arrangement of 2,8,8 to have a full outer shell, which is more stable.  $\text{Cl}^-$  because it has 17+ protons (+ charges) and 18 - electrons (- charges). It has 18 electrons, as its electron arrangement as an atom was 2,8,7 and when it forms an ion, it gains one electron to form an arrangement of 2,8,8 to have a full outer shell, which is more stable.

(d) Calcium loses 2 electrons to form  $\text{Ca}^{2+}$  ending up with a charge of +2. Chlorine will gain only one electron to become  $\text{Cl}^-$  and have a charge of -1. As Ca reacts, it loses the 2 electrons in its outer shell; one to each Cl atom to fill their outer shells. In order to have a neutral compound, one calcium ion is needed to cancel out the charge on two chloride ions with a combined charge of -2.

2018:1

(a) Both atoms have the same number of valence electrons, which determines the group (1). The period is determined by the number of electron shells. Li has 2 electron shells so is found in Period 2; Na has 3 electron shells so is found in Period 3.

(b) Na has 11 protons and electron arrangement of 2,8,1. F has 9 protons and electron arrangement of 2,7. Both atoms need to gain or lose electrons to have a full outer shell and become stable. Na loses one electron to form  $\text{Na}^+$  ion which has a charge of +1 as it now has 10 negative electrons and 11 positive protons. F gains 1 electron to form  $\text{F}^-$  ion which has a charge of -1 as it now has 10 negative electrons and 9 positive protons. Therefore,  $\text{Na}^+$  and  $\text{F}^-$  ions now both have the same electron arrangement of 2,8.

- (c) Magnesium loses 2 electrons to end up with a charge of +2. Fluorine will gain only one electron to have a charge of -1. As Mg reacts, it loses the 2 electrons in its outer shell; one to each F atom to fill their outer shells. In order to have a neutral compound, one magnesium ion is needed to cancel out the charge on two fluoride ions with a combined charge of -2.

### 2017:2

- (a) Sodium and potassium are both in Group 1 of the periodic table. This means they each have one valence electron. Their atom electron arrangements are shown below:  
 Na atom: 2, 8, 1    K atom: 2, 8, 8, 1    The Na and K atoms will each lose their one valence electron to gain a stable full outer shell, as shown by the ion electron arrangements below:  $\text{Na}^+$  : 2, 8     $\text{K}^+$  : 2, 8, 8  
 Oxygen is in Group 16 of the Periodic Table. This means it has six valence electrons. Its atom electron arrangement is: O atom: 2, 6    The O atom will gain two electrons to gain a stable full outer shell, as shown by the ion electron arrangement below:  $\text{O}^{2-}$  : 2, 8  
 Since Na and K each lose one valence electron whereas O gains two electrons, Na and K can transfer electrons to the O atom. This transfer of electrons causes ions to form; the electrostatic attraction between the oppositely charged ions ( $\text{Na}^+$  and  $\text{O}^{2-}$ , and  $\text{K}^+$  and  $\text{O}^{2-}$ ) is called an ionic bond. Each O atom will need to react with two K / Na atoms to get the two electrons it needs. The Na and K atoms cannot react with each other because they each react by losing one electron. Therefore, electron transfer cannot occur between the Na and K atoms.

### 2017:3

- (a) (i) Each silver (Ag) atom loses one electron to form the  $\text{Ag}^+$  ion; however, each oxygen atom requires two electrons to fill its outer shell. Therefore, two Ag atoms react for every O atom, i.e. two Ag atoms lose 2 electrons and one O atom gains 2 electrons. The two  $\text{Ag}^+$  ions have a total charge of +2 to balance the -2 total charge of the  $\text{O}^{2-}$  ion, i.e. an ionic compound has no overall charge.

