QUESTION (2012:2)

(a) Complete the table below by stating the type of particle and the bonding (attractive forces) between the particles for each of the substances.

Substance	Type of particle	Attractive forces between particles
Ammonia, NH_3		
Zinc, Zn		
Silicon dioxide, SiO_2		

(b) Silicon dioxide has a melting point of 1770°C.
Explain why silicon dioxide has a high melting point by referring to the particles and the forces between the particles in the solid.

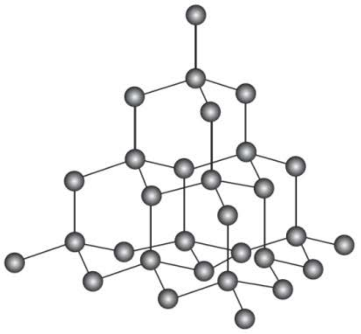
(c) Contrast both the electrical conductivity, and solubility in water, for both zinc, Zn, and zinc chloride, $ZnCl_2$, using your knowledge of structure and bonding.

QUESTION (2011:2)

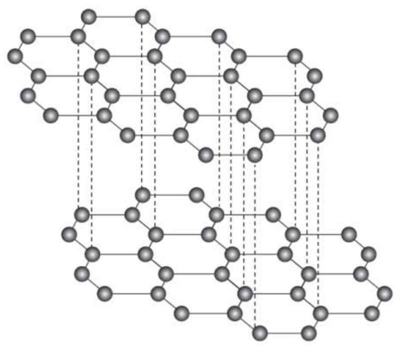
(a) Complete the table below by stating the type of solid, the type of particle present, and the bonding (attractive forces) between particles in the solid state.

Solid	Type of solid	Type of particle	Attractive forces between particles
Na			
P_4			
MgO			
SO_3			

(b) The diagrams below show 3-D structural representations of diamond and graphite. Diamond and graphite are both made up of carbon atoms, but these atoms are arranged differently in each solid.



Structure of diamond



Structure of graphite

(i) Describe the electrical conductivity and hardness of diamond and graphite.

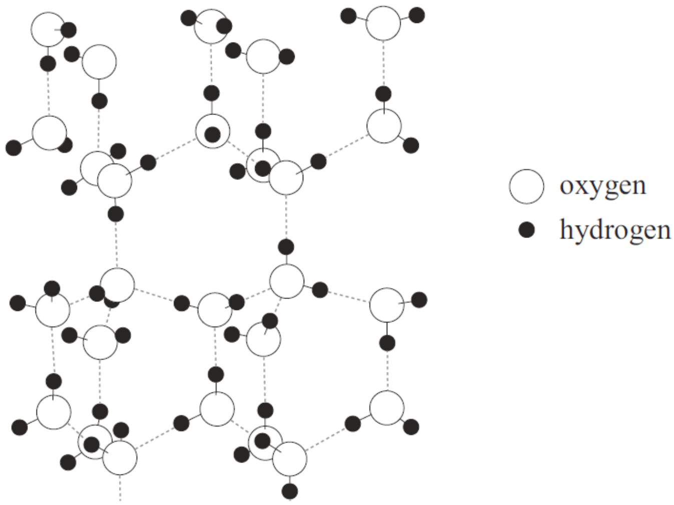
Diamond
electrical conductivity:
hardness:

Graphite
electrical conductivity:
hardness:

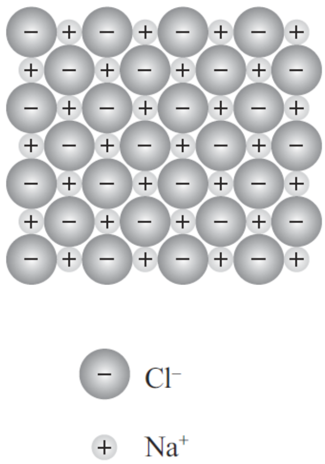
(ii) Discuss the electrical conductivity and hardness of both diamond and graphite, using your knowledge of structure and bonding.

QUESTION (2011:3)

The diagrams below show structural representations of the two solids ice, H_2O, and sodium chloride, NaCl.



Structure of ice



Structure of sodium chloride

(a) Ice melts at 0°C and sodium chloride melts at 801°C.

(i) On **each** diagram above, circle ONE of the forces of attraction which must be overcome for the substance to melt.

Give a reason for your choice.

Ice:
Sodium chloride:

(ii) Discuss the low melting point of ice and the high melting point of sodium chloride, using your knowledge of structure and bonding.

(b) Sodium chloride dissolves in water.
Discuss **how** and **why** sodium chloride dissolves in water, using your knowledge of structure and bonding.

Include a labelled diagram in your answer.

QUESTION (2010:3)

(a) State the type of particles (atoms / ions / molecules) present in the two solids $MgCl_2$ and SiO_2.

(b) The following table shows some physical properties of these two solids.

Solid	$MgCl_2$	SiO_2
Melting point / °C	712	1700
Solubility in water	soluble	insoluble

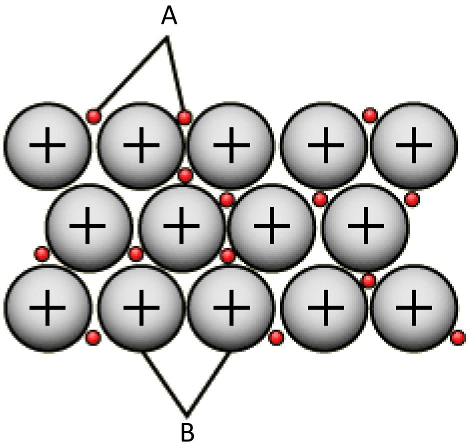
Compare and contrast these physical properties (melting point and solubility in water) of these two solids.

