

## Atoms, Elements and Compounds

(Past Year Topical Questions 2010-2015)

May/June 2010 (31)

5 Carbon and silicon are elements in Group IV. Both elements have macromolecular structures.

(a) Diamond and graphite are two forms of the element carbon.

(i) Explain why diamond is a very hard substance.

.....  
.....  
..... [2]

(ii) Give **one** use of diamond.

..... [1]

(iii) Explain why graphite is a soft material.

.....

..... [2]

(iv) Give **one** use of graphite.

..... [1]

(b) Two of the oxides of these elements are carbon dioxide,  $\text{CO}_2$ , and silicon(IV) oxide,  $\text{SiO}_2$ .

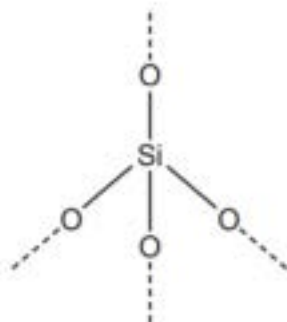
(i) Draw a diagram showing the arrangement of the valency electrons in one molecule of the covalent compound carbon dioxide.

Use x to represent an electron from a carbon atom.

Use o to represent an electron from an oxygen atom.

[3]

(ii) A section of the macromolecular structure of silicon(IV) oxide is given below.



Use this diagram to explain why the formula is  $\text{SiO}_2$  not  $\text{SiO}_4$ .

.....  
..... [2]

(iii) Predict **two** differences in the physical properties of these two oxides.

.....  
..... [2]

[Total: 13]

Oct/Nov 2010 (31)

- 1 The table gives the composition of three particles.

particle	number of protons	number of electrons	number of neutrons
<b>A</b>	15	15	16
<b>B</b>	15	18	16
<b>C</b>	15	15	17

- (a) What is the evidence in the table for each of the following?

- (i) Particle **A** is an atom.

.....  
..... [1]

- (ii) They are all particles of the same element.

.....  
..... [1]

- (iii) Particle **B** is a negative ion.

.....  
..... [2]

(iv) Particles **A** and **C** are isotopes.

.....

..... [2]

(b) (i) What is the electronic structure of particle **A**?

..... [1]

(ii) What is the valency of the element?

..... [1]

(iii) Is the element a metal or a non-metal? Give a reason for your choice.

.....

..... [1]

[Total: 9]

Oct/Nov 2010 (32)

1 The following table gives information about six substances.

substance	melting point /°C	boiling point /°C	electrical conductivity as a solid	electrical conductivity as a liquid
A	839	1484	good	good
B	-210	-196	poor	poor
C	776	1497	poor	good
D	-117	78	poor	poor
E	1607	2227	poor	poor
F	-5	102	poor	good

(a) Which substance could have a macromolecular structure, similar to that of silicon(IV) oxide?

..... [1]

(b) Which substances are solids at room temperature?

..... [1]

(c) Which substance could be a metal?

..... [1]

(d) Which substance could be aqueous sodium chloride?

..... [1]

(e) Which substance is an ionic compound?

..... [1]

(f) Which substances are liquids at room temperature?

..... [1]

[Total: 6]

Oct/Nov 2010 (33)

- 1 The diagrams below show the electron arrangement in two compounds.



- (a) In a water molecule, each hydrogen atom is bonded to the oxygen atom by sharing a pair of electrons.

Why does an oxygen atom share two pairs of electrons rather than just one pair?

.....  
 ..... [1]

- (b) Describe how a potassium atom becomes a potassium ion.

..... [1]

- (c) Why is there a bond between the ions in potassium chloride?

.....  
 ..... [1]

- (d) Solid potassium chloride is a poor conductor of electricity. When dissolved in water it is a good conductor. Explain.

.....  
 ..... [2]

[Total: 5]



2 Vanadium is a transition element.

(a) An atom of the most common isotope of vanadium can be represented as  ${}_{23}^{51}\text{V}$ .

Complete the following table to show the number of protons, electrons and neutrons in each particle.

particle	number of protons	number of electrons	number of neutrons
${}_{23}^{51}\text{V}$			
${}_{23}^{51}\text{V}^{3+}$			
${}_{23}^{50}\text{V}$			

[3]

(b) The major use of vanadium is to make vanadium steel alloys.