### 2016:1

- (a)

	Atomic number	Electron arrangement of atom	Electron arrangement of ion
F	9	2, 7	2, 8
S	16	2, 8, 6	2, 8, 8
Ca	20	2, 8, 8, 2	2, 8, 8

- (b) (i) AgF  
 (ii)  $\text{K}_2\text{SO}_4$   
 (iii)  $\text{Ca}(\text{NO}_3)_2$
- (iv) (i) Na is a group one element, so the Na atom has one valence electron and an electron configuration of 2, 8, 1. The Na atom loses its one valence electron to gain a full outer shell – it now has 1 more proton (11) than electrons; the  $\text{Na}^+$  ion is formed. O is a group sixteen element, so the O atom has six valence electrons and an electron configuration of 2, 6. The O atom gains two electrons to gain a full outer shell – it now has 2 less protons (8) than electrons; the  $\text{O}^{2-}$  ion is formed.

- (ii) The Na atom loses one electron to form the Na<sup>+</sup> ion; however, the O atom requires two electrons to fill its outer shell. Therefore, two Na atoms react for every one O atom. The two Na<sup>+</sup> ions have a total charge of +2 to balance the -2 charge of the O<sup>2-</sup> ion, i.e. an ionic compound has no overall charge. The bonding / attraction between the Na<sup>+</sup> ions and the O<sup>2-</sup> ions is an ionic bond, formed when the electrons lost by the Na are gained by the O.

### 2015:2

- (a) Al<sup>3+</sup> because it has 13 protons (+ charges) and only 10 electrons (- charges). It has only 10 electrons, as its electron arrangement as an atom was 2,8,3, and when it forms an ion, it loses three electrons to form an arrangement of 2,8 to have a full outer shell, which is more stable.  
 S<sup>2-</sup> because it has 16 protons (+ charges) and 18 electrons (- charges). It has 18 electrons, as its electron arrangement as an atom was 2,8,6, and when it forms an ion, it gains two electrons to form an arrangement of 2,8,8 to have a full outer shell, which is more stable.  
 Cl<sup>-</sup> because it has 17 protons (+ charges) and 18 electrons (- charges). It has 18 electrons, as its electron arrangement as an atom was 2,8,7, and when it forms an ion it gains one electron to form an arrangement of 2,8,8 to have a full outer shell, which is more stable.
- (b) An ionic bond is the attraction between a positive ion and a negative ion. It is formed because opposite charges will attract one another. An ionic bond would not form between chloride ions and sulfide ions, as they both have negative charges because they have both gained negative electrons in order to form a full valence shell, and the ions with the same charge will repel each other.

- (c) Elements 1 and 3: AlCl<sub>3</sub>

Aluminium has a charge of +3. In order to have a neutral compound overall, one aluminium ion is required to cancel out the charge on three chloride ions with a combined charge of -3. The charge on the aluminium ion arises as it gives away three electrons in order to have a full outer shell. Because it has to give 3 electrons away and each chlorine has to accept one electron, in order to have a full shell, the ratio of ions required is one to three.

Element 1 and 2: Al<sub>2</sub>S<sub>3</sub>

The aluminium ion has a charge of +3. In order to have a neutral compound overall, two aluminium ions with a combined charge of +6 are required to cancel out the charge on three 2- sulfide ions with a combined charge of - 6. The charge on the aluminium ion arises as aluminium gives away three electrons in order to have a full outer shell. Because it has to give 3 electrons away and sulfur has to accept two electrons in order to have a full shell, the ratio of ions required is two to three.

### 2014:1

- (a) CaCl<sub>2</sub> NaNO<sub>3</sub> Zn(NO<sub>3</sub>)<sub>2</sub>  
 (b)

Atom	Atomic number	Electron arrangement of atom	Electron arrangement of ion	Charge on ion
Mg	12	2,8,2	2,8	+2
Al	13	2,8,3	2,8	+3
O	8	2,6	2,8	-2

- (c) Magnesium ion has a charge of +2 and oxide ion has a charge of -2. A compound overall has to have no charge. Therefore the +2 charge of magnesium ion cancels out the -2 charge of oxide ion, and so therefore the ratio of ions is one to one. The charge on the ions arises, as magnesium has to lose two electrons in order to have a full outer shell and have a charge of +2, and oxygen has to gain two

electrons in order to have a full outer shell and have a charge of  $-2$ . In order to do this, magnesium gives its two electrons straight to oxygen and the ratio is one to one of the two ions.