Your answer must include:

- reference to the type of solid
- the type of particle
- the attractive forces between the particles, for each of the two solids.

QUESTION (2010:4)

The diagrams below show the structure of a metallic solid.



(a) Name the particles in the diagrams above.

Particle	A	B
Name of particle		

(b) Copper is a good conductor of electricity and is ductile. It is often used to make electrical wires.
Use the diagrams above to discuss how the structure of copper allows it to be made into electrical wires.
In your answer you should:
- Describe the particles in copper and the attractive forces between the particles.
- Relate its structure to both properties outlined above.

QUESTION (2009:3)

(a) Complete the table below by stating the type of solid, the type of particle present and identifying the bonding (attractive forces) between the particles in the **solid** state. The first one has been done for you.

Solid	Type of solid	Type of particle	Bonding between particles
Chlorine Cl_2	Molecular	Molecule	Weak intermolecular forces
Silicon dioxide SiO_2			
Copper chloride $CuCl_2$			
Potassium K			
Carbon dioxide CO_2			

(b) Use the information given below to answer the question that follows.
- **Diamond** is a covalent network solid. It has a very high melting point of 3550°C.
- **Magnesium oxide**, MgO, is an ionic solid. It has a high melting point of 2800°C.
- **Sulfur dichloride**, SCl_2, is a molecular substance. It has a low melting point of –80°C.

Discuss the melting points of these three substances by referring to the **particles** and the **forces between the particles** in the solids.

QUESTION (2009:4)

Discuss the electrical conductivity of the following THREE substances using your knowledge of structure and bonding.
Sulfur, S_8, does not conduct electricity in the solid state nor in the liquid state.
Magnesium chloride, $MgCl_2$, conducts electricity when it is dissolved in water, but not in the solid state.
Lead, Pb, **conducts** electricity in the solid state and when molten (liquid).

QUESTION (2008:2)

Complete the table below by stating the type of particle present in each of the solids, and identifying the bonding (attractive forces) between particles.

Solid	Melting point (°C)	Type of particle	Bonding between particles
S_8	119		
$MgCl_2$	712		
Mg	650		
Diamond	3550		

QUESTION (2008:5)

Two of the following substances can conduct electricity.

copper chloride   diamond   graphite   iodine   silicon dioxide

(a) Write the names of these two substances.

(b) Discuss, with reference to structure and bonding, why the substances chosen in (a) are able to conduct electricity. Include any conditions that are required.

QUESTION (2007:3)

(a) Identify the type of particle and describe the bonding (attractive forces between the particles) for each of the solids in the table below.

Solid	Type of solid	Type of particle	Description of bonding
(i) Silver (Ag)	metallic		
(ii) Sulfur (S_8)	molecular		
(iii) Silicon dioxide (SiO_2)	covalent network		

(b) Silicon dioxide (SiO_2) has a melting point of 1700°C and sulfur (S_8) has a melting point of 113°C. Explain the difference in the melting points of these two substances in terms of structure and bonding.

QUESTION (2007:4)

Discuss the following properties of lithium chloride (LiCl), with reference to the particles in the solid and forces between the particles.

- Solid will not conduct electricity.
- Melting point of solid is 610°C.
- Solid dissolves in water but not in cyclohexane.

QUESTION (2007:5)

Use your knowledge of structure and bonding to discuss the following physical properties of diamond and graphite.

- Hardness
- Electrical conductivity
- Melting point

QUESTION (2006:2)

The following table contains oxides of elements from the third row of the Periodic Table.
Complete the table below by:

(a) stating the type of particle found in each substance as an **atom**, **ion** or **molecule**

(b) specifying the attractive force that exists between the particles in the solid state of the substance.

Solid	Type of particle	Attractive force between particles
Sodium oxide		
Sulfur trioxide		
Silicon dioxide		
Aluminium oxide		

QUESTION (2006:5)

The **physical properties** of some crystalline solids are stated below. For each example, explain why the substance has the property stated by relating the **property** to the **structure and bonding** within the solid.

(a) Solid sodium chloride does not conduct electricity. However, if it is melted, sodium chloride will conduct electricity.

(b) Potassium chloride will not dissolve in non-polar solvents, but will dissolve in water.

(c) Copper is easily shaped to form wires.

QUESTION (2006:6)

The following table shows the melting and boiling points of chlorides of some elements of the third row of the Periodic Table.

	Sodium chloride NaCl	Magnesium chloride $MgCl_2$	Phosphorus trichloride PCl_3	Sulfur dichloride SCl_2
Melting point /^oC	801	712	-91	-80
Boiling point/^oC	1465	1418	74	59

(a) Describe the **trend** in melting and boiling points of chlorides across the third row of the periodic table by referring to the data in the table above.

(b) Discuss reasons for the differences in melting and boiling points of all FOUR chlorides, shown in the table above, by referring to the **particles** and **forces between the particles** in the solids.

QUESTION (2005:3)

Complete the following table by:

(a) stating the type of particle found in each solid substance as atoms, ions or molecules,

(b) specifying the attractive force existing between the particles of each solid substance,

(c) describing the relative melting point of each substance as either high or low.

Solid substance	Type of particle in solid – atoms, ions or molecules	Attractive force between particles	Relative melting point of substance – high or low.
calcium chloride ($CaCl_2$)			
diamond (C)			
ice (H_2O)			

QUESTION (2005:4)

(a) Complete the table by classifying substances B to F as: *ionic, metallic, molecular or covalent* network. As an example, the classification for substance A has been done for you.

