Questions
Types of solid

Question One

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

Substance	Type of substance	Type of particle	Attractive forces between particles
C(s) (graphite)	covalent network	atom	Covalent bond
$Cl_2(s)$ (chlorine)	molecular	molecules	weak intermolecular forces
$CuCl_2(s)$ (copper chloride)	ionic	ion	ionic bonds
Cu(s) (copper)	metallic	cation	Metallic bonds

b. i. Explain why chlorine is a gas at room temperature, but copper chloride is a solid at room temperature. In your answer, you should refer to the particles and the forces between the particles in **both** substances.

Cl_2 consists of molecules with weak forces of attraction between them. These are easily broken at low temperatures, so at room temperature there is sufficient energy to separate the molecules from each other so Cl_2 exists as a gas. $CuCl_2$ is an ionic solid, consisting of Cu^{2+} and Cl^- ions held together by strong electrostatic forces. It requires a large amount of energy to overcome these forces, hence solid at room temp.

ii. Using your knowledge of structure and bonding, explain why, although both graphite and copper are good conductors of electricity, copper is suitable for electrical wires, but graphite is not.

Graphite is a 2D network covalent solid. It consists of carbon atoms bonded in layers with delocalised electrons being able to move between the layers hence it conducts electricity. Layers are weakly bonded to each other through the delocalised electron and when force is applied the layers will separate from each other ∴ graphite cannot be drawn into a wire. Cu metal has delocalised electrons which are free to move ∴ can conduct electricity. When pressure applied, layers of ions slide over each other ∴ ductile

Question Two

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	molecule	intermolecular forces
Zinc, Zn	cation	metallic bonds
Silicon dioxide, SiO_2	atom	covalent bonds.

b. Silicon dioxide has a melting point of 1 770 °C. Explain why silicon dioxide has a high melting point by referring to the particles and the forces between the particles in the solid.

SiO_2 is a 3D covalent network solid. With strong covalent bonds between atoms. It requires a large amount of energy to break the 3D array of strong covalent bonds.

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.

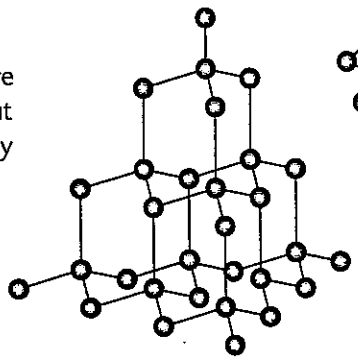
Zn is a metallic solid consisting of cations and delocalised electrons.
$ZnCl_2$ is an ionic solid which consists of Zn^{2+} and Cl^- held together by strong electrostatic attractions in a 3D lattice.
Conductivity - Zn conducts in solid state because delocalised e^- are free to move.
$ZnCl_2$ does not conduct in solid state because the ions are unable to move in the solid.
When $ZnCl_2$ is melted or when it is dissolved in water it does conduct electricity because the ions are free to move.
Solubility - $ZnCl_2$ is soluble in water because the polar water molecules are attracted to the +ve and -ve ions and strength of this attraction is sufficient to overcome the strong ionic bonds. The water molecules can not overcome the metallic bond and hence Zn is not soluble in water

Question Three

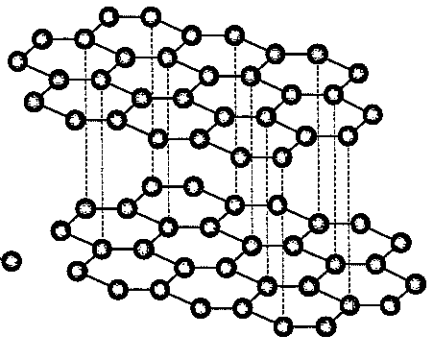
a. Complete the table following by stating the type of solid, the type of particle present, and the bonding (attractive forces) between particles in the **solid** state.

Solid	Type of solid	Type of particle	Attractive forces between particles
Na	metallic	cation	metallic bonds
P_4	molecular	molecule	weak inter-molecular
MgO	ionic	ion	ionic bonds
SO_3	molecular	molecule	weak intermolecular forces

b. The diagrams 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: non conductor hardness: very hard

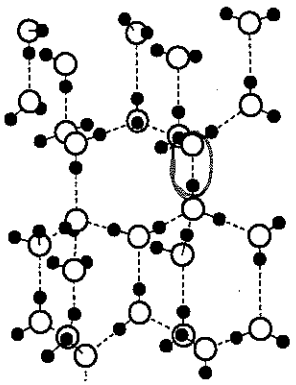
Graphite

electrical conductivity: conductor hardness: soft.