Aluminium ion has a charge of  $+3$ . In order to have a neutral compound overall, two aluminium ions with a combined charge of  $+6$  are required to cancel out the charge on three oxide ions with a combined charge of  $-6$ . The charge on the aluminium ion arises as it gives away three electrons in order to have a full outer shell. Because it has to give 3 electrons away and oxygen has to accept two electrons in order to have a full shell, the ratio of ions required is two to three.

### 2013: 1 ATOMIC STRUCTURE

$F^-$ , Ne, and  $Mg^{2+}$  have the **same** electron arrangement.

(a) Complete the table below.

Use the periodic table in your Resource Booklet.

Atomic number	Number of protons	Number of electrons	Electron arrangement
$F^-$	9	10	2,8
Ne	10	10	2,8
$Mg^{2+}$	12	10	2,8

(b) Compare the atomic structure of  $F^-$ , Ne, and  $Mg^{2+}$ .

In your answer you should:

- describe the difference between an atom and an ion
- explain the charges on  $F^-$ , Ne, and  $Mg^{2+}$  in terms of electron arrangement and number of protons
- relate the position of  $F^-$ , Ne, and  $Mg^{2+}$  on the periodic table to the charges and electron arrangement
- explain why all three have the same electron arrangement.

The difference between an ion and an atom is that an atom has a neutral charge as it has not gained or lost electrons and therefore has the same number of protons (+) and electrons (-) whereas an ion has a charge as the atom it was formed from has either gained or lost electrons to form a full outer shell and therefore has a different number of protons (+) from the number of electrons (-).

#### Explanation of charges

Fluorine has 9 protons and electron arrangement of 2,7. Neon has 10 protons and an electron arrangement of 2,8. Magnesium has 12 protons and an electron arrangement of 2,8,2.

Fluorine gains one electron to have a full outer shell. This is because it is in group 17 and has 7 valence electrons. For fluorine ion, the electron arrangement is 2,8.

Fluorine has a charge of  $-1$  as it now has 10 electrons (negative charges) and nine protons (positive charges).

Neon has no charge as it has the same number of protons and electrons, as it has not gained or lost electrons, as it has an electron arrangement of 2,8 because it is in group 18 of the periodic table and its valence shell is complete.

Magnesium has 12 protons and electron arrangement of 2,8,2.

Magnesium has two electrons in its outer shell as it is in group 2 of the periodic table, which it loses, so its outer shell is full (2,8) and it has a charge of  $+2$ , as it still has 12 protons (positive charges) and now has only 10 electrons (negative charges).

All three have the same electron arrangement as they have gained one electron, lost two electrons or have neither gained or lost electrons. The electron arrangement is 2,8 as this is the nearest possible stable electron arrangement for all three.

**2012: 1 ATOMS AND IONS**

(a) Complete the table below for ions formed by Ca, F, and Cl.

Atom	Atomic number	Electron arrangement of atom	Electron arrangement of ion	Ion symbol
Ca	20			
F	9			
Cl	17			

Atom	Atomic No	Electron arrangement of atom	Electron arrangement of ion	Ion symbol
Ca	20	2,8,8,2	2,8,8	Ca <sup>2+</sup>
F	9	2,7	2,8	F <sup>-</sup>
Cl	17	2,8,7	2,8,8	Cl <sup>-</sup>

- (b) Explain the charges on ALL three ions, in terms of electron arrangement and number of protons.  
(c) Use their positions on the periodic table to explain why two of the atoms form ions with the same charge, AND two of the atoms form ions with the **same electron arrangement**.

F has 9 protons and electron arrangement of 2,7. Cl has 17 protons and an electron arrangement of 2,8,7. Both atoms are in group 17 of the periodic table as they both have 7 electrons in the valence shell. Both atoms gain one electron to have a full outer shell. For F ion the electron arrangement is 2,8, and for Cl ion it is 2,8,8.

F has a charge of  $-1$  as it now has 10 electrons ( $-$ ) and 9 protons ( $+$ ). Cl has a charge of  $-1$  as it now has 18 electrons ( $-$ ) and 17 protons ( $+$ ).