Substance	Melting point (^oC)	Conductivity	Hardness of solid	Classification
A	770	conducts when molten but not when solid	brittle	ionic
B	1083	high	malleable	
C	–190	none	brittle	
D	1700	none	hard	
E	–57	none	brittle	
F	801	conducts when molten but not when solid	brittle	

(b) Explain why substance A will conduct electricity when molten, but not when solid.

QUESTION (2005:5)

For each of the three uses of different crystalline solids below, discuss the property identified by relating the property to the structure and bonding within the solid.

(a) Silver (Ag) is easily shaped and may be used to make jewellery.

(b) Copper (Cu) is a good conductor of electricity and is used for electrical wires.

(c) Silicon dioxide (SiO_2) has a very high melting point and is used to make glass.

QUESTION (2005:6)

Some properties of two solids are shown in the table below.

Solid	Melting point (^oC)	Solubility
iodine (I_2)	Sublimes when gently heated	Soluble in cyclohexane
potassium iodide (KI)	681	Soluble in water

Discuss the properties of iodine and potassium iodide, in terms of the structure and bonding within each solid.

QUESTION (2004:3)

Melting points of the chlorides of selected third-row elements are given in the table below.

Name of substance	Formula	Melting point (°C)	Type of bonding
sodium chloride	$NaCl$	801	
magnesium chloride	$MgCl_2$	712	
silicon chloride	$SiCl_4$	-68	
sulfur dichloride	SCl_2	-80	

(a) Describe the trend shown by the melting points of third-row chlorides in the table above.

(b) This trend in melting points is due to the type of bonding involved in each of the substances.

For each of the substances below, describe the type of bonding that must be broken to melt the substance.

QUESTION (2004:4)

Complete the following table by:

(a) stating the type of particle found in the solid substance as atoms, ions or molecules,

(b) specifying the attractive force that is broken when the solid substance melts,

(c) describing the attractive force existing between the particles of the solid as weak or strong.

Name of solid substance	Type of particle in solid – atoms, ions or molecules	Attractive force broken when solid melts	Attractive force between particles – weak or strong
Sulfur (S_8)			
Copper (Cu)			
magnesium oxide (MgO)			
diamond (C)			

QUESTION (2004:5)

Explain, in terms of structure AND bonding within each solid, why the solid has the property described.

Property	Explanation in terms of structure and bonding within the solid
Solid magnesium chloride, $MgCl_2$, is a poor conductor of electricity. However, when melted, magnesium chloride is a good electrical conductor.	
Chlorine, Cl_2, has a low melting point of –101°C.	
A piece of zinc, Zn, can be easily re-shaped without breaking into smaller pieces.	

QUESTION (2004:6)

Carbon and silicon are both elements found in Group 14 of the periodic table. Both elements show a combining power of +4 in forming oxides, with the respective formulae CO_2 and SiO_2. Some properties of these oxides are as follows:

Oxide	Melting point (°C)	Conductivity of solid	Hardness of solid
CO_2	sublimes at –78	Poor	brittle
SiO_2	1700	Poor	Very hard

Discuss the structure and bonding within carbon dioxide and silicon dioxide, and relate these to the properties shown in the table above.

ANSWERS

QUESTION (2012:2)

(c) Complete the table below by stating the type of particle and the bonding (attractive forces) between the particles for each of the substances.

Substance	Type of particle	Attractive forces between particles
Ammonia, NH_3	molecule	intermolecular
Zinc, Zn	atom / cations and electrons	metallic
Silicon dioxide, SiO_2	atom	covalent

(d) Silicon dioxide has a melting point of 1770°C.
Explain why silicon dioxide has a high melting point by referring to the particles and the forces between the particles in the solid.

Silicon dioxide is a covalent network solid. It is made up of silicon and oxygen atoms, with only strong covalent bonds between them. Because the covalent bonds are strong / there are a large number of covalent bonds, it requires a lot of energy to break these bonds and therefore the melting point is high.

(c) Contrast both the electrical conductivity, and solubility in water, for both zinc, Zn, and zinc chloride, $ZnCl_2$, using your knowledge of structure and bonding.

Zinc atoms are held together in a 3–D lattice by metallic bonding in which valence electrons are attracted to the nuclei of neighbouring atoms.
Zinc chloride is made up of positive zinc ions and negative chloride ions held together by electrostatic attractions in a 3–D lattice.

Conductivity: Zinc chloride does not conduct electricity as a solid as these ions are not free to move around. (When dissolved in water, the ions are free to move and carry the charge so zinc chloride solution conducts electricity.)
In zinc metal the delocalised electrons / valence electrons are free to move through the lattice; therefore they are able to conduct electricity.

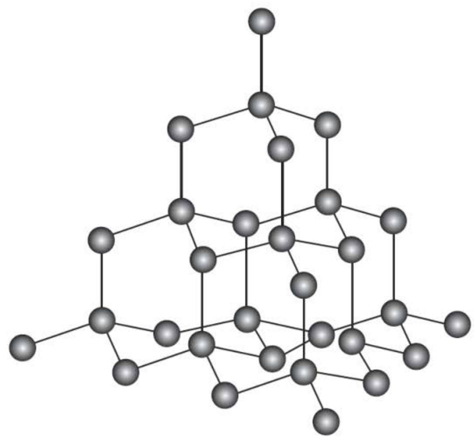
Solubility: Zinc does not dissolve in water because water molecules are not attracted to the zinc atoms in the metallic lattice.
Water molecules are polar. When zinc chloride is dissolved in water the attractions between the polar water molecules and between the ions in the salt are replaced by attractions between the water molecules and the ions. The negative charge on the oxygen ends of the water molecules are attracted to the positive Zn^{2+} ions, and the positive hydrogen ends of the water molecules are attracted to the negative Cl^- ions.