(i) Explain the phrase *steel alloys*.

.....  
 ..... [2]

(ii) State the name and use of another steel alloy.

name .....

use ..... [2]

(c) Two of the oxidation states of vanadium are +3 and +4.

(i) Write the formula of vanadium(III) oxide and of vanadium(IV) oxide.

vanadium(III) oxide .....

vanadium(IV) oxide ..... [2]

May/June 2011 (31)

2 Selenium and sulfur are in Group VI. They have similar properties.

(a) One of the main uses of selenium is in photoelectric cells. These cells can change light into electrical energy.

(i) Name a process which can change light into chemical energy.

.....

(ii) Name a device which can change chemical energy into electrical energy.

..... [2]

(b) The electron distribution of a selenium atom is  $2 + 8 + 18 + 6$ .

(i) Selenium forms an ionic compound with potassium. Draw a diagram which shows the formula of this ionic compound, the charges on the ions and the arrangement of the **valency** electrons around the negative ion.

Use o to represent an electron from an atom of potassium.

Use x to represent an electron from an atom of selenium.

[3]

- (ii) Draw a diagram showing the arrangement of the valency electrons in one molecule of the covalent compound selenium chloride.  
 Use x to represent an electron from an atom of selenium.  
 Use o to represent an electron from an atom of chlorine.

[3]

- (iii) Predict **two** differences in the physical properties of these two compounds.

.....  
 .....

[2]

May/June 2011 (32)

- 1 Choose an element from the list below which best fits the description.

**Rb      Fe      Si      I      P      Sr**

- (a) An element which reacts with cold water. .... [1]  
 (b) It is a solid at room temperature and exists as diatomic molecules,  $X_2$ . .... [1]  
 (c) It can form two oxides,  $XO$  and  $X_2O_3$ . .... [1]  
 (d) This element has a hydride of the type  $XH_3$ . .... [1]  
 (e) It has a macromolecular structure similar to that of carbon. .... [1]

[Total: 5]

Oct/Nov 2011 (31)/Q1

(c) Lithium oxide is an ionic compound.

(i) Identify another ionic oxide in the list on page 3.

..... [1]

(ii) Draw a diagram which shows the formula of lithium oxide, the charges on the ions and the arrangement of the valency electrons around the negative ion.  
Use x to represent an electron from an atom of oxygen.  
Use o to represent an electron from an atom of lithium.

[2]

Oct/Nov 2011 (32)

1 Cobalt is an element in Period 4 of the Periodic Table.

(a) Use your copy of the Periodic Table to help you complete the table below.

particle	number of protons	number of neutrons	number of electrons
Co			
Co <sup>2+</sup>			

[2]

(b) <sup>60</sup>Co is a cobalt isotope.

(i) Explain the term *isotope*.

.....

.....

..... [2]

(ii) Explain why two isotopes of the same element have identical chemical properties.

..... [1]

(iii) State **one** industrial use and **one** medical use of radioactive isotopes.

industrial use ..... [1]

medical use ..... [1]

[Total: 7]

Oct/Nov 2011 (33)/Q1

(b) Predict the formula of each of the following compounds.

(i) germanium oxide .....

(ii) tellurium bromide ..... [2]

(c) Give the formula of each of the following ions.

(i) strontium .....

(ii) fluoride ..... [2]

May/June 2012 (32)

- 1 The table below includes information about some of the elements in Period 2.

element	carbon	nitrogen	fluorine	neon
symbol	C	N	F	Ne
structure	macromolecular	simple molecules N <sub>2</sub>	simple molecules F <sub>2</sub>	single atoms Ne
boiling point/°C	4200	-196	-188	-246

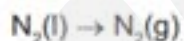
- (a) Why does neon exist as single atoms but fluorine exists as molecules?

.....  
..... [2]

- (b) What determines the order of the elements in a period?

..... [1]

- (c) When liquid nitrogen boils the following change occurs.



The boiling point of nitrogen is very low even though the bond between the atoms in a nitrogen molecule is very strong. Suggest an explanation.

.....  
..... [2]

- (d) Draw a diagram showing the arrangement of the outer shell (valency) electrons in a molecule of nitrogen.