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

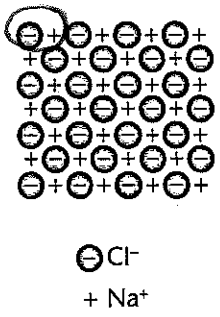
Diamond is a 3D covalent network. Each carbon atom is covalently bonded to 4 other carbon atoms. This leads to a 3D array of strongly bonded C atoms, resulting in a very hard structure. Since all electrons are involved in bonding there are no free electrons thus diamond does not conduct. Graphite is a 2D network made up of layers of covalently bonded C atoms arranged in hexagonal rings. The layers are attracted by weak intermolecular forces. There are delocalised electrons which move between the layers. Graphite is soft because the carbon layers move easily over each other. It conducts electricity due to presence of delocalised electrons

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



O oxygen
● hydrogen

Structure of ice



Cl^-
$+ Na^+$

Structure of sodium chloride

Ice melts at 0 °C and sodium chloride melts at 801 °C.

i. On **each** diagram, circle ONE of the forces of attraction which must be overcome for the substance to melt. Give a reason for your choice.

Ice: The weak intermolecular forces need to be overcome (the forces between the molecules due to dipole-dipole attraction).

Sodium chloride:

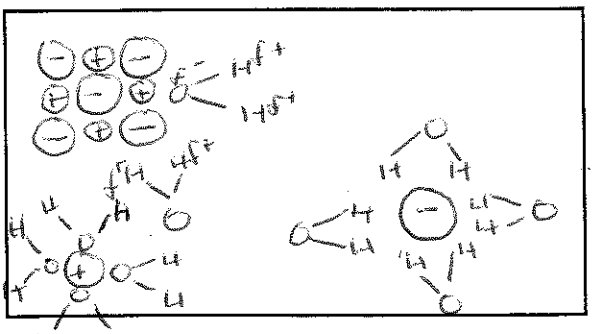
The electrostatic forces between the +ve and -ve ions need to be broken. These are very strong

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

The melting point of ice is very low because the forces of attraction between water molecules are not very strong and easily broken. The ionic bonds (electrostatic) forces are very strong and they require a lot of energy for them to be broken (which is required for NaCl to melt). Hence M.Pt of NaCl is very high.

d. 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.

NaCl is able to dissolve in water because the polar water molecules are attracted to the +ve and -ve ions in the NaCl lattice. The negative end of the water dipole is attracted to the +ve Sodium ion and the +ve end of the water dipole is attracted to the -ve chloride ion. The attractions of the dipoles to the ions are strong enough to pull the ions from the lattice.



Question Four

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

Solid	magnesium chloride, $MgCl_2$	silicon dioxide, SiO_2
Particles (atoms / ions / molecules)	i. ions	ii. atoms

b. The table shows some physical properties of the two solids.

Solid	$MgCl_2$	SiO_2
Melting point / °C	712	1 700
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.

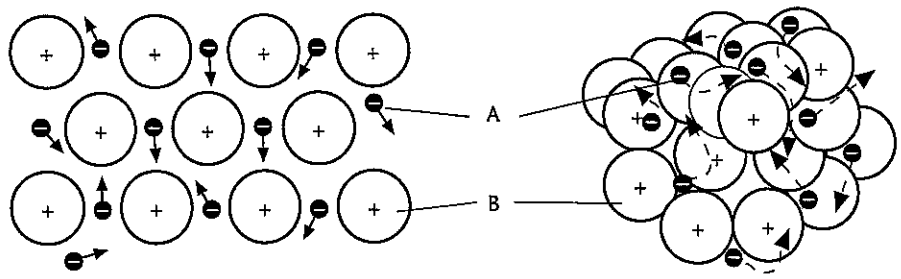
$MgCl_2$ is an ionic solid. It is made up of a 3D lattice of Mg^{2+} and Cl^- ions held together by strong electrostatic forces (ionic bond). Because the electrostatic forces are strong, it requires a lot of energy to melt $MgCl_2$. It is soluble because the +ve and -ve ions are attracted to the polar water molecules, this causes the salt to break apart (dissolve).

SiO_2 is a 3D covalent network. Each Silicon atom is bonded to 4 oxygen atoms to form a strong, rigid lattice. These attractive forces are very strong, therefore a large amount of energy is required to break them, thus the high M.Pt.

SiO_2 is not soluble in water because there are no charged particles to be attracted to the polar water molecule.

c. The diagrams show the structure of a metallic solid.

2-D picture of a metallic lattice **3-D picture of a metallic lattice**



i. Name the particles in the diagrams above.

Particle	Name of particle
A	electron
B	cation (positive ion)

ii. Copper metal 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 atomic structure of copper allows this metal to be made into electrical wires.

In your answer, you should:

- describe the particles in copper metal and the attractive forces between the particles
- relate the structure of the metal to both properties outlined above.

Cu metal cations are arranged in ordered layers. The cations are held together by metallic bonding where strong attractive forces result between the delocalised electrons and the positive cations. The bonding is non directional, so the layers can move over each other without disrupting the lattice, thus metal can be drawn into a wire. Cu is a good conductor of electricity due to the delocalised electrons being free to move.