QUESTION (2011:2)

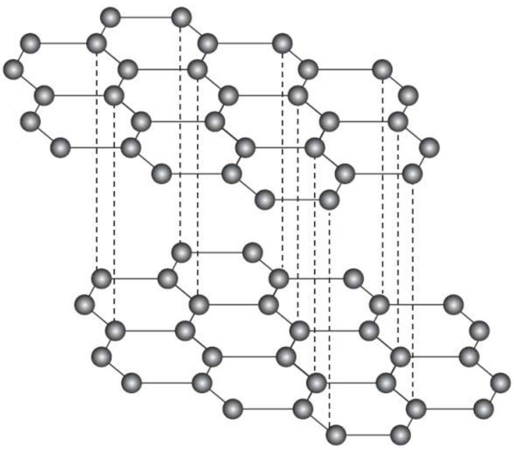
(a) Complete the table below by stating the type of solid, the type of particle present, and the bonding (attractive forces) between particles in the solid state.

Solid	Type of solid	Type of particle	Attractive forces between particles
Na	metallic	atom	metallic bond
P_4	molecular	molecule	weak intermolecular forces
MgO	ionic	ion	ionic bond
SO_3	molecular	molecule	weak intermolecular forces

(b) The diagrams below show 3-D structural representations of diamond and graphite. Diamond and graphite are both made up of carbon atoms, but these atoms are arranged differently in each solid.



Structure of diamond



Structure of graphite

(i) Describe the electrical conductivity and hardness of diamond and graphite.

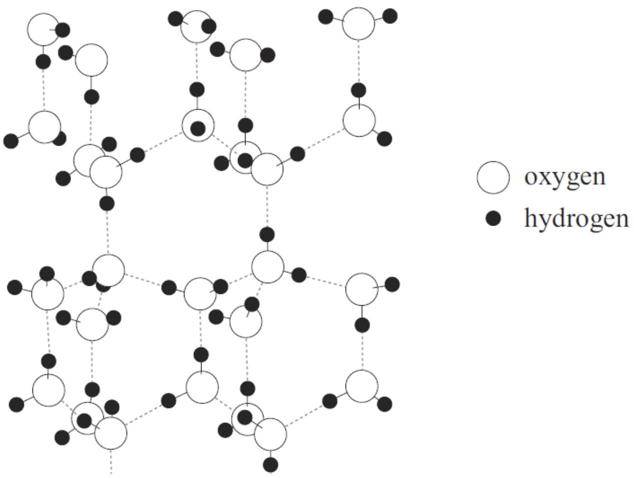
Diamond
electrical conductivity: Diamond does not conduct electricity
hardness: is hard.
Graphite
electrical conductivity: Graphite does conduct electricity
hardness: is soft.

(ii) Discuss the electrical conductivity and hardness of both diamond and graphite, using your knowledge of structure and bonding.

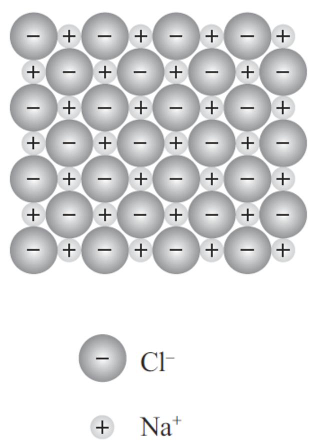
Diamond consists of C atoms each covalently bonded to four other C atoms, forming a 3-D tetrahedral arrangement. Graphite consists of C atoms each covalently bonded to three other C atoms in a 2-D or layered arrangement with weak intermolecular forces of attraction between the layers or sheets. In diamond, the covalent bonds between the carbon atoms are very strong and hold the atoms in place, making it difficult to break the bonds. Therefore diamond is a very hard substance. However in graphite, although the bonds between the covalently bonded carbon atoms in the layers are strong, the forces between the layers are weak, resulting in the layers sliding over each other. Therefore graphite is a soft substance. However, in graphite each carbon atom is bonded to three others in the layers and has one valence electron, which is free to move. These delocalised electrons result in the ability of graphite to conduct electricity. In diamond, all of the valence electrons in each carbon atom are involved in bonding to other carbons. There are no mobile electrons to carry charge. Therefore, diamond is unable to conduct.

QUESTION (2011:3)

The diagrams below show structural representations of the two solids ice, H_2O, and sodium chloride, NaCl.



Structure of ice



Structure of sodium chloride

(a) Ice melts at 0°C and sodium chloride melts at 801°C.

(i) On **each** diagram above, circle ONE of the forces of attraction which must be overcome for the substance to melt.

H_2O – weak force of attraction circled (*force between adjacent molecules*).
NaCl – ionic bond circled (*force between positive and negative ions*).

(ii) Discuss the low melting point of ice and the high melting point of sodium chloride, using your knowledge of structure and bonding.

Sodium and chloride ions are held together by strong ionic bonds. A large amount of energy is required to overcome these forces. Hence NaCl has a high melting point. The forces of attraction between neighbouring water molecules in ice are weak. Only a small amount of energy is required to separate the water molecules from each other, hence ice has a low melting point.

(b) Sodium chloride dissolves in water.
Discuss **how** and **why** sodium chloride dissolves in water, using your knowledge of structure and bonding.