[2]

[Total: 7]

- 2 Diamond and graphite are different forms of the same element, carbon. Explain the following in terms of their structure.

- (a) Graphite is a soft material which is used as a lubricant.

.....  
..... [2]

- (b) Diamond is a very hard material which is used for drilling and cutting.

.....  
..... [2]

- (c) Graphite is a good conductor of electricity and diamond is a poor conductor.

.....  
..... [2]

[Total: 6]



Oct/Nov 2012 (32)

1 This question is concerned with the elements in Period 5, Rb to Xe.

(a) The electron distributions of some of these elements are given in the following list.

element A	$2 + 8 + 18 + 8 + 2$
element B	$2 + 8 + 18 + 18 + 8$
element C	$2 + 8 + 18 + 18 + 5$
element D	$2 + 8 + 18 + 18 + 6$
element E	$2 + 8 + 18 + 18 + 4$
element F	$2 + 8 + 18 + 18 + 7$

(i) Identify element C. .... [1]

(ii) Which element in the list does not form any compounds?

..... [1]

(iii) Which element in the list forms a chloride of the type  $\text{XCl}_2$ ?

..... [1]

(iv) Which **two** elements would react together to form a compound of the type  $\text{XY}_4$ ?

..... [1]

(v) Which element in the list would react with cold water to form an alkaline solution and hydrogen?

..... [1]

- (b) Predict **two** differences in physical properties and **two** differences in chemical properties between rubidium and the transition metal niobium.

physical .....

.....

.....

chemical .....

.....

..... [4]

[Total: 9]

May/June 2013 (31)

- 2 An element, **M**, has the electron distribution  $2 + 8 + 18 + 3$ .

- (a) Which group in the Periodic Table is element **M** likely to be in?

..... [1]

- (b) Predict whether element **M** is a poor or a good conductor of electricity.  
Give a reason for your answer.

..... [1]

- (c) Binary compounds contain two atoms per molecule, for example  $\text{HCl}$ .  
Identify an element which could form a binary compound with element **M**.

..... [1]

- (d) Predict the formula of the sulfate of **M**. The formula of the sulfate ion is  $\text{SO}_4^{2-}$ .

..... [1]

May/June 2013 (33)

1 Substances can be classified as:

elements      mixtures      compounds

Elements can be divided into:

metals      non-metals

(a) Define each of the following terms.

(i) *element*

.....  
..... [2]

(ii) *compound*

.....  
..... [2]

(iii) *mixture*

.....  
..... [1]

(b) Classify each of the following as either an element, compound or mixture.

(i) brass ..... [1]

(ii) carbon dioxide ..... [1]

(iii) copper ..... [1]

(c) Which physical property is used to distinguish between metals and non-metals?  
It is possessed by all metals but by only one non-metal.

..... [1]

[Total: 9]

Oct/Nov 2013 (32)

- 1 The table gives the melting points, the boiling points and the electrical properties of six substances A to F.

substance	melting point /°C	boiling point /°C	electrical conductivity as a solid	electrical conductivity as a liquid
A	-210	-196	does not conduct	does not conduct
B	777	1627	does not conduct	good conductor
C	962	2212	good conductor	good conductor
D	-94	63	does not conduct	does not conduct
E	1410	2355	does not conduct	does not conduct
F	1064	2807	good conductor	good conductor

- (a) Which **two** substances could be metals? ..... [1]
- (b) Which substance could be nitrogen? ..... [1]
- (c) Which substance is an ionic solid? ..... [1]
- (d) Which substance is a liquid at room temperature? ..... [1]
- (e) Which substance has a giant covalent structure similar to that of diamond? ..... [1]
- (f) Which **two** substances could exist as simple covalent molecules? ..... [1]

[Total: 6]

Oct/Nov 2013 (32)/Q2

- (b) The halogens react with other non-metals to form covalent compounds.  
Draw a diagram which shows the arrangement of the valency electrons in one molecule of the covalent compound arsenic trifluoride.

The electron distribution of an arsenic atom is  $2 + 8 + 18 + 5$ .

Use x to represent an electron from an arsenic atom.

Use o to represent an electron from a fluorine atom.