Ca has 20 protons and electron arrangement of 2,8,8,2. Ca has two electrons in its outer shell, which it loses, so its new outer shell is full (2,8,8) and it has a charge of  $+2$ , as it still has 20 protons ( $+$ ) and now has only 18 electrons ( $-$ ). Therefore Ca and Cl ions now both have the same electron configuration of 2,8,8.

### 2011: 1 IONS AND IONIC FORMULAE

- (a) Explain why the ions formed by sodium and oxygen both have the same electron arrangement.  
In your answer you should:

- describe an ion
- describe the atomic structures of a sodium ion and an oxide ion
- state the charge on the sodium ion and the oxide ion
- explain the charges on both ions in terms of electron arrangement and number of protons.

#### Description of ion

An ion is a charged particle formed when an atom or group of atoms that has lost or gained electron(s) and therefore carries a charge / full outer shell / stable.

#### Explanation of charges

Sodium has 11 protons and electron arrangement of 2,8,1.

Sodium has one electron in its outer shell, which it loses, so its outer shell is full (2,8) and it has a charge of  $+1$ , as it still has 11 protons (positive charges) and now has only 10 electrons (negative charges).

Oxygen has 8 protons and electron arrangement of 2,6. Oxygen has 6 electrons in its outer shell, and so it gains two electrons, so its outer shell is full (2,8) and so has a charge  $-2$ , as it still has 8 protons (positive charges) and now has 10 electrons (negative charges).

- (b) Element X is between numbers 11 and 18 on the Periodic Table.  
An atom of element X forms an ion. This ion combines with the hydroxide ion to form a neutral compound,  $X(\text{OH})_3$ .

Determine what element X is and justify your answer. In your answer you should:

- consider the ratio of X ions to hydroxide ions
- use the formula  $X(\text{OH})_3$  to determine the charge of the X ion
- explain how you would use the Periodic Table in your Resource Booklet to find out which group element X is in
- name element X.

**Ratio of X ions to  $\text{OH}^-$  ions 1:3**

**Charge of X**

Hydroxide ion has a charge of  $-1$ . Because there are three hydroxide ions overall, the total negative charge is  $-3$ . Therefore to form a neutral compound, X must have a charge of  $+3$ , as there is only one X ion in the formula. Therefore X loses three electrons to have a charge of  $+3$ .

**How to find group for X**

The only element between 11–18 that has three electrons in its valence shell is aluminium in group 13, OR it must be in group 13 to have three valence electrons.

**What is X?** Aluminium.

**2011: 1 IONIC COMPOUNDS (SAMPLE)**

(a) Magnesium and calcium atoms both form ions with a charge of  $+2$ . Magnesium atoms form  $Mg^{2+}$  ions, and calcium atoms form  $Ca^{2+}$  ions.

Explain why magnesium and calcium atoms form ions with the same charge of  $+2$ . In your answer, you should:

define an ion

explain why atoms form ions

- identify the group on the periodic table where the two atoms are found
- explain why both magnesium and calcium ions have a charge of  $+2$ .

An ion is charged particle formed when an atom or group of atoms have lost or gained an electron and therefore carry a charge.

Explanation of formation of ions:

If the outer shell (valence) of an atom is not filled, the atom is unstable. It will react to gain a full outer shell to become more stable, by either losing or gaining electrons and making it into an ion.

Identification of Group:

Magnesium and calcium are in the same group on the periodic table (Group 2).

Explanation of why both form  $+2$  ions:

The atoms have the same number of electrons (two) in their outer shell. (Students may give the electron configuration instead.)

Both Mg and Ca need to lose two outer electrons to become stable by having a full outer shell. Each ion ( $Mg^{2+}$  and  $Ca^{2+}$ ) ends up with two less electrons than there are protons in its nucleus, so the ion has a charge of  $+2$ .

(b) Sodium and beryllium atoms form ions with different charges.

Complete the table below.

Element	Periodic table group number	Electron arrangement of atom	Charge on the ion that the atom forms
Sodium			
Beryllium			

Element	Periodic table group number	Electron arrangement of atom	Charge on the ion that the atom forms
Sodium	1	2.8.1	+1 (or 1+)
Beryllium	2	2.2	+2 (or 2+)

(c) Explain why the ions in sodium hydroxide combine to give the formula NaOH but the ions in beryllium hydroxide combine to give the formula  $Be(OH)_2$ .