Include a labelled diagram in your answer.

When sodium chloride dissolves in water the ionic lattice breaks up. Water molecules are polar. The positive hydrogen ends of the water molecules are attracted to the negative ions (Cl^-) in the lattice, and the negative oxygen ends of the water molecules are attracted to the positive ions (Na^+). The attraction of the polar water molecules for the ions is sufficient to overcome the attractive forces between the Na^+ and Cl^- ions, allowing them to be removed from the lattice. Hence the sodium chloride solid dissolves, forming separate Na^+ and Cl^- (ions) in aqueous solution.

QUESTION (2010:3)

(a) State the type of particles (atoms / ions / molecules) present in the two solids $MgCl_2$ and SiO_2.
$MgCl_2$ is made up of ions
SiO_2 is made up of atoms.

(b) The following table shows some physical properties of these two solids.

Solid	$MgCl_2$	SiO_2
Melting point / °C	712	1700
Solubility in water	soluble	insoluble

Compare and contrast these physical properties (melting point and solubility in water) of these two solids.

Your answer must include:

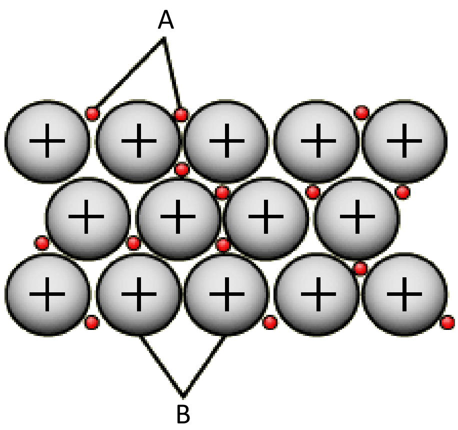
- reference to the type of solid
- the type of particle
- the attractive forces between the particles, for each of the two solids.

Both solids have a high melting point.
$MgCl_2$ has a high melting point. It is an ionic solid. It consists of a 3–D lattice of positive Mg^{2+} ions and Cl^- ions and the ions are held together by strong ionic bonds. As a lot of energy is required to overcome these strong bonds to separate the ions, the solid has a high melting point.

SiO_2 is a covalent network solid. The atoms in SiO_2 are held together by strong covalent bonds. A lot of energy is required to break these bonds in order for the solid to melt; therefore it has a high melting point.
$MgCl_2$ is soluble in water, whereas SiO_2 is not.
Water molecules are polar. When $MgCl_2$ is placed in water, the oxygen ends of the water molecules are attracted to the positive Mg^{2+} ions, and the hydrogen ends of the water molecules are attracted to the negative Cl^{-} ions. The water molecules then pull ions from/destroy the lattice, resulting in the solid dissolving.
SiO_2 is not soluble in water, as the covalent bonds are too strong to be broken by the attraction to the water molecules.

QUESTION (2010:4)

The diagrams below show the structure of a metallic solid.



(a) Name the particles in the diagrams above.

Particle	A	B
Name of particle	loosely held) valence electrons / delocalised electrons	atoms / positive ions / cations / positive kernel (of the metal atom)

(b) Copper is a good conductor of electricity and is ductile. It is often used to make electrical wires.
Use the diagrams above to discuss how the structure of copper allows it to be made into electrical wires.
In your answer you should:

- Describe the particles in copper and the attractive forces between the particles.
- Relate its structure to both properties outlined above.

Copper is composed of Cu atoms /cations (NOT protons or nuclei) held together in a 3–D lattice by metallic bonding, in which valence electrons are attracted to the nuclei of neighbouring atoms. The delocalised electrons / valence electrons are free to move through the lattice; therefore they are able to conduct electricity. The attraction of the Cu atoms for the valence electrons is not in any particular direction; therefore Cu atoms can move past one another, and so Cu is ductile and can be drawn out into wires without breaking.

QUESTION (2009:3)

(c) Complete the table below by stating the type of solid, the type of particle present and identifying the bonding (attractive forces) between the particles in the **solid** state. The first one has been done for you.

Solid	Type of solid	Type of particle	Bonding between particles
Chlorine Cl_2	Molecular	Molecule	Weak intermolecular forces
Silicon dioxide SiO_2	covalent network	atom	covalent bond
Copper chloride $CuCl_2$	ionic	ion	ionic bond / electrostatic attraction
Potassium K	metallic	atoms / positive ions	metallic bonding
Carbon dioxide CO_2	molecular	molecule	weak intermolecular forces

(d) Use the information given below to answer the question that follows.

- **Diamond** is a covalent network solid. It has a very high melting point of 3550°C.
- **Magnesium oxide**, MgO, is an ionic solid. It has a high melting point of 2800°C.
- **Sulfur dichloride**, SCl_2, is a molecular substance. It has a low melting point of –80°C.

Discuss the melting points of these three substances by referring to the **particles** and the **forces between the particles** in the solids.

Diamond is made of carbon atoms. Each carbon atom is covalently bonded to 4 other C atoms in a tetrahedral arrangement, which forms a covalent network solid. The covalent bonds between the carbon atoms are very strong and require a large amount of energy to break them.
Magnesium oxide is made of positive magnesium ions and negative oxide ions, held together by strong electrostatic attractions in a 3–D lattice structure. As these electrostatic attractions (ionic bonds) are strong, they require a large amount of energy to overcome them.
Sulfur dichloride is a molecular solid, made of molecules. There are weak intermolecular forces holding the molecules together, and they require a small amount of energy to be overcome.