[3]

Oct/Nov 2013 (33)

1 Zirconium (Zr) is a metal in Period 5. Its main oxidation state is +4.

(a) The following are all zirconium atoms:  ${}_{40}^{90}\text{Zr}$ ,  ${}_{40}^{91}\text{Zr}$  and  ${}_{40}^{92}\text{Zr}$ .

In terms of numbers of electrons, neutrons and protons, how are these three atoms the same and how are they different?

They are the same because .....

.....

They are different because .....

..... [3]

(b) Containers for fuel rods in nuclear reactors are made of zirconium.  
Nuclear reactors are used to produce energy and to make radioactive isotopes.

(i) Which isotope of a different element is used as a fuel in nuclear reactors?

..... [1]

(ii) State one medical and one industrial use of radioactive isotopes.

.....

..... [2]

May/June 2014 (31)

- 1 The table below gives the composition of six particles which are either atoms or ions.

particle	number of protons	number of neutrons	number of electrons
A	33	40	33
B	19	20	18
C	34	45	36
D	33	42	33
E	13	14	13
F	24	28	21

- (a) Which particles are atoms? Explain your choice.

.....  
..... [2]

- (b) Which particle is a negative ion and why has this particle got a negative charge?

.....  
..... [2]

- (c) Which particles are positive ions?

..... [1]

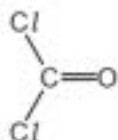
- (d) Explain why particle A and particle D are isotopes.

.....  
..... [2]

[Total: 7]

May/June 2014 (32)/Q5

(c) The structural formula of carbonyl chloride is given below.



Draw a diagram showing the arrangement of the valency electrons around the atoms in one molecule of this covalent compound.

Use  $\circ$  to represent an electron from an oxygen atom.

Use  $\times$  to represent an electron from a chlorine atom.

Use  $\bullet$  to represent an electron from a carbon atom.

[3]



May/June 2014 (32)/Q6

(b) Scandium fluoride is an ionic compound. The valency of scandium in scandium fluoride is three.

Draw a diagram which shows the formula of this compound, the charges on the ions and the arrangement of the valency electrons around the negative ions.

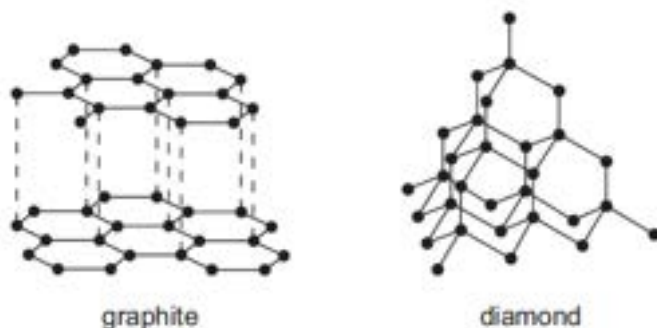
Use x to represent an electron from a fluorine atom.

Use o to represent an electron from a scandium atom.

[3]

Oct/Nov 2014 (31)

- 2 Two macromolecular forms of carbon are graphite and diamond. The structures of graphite and diamond are given below.



- (a) Explain in terms of its structure why graphite is soft and is a good conductor of electricity.

.....

.....

.....

.....

[3]

- (b) State two uses of graphite which depend on the above properties.

It is soft .....

.....

It is a good conductor of electricity .....

.....

[2]

(c) Silicon(IV) oxide also has a macromolecular structure.

(i) Describe the macromolecular structure of silicon(IV) oxide.

.....  
..... [1]

(ii) Predict two physical properties which diamond and silicon(IV) oxide have in common.

.....  
..... [2]

[Total: 8]

Oct/Nov 2014 (31)

(a) Nitrogen reacts with lithium to form the ionic compound lithium nitride,  $\text{Li}_3\text{N}$ .

(i) Write the equation for the reaction between lithium and nitrogen.

..... [2]

(ii) Lithium nitride is an ionic compound. Draw a diagram which shows its formula, the charges on the ions and the arrangement of the valency electrons around the negative ion.

Use x for an electron from a lithium atom.  
Use o for an electron from a nitrogen atom.

[2]

(b) Nitrogen fluoride is a covalent compound.

- (i) Draw a diagram showing the arrangement of the valency electrons in one molecule of the covalent compound nitrogen trifluoride,  $\text{NF}_3$ .