In your answer, you should:

- compare the charges on the individual ions found in the compounds sodium hydroxide and beryllium hydroxide
- explain why the ions combine in the ratios the way they do to form the compounds NaOH and Be(OH)<sub>2</sub>.

Comparison of charges on ions:

When these elements react, Na loses one electron and forms a +1 ion, while Be loses two electrons and forms a +2 ion in order to adopt the stable electron configuration. The hydroxide carries a charge of -1.

Explanation of formation of compounds:

An ionic compound is electrically neutral therefore all the positive charges must balance the negative charges. Therefore it requires one OH<sup>-</sup> for each Na<sup>+</sup> ion but two OH<sup>-</sup> ions for each Be<sup>2+</sup> ion to form a neutral compound/ balance the charges.

*NOTE: Isotopes has been removed from AS90944 v2. However you might still be asked to describe differences and similarities between two atoms, given their atomic and mass numbers.*

### 2011 : 2 ISOTOPES AND IONS (SAMPLE)

- (a) Lithium atoms can exist in different forms (called isotopes). Two of these are Lithium-6 ( ${}^6_3\text{Li}$ ) and Lithium-7 ( ${}^7_3\text{Li}$ ).

Explain why  ${}^6_3\text{Li}$  and  ${}^7_3\text{Li}$  are both neutral atoms. In your answer, you should fully describe their atomic structure and state their electron configuration.

Atomic structure:  ${}^6_3\text{Li} - 3\text{p}, 3\text{n}, 3\text{e}$      ${}^7_3\text{Li} - 3\text{p}, 4\text{n}, 3\text{e}$

Electron configuration: Both – 2.1

Explanation of neutrality

Both  ${}^6_3\text{Li}$  and  ${}^7_3\text{Li}$  have equal numbers of protons and electrons, ie 3p and 3e. An atom is neutral when it has equal numbers of protons and electrons.

- (b) Beryllium can exist as an isotope in the form of beryllium-7 ( ${}^7_4\text{Be}$ ).

Discuss how the mass of  ${}^7_4\text{Be}$  compares with  ${}^6_3\text{Li}$  and  ${}^7_3\text{Li}$ . In your answer, you should:

consider the atomic structure of each atom

consider the meaning of the numbers '6' and '7' in terms of the atomic structures

explain how the particles within an atom contribute to its overall mass.

You may draw labelled diagrams in the box below to support your answer.

Atomic structure:  ${}^7_4\text{Be} - 4\text{p}, 3\text{n}, 4\text{e}$

See above for  ${}^6_3\text{Li}$  and  ${}^7_3\text{Li}$

Relevance of numbers: 6 and 7 refer to the total mass of the elements.

Explanation of mass: Overall mass of an atom is made up of protons and neutrons, as the mass of electrons is negligible.

Comparison of masses:  ${}^7_4\text{Be}$  will have the same atomic mass as  ${}^7_3\text{Li}$  because the total number of protons and neutrons is the same AND  ${}^7_4\text{Be}$  is heavier than  ${}^6_3\text{Li}$  as it has one more proton.

### 2010 :2 ALUMINIUM OXIDE (expired AS90189)

Aluminium reacts with oxygen to form aluminium oxide. The formula of aluminium oxide contains two aluminium ions and three oxide ions.

Discuss why the formula has two aluminium ions and three oxide ions.

In your answer you should:

- State the formula for aluminium oxide.
- State the electron configuration of the aluminium atom, the oxygen atom, the aluminium ion, and the oxide ion.
- Use the electron configurations and numbers of electrons lost or gained when forming ions to justify the formula of aluminium oxide.

*You may support your answer with diagrams.*



Electron configurations: Aluminium 2.8.3 Aluminium ion 2.8 Oxygen 2.6 Oxygen ion 2.8

Because aluminium has three electrons in its outer (valence) shell, it loses 3 electrons, giving it a full outer shell / becomes stable, gaining a positive charge.

Each oxygen has 6 electrons in its outer (valence) shell so giving it 2 electrons gives it a full outer shell / becomes stable gaining a negative charge.