QUESTION (2009:4)

Discuss the electrical conductivity of the following THREE substances using your knowledge of structure and bonding.

Sulfur, S_8, does not conduct electricity in the solid state nor in the liquid state.

Magnesium chloride, $MgCl_2$, conducts electricity when it is dissolved in water, but not in the solid state.

Lead, Pb, **conducts** electricity in the solid state and when molten (liquid).

Sulfur is made up of sulfur molecules in which sulfur atoms are covalently bonded to each other. It does not contain mobile charged particles (no free electrons or mobile ions). Therefore sulfur cannot conduct in the solid or liquid state.

Magnesium chloride (solid) consists of a 3-D lattice of Mg^{2+} and Cl^{-} ions. Although charged particles are present, they are held in position by (strong) ionic bonds, and the solid does not conduct electricity.

When the $MgCl_2$ solid is dissolved in water, the ions are no longer held in the lattice. Because of this, the solution can conduct electricity.

Lead atoms are held together in a 3-D lattice by metallic bonding, in which valence electrons are attracted to the nuclei of neighbouring atoms. Lead's valence electrons are free to move throughout the structure in both the solid and liquid state.

QUESTION (2008:2)

Complete the table below by stating the type of particle present in each of the solids, and identifying the bonding (attractive forces) between particles.

Solid	Melting point (°C)	Type of particle	Bonding between particles
S_8	119	molecule	van der Waals force or weak intermolecular force
$MgCl_2$	712	ion	Ionic bond
Mg	650	Atom	Metallic bond
Diamond	3550	atom	Covalent bond

QUESTION (2008:5)

Two of the following substances can conduct electricity.

copper chloride   diamond   graphite   iodine   silicon dioxide

(a) Write the names of these two substances.

(b) Discuss, with reference to structure and bonding, why the substances chosen in (a) are able to conduct electricity. Include any conditions that are required.

Substances ONE and TWO are graphite and copper chloride.

In graphite (solid) each carbon atom is covalently bonded to 3 others. (This leaves one electron that is) delocalised and is free to move. Because this electron is free to move, it carries charge and so graphite conducts electricity. Copper chloride (solid) consists of a 3-D lattice of Cu^{2+} and Cl^- ions. Although charged particles are present, they are held in position by strong ionic bonds, and the solid does not conduct electricity. When the $CuCl_2$ solid is melted, the ions become free moving, and the free moving ions means the liquid can conduct electricity. When $CuCl_2$ is dissolved in water the ions are then free to move because the ions are no longer held in the lattice. Because of this, the solution can conduct electricity.

QUESTION (2007:3)

(a) Identify the type of particle and describe the bonding (attractive forces between the particles) for each of the solids in the table below.

Solid	Type of solid	Type of particle	Description of bonding
(i) Silver (Ag)	metallic	(Ag) atoms	Metallic bonding / valence electrons are attracted to the nuclei of neighbouring atoms.
(ii) Sulfur (S_8)	molecular	(S_8) molecules	Intermolecular forces / dispersion forces / Van Der Waals forces / London forces.
(iii) Silicon dioxide (SiO_2)	covalent network	(Si and O) atoms	Covalent bonds.

(b) Silicon dioxide (SiO_2) has a melting point of 1700°C and sulfur (S_8) has a melting point of 113°C. Explain the difference in the melting points of these two substances in terms of structure and bonding.

The atoms in SiO_2 are held together by strong covalent bonds. A lot of energy is required to break these bonds in order for the substance to melt. When S_8 melts, the weak intermolecular forces between molecules must be broken. Less energy is required to break these forces.

QUESTION (2007:4)

Discuss the following properties of lithium chloride (LiCl), with reference to the particles in the solid and forces between the particles.

- Solid will not conduct electricity.
- Melting point of solid is 610°C.
- Solid dissolves in water but not in cyclohexane.

LiCl consists of positive Li^+ and negative Cl– ions in a lattice, held together by strong electrostatic attractions / strong ionic bonds between oppositely charged ions. When solid, the ions are held in

fixed positions in the lattice and cannot move. As there is no free moving charge, LiCl cannot conduct electricity when solid. When LiCl melts, the strong electrostatic attractions / ionic bonds between the ions need to be broken so that ions are separated. This requires a lot of energy. Hence, the high melting point of 610^{o}C.
Water molecules are polar, meaning they have a partial negative charge on the oxygen atoms and a partial positive charge on the hydrogen atoms. When LiCl is placed in water, the oxygen ends of the water molecules are attracted to the positive Li^{+} ions, and the hydrogen ends of the molecules are attracted to the negative Cl^{-} ions. The water molecules then pull ions from the lattice, resulting in the solid dissolving. Cyclohexane is a non-polar solvent, meaning that the molecule has no charge separation. Therefore, cyclohexane is unable to attract ions from the lattice and the LiCl will not dissolve in the non-polar solvent.

QUESTION (2007:5)

Use your knowledge of structure and bonding to discuss the following physical properties of diamond and graphite.
- Hardness
- Electrical conductivity
- Melting point

Diamond consists of C atoms each covalently bonded to 4 other C atoms (tetrahedrally) in a 3D arrangement. Graphite consists of C atoms each covalently bonded to 3 other C atoms (in a trigonal planar shape) in a 2D arrangement, forming layers with weak van der Waals forces between them.
Diamond is very hard, while graphite is soft and slippery. The covalent bonds between C atoms are in 3D and very strong, thus difficult to break. Therefore, diamond is very hard. The weak attractions between the layers of atoms in graphite are easily broken. Therefore, graphite is soft and the layers can slide over each other.
Graphite will conduct electricity while diamond will not. Graphite will conduct electricity, as each carbon atom is bonded to only three others, resulting in one valence electron being free to move. These free-moving electrons result in graphite's being an electrical conductor. In diamond, all of the valence electrons in each C atom are involved in bonding to other carbons. Therefore, diamond is unable to conduct.
Both diamond and graphite have a high melting point. In order to melt both diamond and graphite, strong covalent bonds between carbon atoms must be broken. Because of their strength, a lot of energy is required to break these bonds and separate atoms. Therefore, both diamond and graphite have a high melting point.