Use x for an electron from a nitrogen atom.  
Use o for an electron from a fluorine atom.

[2]

- (ii) Lithium nitride has a high melting point,  $813^\circ\text{C}$ . Nitrogen trifluoride has a low melting point,  $-207^\circ\text{C}$ .  
Explain why the melting points are different.

.....  
.....  
..... [2]

[Total: 8]

May/June 2015 (32)

- 1 Complete the following table which gives the number of protons, electrons and neutrons in each of the five particles.

particle	number of protons	number of electrons	number of neutrons
.....	19	19	20
${}^{56}_{26}\text{Fe}$	.....	.....	.....
.....	3	2	4
${}^{70}_{31}\text{Ga}^{3+}$	.....	.....	.....
.....	34	36	45

[Total: 8]

- 2 The table shows the melting points, boiling points and electrical properties of five substances, A to E.

substance	melting point /°C	boiling point /°C	electrical conductivity of solid	electrical conductivity of liquid
A	-7	59	poor	poor
B	1083	2567	good	good
C	755	1387	poor	good
D	43	181	poor	poor
E	1607	2227	poor	poor

Choose a substance from the table above to match each of the following descriptions. A substance may be used once, more than once or not at all. Justify each choice with evidence from the table.

One has been completed as an example.

This substance is covalent and is a solid at room temperature (25°C). ..... **D**.....

evidence *Its melting point is above room temperature. It has a low melting point and it does*

*not conduct as a liquid, so it is covalent.*

(a) This substance has a giant covalent structure. ....

evidence .....  
..... [3]

(b) This substance is a metal. ....

evidence .....  
..... [2]

(c) This substance is a liquid at room temperature (25 °C). ....

evidence .....  
..... [3]

(d) This substance is an ionic solid. ....

evidence .....  
..... [3]

3 Calcium reacts with nitrogen to form the ionic compound calcium nitride,  $\text{Ca}_3\text{N}_2$ .

- (a) Draw a diagram, based on the correct formula, which shows the charges on the ions and the arrangement of the electrons around the negative ion.

Use o to represent an electron from a calcium atom.  
Use x to represent an electron from a nitrogen atom.

[3]

(b) In the lattice of calcium nitride, the ratio of calcium ions to nitride ions is 3:2.

- (i) What is meant by the term *lattice*?

.....  
..... [2]

- (ii) In terms of ionic charges, explain why the ratio of ions is 3:2.

.....  
..... [2]

May/June 2015 (33)

1 Use your copy of the Periodic Table to help you answer these questions.

(a) Predict the formula of each of the following compounds.

(i) aluminium fluoride ..... [1]

(ii) arsenic oxide ..... [1]

(iii) silicon bromide ..... [1]

(b) Deduce the formula of each of the following ions.

(i) phosphide ..... [1]

(ii) barium ..... [1]

(iii) francium ..... [1]

(c) Draw a diagram showing the arrangement of the valency electrons in one molecule of the covalent compound carbon dioxide.

Use x to represent an electron from a carbon atom.

Use o to represent an electron from an oxygen atom.

[3]

[Total: 9]



Oct/Nov 2015 (31)

1 (a) The symbols of six particles are shown below.



Select from the list of particles to answer the following questions. A particle may be selected once, more than once or not at all.

- (i) Which **two** ions have the same electronic structure? ..... [1]
- (ii) Which ion has the same electronic structure as an atom of argon? ..... [1]
- (iii) Which atom can form an ion of the type  $\text{X}^{3-}$ ? ..... [1]
- (iv) Which atom can form a hydride which has a formula of the type  $\text{XH}_4$ ? ..... [1]

(b) (i) How many protons, neutrons and electrons are there in one copper(II) ion  ${}^{64}_{29}\text{Cu}^{2+}$ ?

number of protons .....

number of neutrons .....

number of electrons .....

[2]

(ii)  ${}^{45}_{21}\text{Sc}$  represents an atom of scandium.

How many nucleons and how many charged particles are there in one atom of scandium?

number of nucleons .....

number of charged particles .....

[2]

(c) Two different atoms of sodium are  ${}^{23}_{11}\text{Na}$  and  ${}^{24}_{11}\text{Na}$ .

