6092 Chemistry: Summary on Chemical Bonding

Chemical Bonding	Ionic Compounds	Covalent Substances		Metals (Element)
	Giant Ionic Structure	Simple Molecular Structure	Giant Molecular Structure	Giant Metallic Structure
Hardness	Hard The oppositely charged ions are **very closely packed in an orderly manner**. The ions are held together at their **fixed positions** by **strong electrostatic forces of attraction**. Hence, a **large** amount of energy is required to overcome the strong electrostatic forces of attraction between oppositely charged ions, making ionic compounds hard.	-	Hard: Diamond Each carbon atom is covalently bonded to **4 carbon atoms** in a **tetrahedral arrangement**. As such, all carbon atoms are held in their **rigid** and **fixed positions**. Hence, a **large** amount of energy is required to **break** the **numerous strong covalent bonds** between the carbon atoms, making diamond hard. Soft & Slippery: Graphite A **small** amount of energy is required to **overcome** the **weak intermolecular forces of attraction** between **each layer of carbon atoms**. Hence, when a force is applied, the layers can **slide over** each other easily, making graphite soft and slippery.	Soft, Malleable and Ductile The **metal atoms** are neatly arranged in an **orderly manner**. When a force is applied to the metal, the **layer of atoms** can **slide over** one another easily **without breaking** the metallic bonds. Hence, metals are malleable and ductile.
Conducts Electricity in Solid State	No In the **solid state**, the **oppositely charged ions** are held together by strong electrostatic forces of attraction at their **fixed positions**. Hence, there are **no mobile ions** to function as **charge carriers** to conduct electricity.	No The electrons are **shared** within the covalent bond. Hence, there are **no mobile electrons or mobile ions** to function as **charge carriers** to conduct electricity.	No: Diamond All the **4** valence electrons of each carbon atom are used in covalent bonding. Hence, there are **no mobile electrons or mobile ions** to function as **charge carriers** to conduct electricity. Yes: Graphite Each carbon atom is covalently bonded to **3** other carbon atoms. Thus, **3 out of 4** valence electrons are used in covalent bonding. As such, there is **one free electron** from **each carbon atom** to **become delocalised** to **move along the layer** of carbon atoms. These **mobile electrons** function as **charge carriers** to allow each graphite layer to conduct electricity.	Yes Metals consist of a **lattice of positive metal ions** in a **'sea of delocalised electrons'**. This **'sea of delocalised electrons'** are mobile and function as **charge carriers** to move from the negative terminal to the positive terminal of the electrical circuit to allow the metals to conduct electricity.
Conducts Electricity in Aqueous / Molten State	Yes In the **aqueous** or **molten state**, the giant ionic lattice is **broken down**, and there are **mobile ions** to function as **charge carriers** to allow the aqueous or molten ionic compounds conduct electricity.			

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Chemical Bonding	Ionic Compounds	Covalent Substances		Metals (Element)
	Giant Ionic Structure	Simple Molecular Structure	Giant Molecular Structure	Giant Metallic Structure
Examples	sodium chloride, $NaCl$ magnesium oxide, MgO aluminium fluoride, AlF_3	carbon dioxide, CO_2 oxygen O_2, iodine, I_2	diamond, sand [silicon(IV) oxide / silicon dioxide], graphite	sodium, magnesium, aluminium
Formed generally between	metal and non-metal	non-metals	non-metals	-
Physical state	solid	gas / liquid	solid	solid (except mercury)
Type of attractive forces / bonds present	**strong electrostatic forces** of attraction between oppositely charged ions	**weak intermolecular forces** of attraction between molecules	network of numerous **strong covalent bonds** between atoms	**strong electrostatic forces** of attraction between positive metal ions and 'sea of delocalised electrons'
Types of particles present	oppositely charged **ions**	**molecules**	**atoms**	positive metal ions and **'sea of delocalised electrons'**
Melting / Boiling Point	High **Large** amount of energy is required to **overcome** the **strong electrostatic forces of attraction** between the **oppositely** charged ions.	Low Most covalent substances exist as **simple, discrete molecules**. Hence, **small** amount of energy is required to **overcome** the **weak intermolecular forces of attraction** between the **molecules**.	High Diamond: Each carbon atom is covalently bonded to **4 carbon atoms** in a **tetrahedral arrangement**. Hence, a **large** amount of energy is required to **break** the **numerous strong covalent bonds** between the carbon atoms. Graphite Each carbon atom is covalently bonded to **3 carbon atoms**, forming a continuous **layer** of **hexagonal rings**. Hence, a **large** amount of energy is required to **break** the **numerous strong covalent bonds** between carbon atoms.	High **Large** amount of energy is required to overcome the strong **electrostatic forces of attraction** between the oppositely charged **metal cations** and the **'sea of delocalised electrons'**.
Soluble in water	Generally soluble	No (except hydrogen chloride, ammonia)	No	react with water to give metal hydroxide and hydrogen gas
Soluble in organic solvents	No	Yes	No	No