QUESTION (2006:2)

The following table contains oxides of elements from the third row of the Periodic Table.
Complete the table below by:
(a) stating the type of particle found in each substance as an **atom**, **ion** or **molecule**
(b) specifying the attractive force that exists between the particles in the solid state of the substance.

Solid	Type of particle	Attractive force between particles
Sodium oxide	ion	ionic bond or electrostatic or attractive force between ions
Sulfur trioxide	molecule	van der waals force or intermolecular force
Silicon dioxide	atom	covalent bond
Aluminium oxide	ion	ionic bond or electrostatic or attractive force between ions

QUESTION (2006:5)

The **physical properties** of some crystalline solids are stated below. For each example, explain why the substance has the property stated by relating the **property** to the **structure and bonding** within the solid.

(a) Solid sodium chloride does not conduct electricity. However, if it is melted, sodium chloride will conduct electricity.

Sodium chloride consists of a 3-D lattice of Na^+ and Cl^- ions. Although charged particles are present, they are held in position by strong ionic bonds. When the solid is melted the ions become free moving, and the free moving charge means the liquid will conduct electricity.

(b) Potassium chloride will not dissolve in non-polar solvents, but will dissolve in water.

Potassium chloride consists of a 3-D lattice of K^+ and Cl^- ions. The ions are held in position by strong ionic bonds. The molecules of a non–polar solvent are not attracted towards the ions and so KCl is insoluble.

KCl is soluble in water as the polar water molecules are attracted towards the ions, and the attraction is sufficient to pull the ions from the lattice.

(c) Copper is easily shaped to form wires.

Copper consists of Cu atoms held together in a 3-D lattice by metallic bonding, in which valence electrons are attracted to the nuclei of neighbouring atoms. As this is a non-directional force, layers of atoms can slide over each other without breaking the metallic bond and disrupting the structure and breaking the metal

QUESTION (2006:6)

The following table shows the melting and boiling points of chlorides of some elements of the third row of the Periodic Table.

	Sodium chloride NaCl	Magnesium chloride $MgCl_2$	Phosphorus trichloride PCl_3	Sulfur dichloride SCl_2
Melting point /^oC	801	712	-91	-80
Boiling point/^oC	1465	1418	74	59

(a) Describe the **trend** in melting and boiling points of chlorides across the third row of the periodic table by referring to the data in the table above.
Melting or boiling point of chloride decreases across the period.

(b) Discuss reasons for the differences in melting and boiling points of all FOUR chlorides, shown in the table above, by referring to the **particles** and **forces between the particles** in the solids.
NaCl and $MgCl_2$ both have high melting and boiling points. These are ionic substances. They consist of a 3-D lattice of positive metal ions and Cl^- ions and the ions are held together by strong ionic bonds. As a lot of energy is required to overcome these strong forces and separate the ions, the substances have high melting and boiling points.
PCl_3 and SCl_2 both have low melting and boiling points. These are molecular substances. They consist of molecules and the molecules are attracted to each other by weak intermolecular or van der Waals forces. As not much energy is required to overcome these weak forces and separate the molecules, the substances have low melting and boiling points.

QUESTION (2005:3)

Complete the following table by:

(a) stating the type of particle found in each solid substance as atoms, ions or molecules,

(b) specifying the attractive force existing between the particles of each solid substance,

(c) describing the relative melting point of each substance as either high or low.

Solid substance	Type of particle in solid – atoms, ions or molecules	Attractive force between particles	Relative melting point of substance – high or low.
calcium chloride ($CaCl_2$)	ions	Ionic bond / electrostatic forces between ions	high
diamond (C)	Atoms	Covalent bond	high
ice (H_2O)	Molecules	Van der Waals / intermolecular / permanent dipole attraction	low

QUESTION (2005:4)

(a) Complete the table by classifying substances B to F as: *ionic, metallic, molecular or covalent* network. As an example, the classification for substance A has been done for you.

Substance	Melting point (^oC)	Conductivity	Hardness of solid	Classification
A	770	conducts when molten but not when solid	brittle	ionic
B	1083	high	malleable	Metallic
C	–190	none	brittle	Molecular
D	1700	none	hard	Covalent network
E	–57	none	brittle	Molecular
F	801	conducts when molten but not when solid	brittle	ionic

(b) Explain why substance A will conduct electricity when molten, but not when solid.

In the solid state, the ions are held in fixed positions by strong electrostatic attractions, or, ionic bonds. When molten, the charged ions are separated and free to move and conduct electricity.

QUESTION (2005:5)

For each of the three uses of different crystalline solids below, discuss the property identified by relating the property to the structure and bonding within the solid.

(a) Silver (Ag) is easily shaped and may be used to make jewellery.

Silver atoms are held together in a 3-D lattice by metallic bonding, in which valence electrons are attracted to the nuclei of neighbouring atoms. As this is a non-directional force, layers of atoms can slide over each other without breaking the metallic bond and disrupting the structure and breaking the metal.