(i) Explain why these two atoms are isotopes.

.....

..... [2]

- (ii)  $^{24}_{11}\text{Na}$  is radioactive. It changes into an atom of a different element which has one more proton.

Identify this element.

..... [1]

- (iii) State two uses of radioactive isotopes.

.....  
..... [2]

[Total: 13]

Oct/Nov 2015 (31)

- 6 Carbon and silicon are elements in Group IV. They both form oxides of the type  $\text{XO}_2$ .

- (a) Silicon(IV) oxide,  $\text{SiO}_2$ , has a macromolecular structure.

- (i) Describe the structure of silicon(IV) oxide.

.....  
.....  
.....  
.....  
..... [3]

- (ii) State three properties which silicon(IV) oxide and diamond have in common.

.....  
.....  
..... [3]

- (b) Explain why the physical properties of carbon dioxide are different from those of diamond and silicon(IV) oxide.

.....  
..... [1]

Oct/Nov 2015 (32)

- 6 The table below shows the elements in the third period of the Periodic Table, the number of electrons in their outer energy level, their oxidation state in their common compounds and their melting points.

element	Na	Mg	Al	Si	P	S	Cl	Ar
number of outer electrons	1	2	3	4	5	6	7	8
oxidation state	+1	+2	+3	+4/-4	-3	-2	-1	0
melting point/°C	98	650	660	1414	317	115	-101	-189

- (b) The first three elements, Na, Mg and Al, are metals.

Describe the structure of a typical metal.

.....  
 .....  
 ..... [3]

- (c) Explain why Na, Mg and Al are good conductors of electricity.

..... [1]

- (d) Which element exists as diatomic molecules of the type  $X_2$ ?

..... [1]

- (e) Silicon has a similar structure to diamond.

Explain why silicon has the highest melting point in the period.

.....  
 ..... [2]

- (f) Sodium chloride is a crystalline solid with a high melting point. It dissolves in water to give a neutral solution. Phosphorus trichloride is a liquid at room temperature. It reacts with water to form an acidic solution.

Suggest an explanation for these differences in properties.

.....  
.....  
..... [2]

- (h) Draw a dot-and-cross diagram showing the bonding in magnesium oxide. Show outer electrons only.

[3]

Oct/Nov 2015 (33)

3 Lithium bromide is an ionic compound. It can be electrolysed when it is molten or in aqueous solution. It cannot be electrolysed as a solid.

(a) Solid lithium bromide is a poor conductor of electricity. The ions cannot move to the electrodes, they are held in an ionic lattice by strong forces.

(i) Describe the motion of the ions in the solid state.

..... [1]

(ii) Define the term *ionic bonding*.

.....  
..... [2]

(iii) What is meant by the term *ionic lattice*?

.....  
..... [2]

May/June 2015 (31)/Q1

(b) State what is meant by the terms

(i) *element*,

.....  
..... [1]

(ii) *compound*,

.....  
..... [1]

(iii) *ion*,

.....  
..... [1]

2 Carbon and silicon are elements in Group IV of the Periodic Table. Both carbon and silicon exist as more than one isotope.

(a) Define the term *isotopes*.

.....  
 ..... [2]

(b) Complete the following table which gives information about carbon atoms and silicon atoms.

	carbon	silicon
proton number		
electronic structure		
nucleon number	12	28
number of neutrons in one atom		

[3]

(c) Silicon has a giant structure which is similar to the structure of diamond.

(i) Name the type of bond which is present between silicon atoms in silicon.

..... [1]

(ii) Suggest **two** physical properties of silicon.

Use your knowledge of structure and bonding to explain why silicon has these physical properties.

property 1 .....

reason 1 .....

property 2 .....

reason 2 .....

[4]

(e) Carbon dioxide,  $\text{CO}_2$ , is a gas at room temperature and pressure, whereas silicon(IV) oxide,  $\text{SiO}_2$ , is a solid.

(i) Name the type of structure which the following compounds have.

carbon dioxide ..... [1]

silicon(IV) oxide ..... [1]

(ii) Use your knowledge of structure and bonding to explain why carbon dioxide is a gas at room temperature and pressure, whereas silicon(IV) oxide is a solid.

.....  
.....  
.....  
..... [3]