Aluminium loses three electrons, so it has a +3 charge. Oxygen gains two electrons so it has a -2 charge.

As the compound is neutral, three oxide ions are required to balance out the two aluminium ions as  $3 \times -2 = 2 \times +3$ .

### 2009 :1 ATOMIC STRUCTURE (expired AS90189)

Some elements have isotopes. Isotopes of an element have the same number of protons, but different numbers of neutrons. Carbon-12 ( $^{12}_6\text{C}$ ) and carbon-13 ( $^{13}_6\text{C}$ ) are isotopes of carbon.

- Explain why  $^{12}_6\text{C}$  and  $^{13}_6\text{C}$  are neutral atoms. You should describe their atomic structure, and state their electron configuration.
- Explain how the particles within an atom contribute to its overall mass.
- Nitrogen can exist as an isotope in the form of nitrogen-13 ( $^{13}_7\text{N}$ ).

Discuss how the **mass** of  $^{13}_7\text{N}$  compares with  $^{12}_6\text{C}$  and  $^{13}_6\text{C}$ .

In your answer consider:

- the atomic structure of each atom
- the relevance of the numbers "12" and "13" in terms of atomic structure.

Diagram(s) may be used to support your discussion.

- $^{12}\text{C}$ : 6 protons, 6 neutrons, electron configuration of 2.4  
 $^{13}\text{C}$ : 6 protons, 7 neutrons, electron configuration of 2.4  
 $^{12}\text{C}$  and  $^{13}\text{C}$  are neutral as they both contain equal numbers of protons and electrons.
- The overall mass of an atom is made up of protons and neutrons, as the mass of the electrons is negligible.
- $^{13}\text{N}$  will have the same atomic mass as  $^{13}\text{C}$  because the total number of protons and neutrons is the same.  $^{13}\text{N}$  is heavier than  $^{12}\text{C}$  because it has one extra proton.

2008 :1 (expired AS90189)

Oxygen atoms are made of protons, neutrons, and electrons.

One type of oxygen atom can be represented as  ${}^{18}_8\text{O}$ .

- (a)
- Draw a diagram to show the arrangement of the electrons, protons, and neutrons within the above oxygen atom.
  - Explain, with reference to the diagram, why the atom is neutral.

Diagram showing 8 protons and 10 neutrons in nucleus, with 8 electrons orbiting, 2 in first shell, six in second.

Atom is neutral as there are the same number of positive particles / charges / protons as negative particles / charges / electrons.

- (b) Use the table of ions in the Resource Booklet to fill in the missing name or formula for each of the compounds below.

Scientific name	Formula
(i)	FeSO <sub>4</sub>
Ammonium nitrate	(ii)
(iii)	KNO <sub>3</sub>
Calcium hydrogen carbonate	(iv)

Scientific name	Formula
(i) Iron(II) sulfate	FeSO <sub>4</sub>
Ammonium nitrate	(ii) (NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>
(iii) Potassium nitrate	KNO <sub>3</sub>
Calcium hydrogen carbonate	(iv) Ca(HCO <sub>3</sub> ) <sub>2</sub>

- (c) Both potassium and magnesium form compounds with hydroxide ions.

- (i) Complete the table below for potassium and magnesium:

Element	Periodic Table Group Number	Electron arrangement of atom	Charge on ion that forms
Potassium			
Magnesium			
Element	Periodic Table Group Number	Electron arrangement of atom	Charge on ion that forms
Potassium	1	2.8.8.1	1+
Magnesium	2	2.8.2	2+

- (ii) Discuss why potassium hydroxide has the formula KOH, while magnesium hydroxide has the formula Mg(OH)<sub>2</sub>. Refer to:
- the information in part (i)
  - the changes in the electron arrangements of potassium and magnesium when they react.

When these elements react, K loses one electron and forms a +1 ion, while Mg loses two electrons and forms a +2 ion, in order to adopt the stable electron configuration 2,8,8 and 2,8 respectively.

Hydroxide carries a charge of -1, therefore it requires one OH<sup>-</sup> for each K<sup>+</sup> ion but two OH<sup>-</sup> ions for each Mg<sup>2+</sup> ion to form a neutral compound/ balance out the charges.