(b) Copper (Cu) is a good conductor of electricity and is used for electrical wires.

Copper atoms are held together in a 3-D lattice by metallic bonding, in which valence electrons are attracted to the nuclei of neighbouring atoms. Conduction of electricity requires free moving charges, which are the moving valence electrons.

(c) Silicon dioxide (SiO_2) has a very high melting point and is used to make glass.

Silicon dioxide consists of silicon and oxygen atoms held together by covalent bonds in a tetrahedral arrangement, so that a 3-D network exists. As the covalent bonds are strong, they are difficult to overcome and break, making it difficult to separate the atoms, so the structure has a high melting point.

QUESTION (2005:6)

Some properties of two solids are shown in the table below.

Solid	Melting point (^oC)	Solubility
iodine (I_2)	Sublimes when gently heated	Soluble in cyclohexane
potassium iodide (KI)	681	Soluble in water

Discuss the properties of iodine and potassium iodide, in terms of the structure and bonding within each solid.

Iodine consists of I_2 molecules and weak intermolecular forces / weak Van der Waals forces exist between the molecules. As these attractions are weak, the molecules are easily separated and the melting point is low. Iodine molecules are non-polar, therefore iodine is soluble in a non-polar solvent such as cyclohexane. Since both molecules have similar weak intermolecular forces, then weak forces will exist between the two different molecules. Potassium iodide is an ionic solid consisting of ions held together by strong ionic bonds / electrostatic attractions. As these attractions are strong, more energy is needed to separate the ions (than the molecules of iodine) so that potassium iodide has a high melting point. Ionic solids are soluble in water as the ions are separated from the lattice due to attraction towards the polar water molecules.

QUESTION (2004:3)

Melting points of the chlorides of selected third-row elements are given in the table below.

Name of substance	Formula	Melting point (°C)	Type of bonding
sodium chloride	NaCl	801	ionic
magnesium chloride	$MgCl_2$	712	Ionic
silicon chloride	$SiCl_4$	-68	Van der Waals / intermomecular
sulfur dichloride	SCl_2	-80	Van der Waals / intermomecular

(a) Describe the trend shown by the melting points of third-row chlorides in the table above.

Going across the third row / from left to right, the melting points decrease.

(b) This trend in melting points is due to the type of bonding involved in each of the substances.

For each of the substances below, describe the type of bonding that must be broken to melt the substance. (see table)

QUESTION (2004:4)

Complete the following table by:

(a) stating the type of particle found in the solid substance as atoms, ions or molecules,

(b) specifying the attractive force that is broken when the solid substance melts,

(c) describing the attractive force existing between the particles of the solid as weak or strong.

Name of solid substance	Type of particle in solid – atoms, ions or molecules	Attractive force broken when solid melts	Attractive force between particles – weak or strong
Sulfur (S_8)	molecules	Van der Waals / intermolecular	weak
Copper (Cu)	atoms / ions	metallic bond	strong
magnesium oxide (MgO)	ions	ionic bond	strong
diamond (C)	atoms	covalent bond	strong

QUESTION (2004:5)

Explain, in terms of structure AND bonding within each solid, why the solid has the property described.

Property	Explanation in terms of structure and bonding within the solid
Solid magnesium chloride, $MgCl_2$, is a poor conductor of electricity. However, when melted, magnesium chloride is a good electrical conductor.	Solid $MgCl_2$ is a lattice of Mg2$^+$ and Cl^- ions held together by strong ionic bonds. These forces hold the ions in a fixed position. As there is no charge able to move, the solid will not conduct electricity. When melted the Mg^{2+} and Cl^- ions become free moving, and this free moving charge allows the liquid to conduct electricity.
Chlorine, Cl_2, has a low melting point of –101°C.	Cl_2 consists of Cl_2 molecules. The force existing between the molecules is a weak Van der Waals force. As little energy is needed to overcome this weak force the melting point is very low.
A piece of zinc, Zn, can be easily re-shaped without breaking into smaller pieces.	Zinc atoms are held together in a 3-D lattice by metallic bonding in which valence electrons are attracted to the nuclei of neighbouring atoms. As this is a non–directional force, layers of atoms can slide over each other without breaking the metallic bond and disrupting the structure and breaking the metal.

QUESTION (2004:6)

Carbon and silicon are both elements found in Group 14 of the periodic table. Both elements show a combining power of +4 in forming oxides, with the respective formulae CO_2 and SiO_2. Some properties of these oxides are as follows:

Oxide	Melting point (°C)	Conductivity of solid	Hardness of solid
CO_2	sublimes at –78	Poor	brittle
SiO_2	1700	Poor	Very hard

Discuss the structure and bonding within carbon dioxide and silicon dioxide, and relate these to the properties shown in the table above.

CO_2

Exists as molecules. Weak van der Waals forces exist between the molecules.

As all valence electrons are involved in forming covalent bonds there are no free moving charges and so no electrical conduction.

As the van der Waals forces between molecules are weak these are easily overcome hence little energy is required to separate the molecules [therefore has a low MP/sublimes at -78°C].

Also since the weak van der Waals forces allow the molecules to be easily separated this makes it brittle / (easy to break the solid).

SiO_2

Exists as 3-D covalent network. Strong covalent bonds hold the Si and O atoms together in a 3-D arrangement. As all valence electrons are involved in forming covalent bonds there are no free moving charges and so no electrical conduction. As the covalent bonds between atoms are strong they require a lot of energy to overcome and separate atoms so the melting point is very high. Also since the strong covalent bonds hold the atoms firmly in the 3-D structure, the solid is very hard.