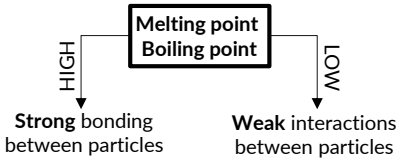
**ST ANDREW'S SECONDARY SCHOOL**

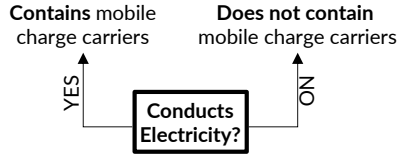
NAME _____ CLASS _____

## CHEMISTRY

### Chemical Bonding in Substances : A Summary

*Bonding ⟺ Structure ⟺ Properties*




**TEMPLATE** ① State the structure. ② Describe the structure. ③ Relate the structure to its property.

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| | Bonding | **COVALENT** | | **METALLIC** | **IONIC** |
| | Structure | **Simple molecular** | **Giant covalent** | **Giant metallic** | **Giant ionic** |
| | Composition | Molecules | Non-metallic atoms | Metal atoms | Ions: Anions & Cations |
| | Example | $CO_2$ / $I_2$ | Diamond / Graphite | Fe / Cu | NaCl / MgO |
| Properties | Melting and Boiling points / Volatility | ① (substance) has a simple molecular structure.<br>② It consists of discrete molecules held together by weak intermolecular forces of attraction.<br>③ Very little energy is sufficient to overcome these forces. Hence it has low melting and boiling points. | <u>Diamond</u><br>① Diamond has a giant covalent structure.<br>② Each carbon atom is covalently bonded to 4 other carbon atoms in a tetrahedral arrangement, forming a continuous covalent network for its structure.<br>③ These strong covalent bonds require large amount of energy to overcome. Hence, it has high melting and boiling points.<br><br><u>Graphite</u><br>① Graphite has a giant covalent structure.<br>② Each carbon atom is covalently bonded to 3 other carbon atoms in a giant covalent network.<br>③ These strong covalent bonds require large amount of energy to overcome. Hence, it has high melting and boiling points. | ① (metal) has a giant metallic structure.<br>② It is held together by strong electrostatic forces of attraction between the positively charged cations and the 'sea' of delocalised electrons.<br>③ Large amount of energy is required to overcome these forces. Hence, it has high melting and boiling points.<br><br>(exception: Hg) | ① (substance) has a giant ionic structure.<br>② It is held together by strong electrostatic forces of attraction between the oppositely charged ions in a giant ionic lattice.<br>③ Large amount of energy is required to overcome these forces. Hence, it has high melting and boiling points. |

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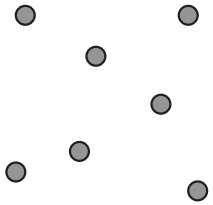
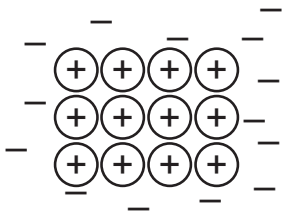
| | Electrical Conductivity | ① (substance) has a simple covalent structure.<br>② It consists of discrete molecules that are electrically neutral.<br>③ Since it does not contain any mobile charged particles, it cannot conduct electricity. | <u>Diamond</u><br>① Diamond has a giant covalent structure.<br>② Each carbon atom uses all 4 of its valence electrons to form covalent bonds with 4 other carbon atoms.<br>③ Hence, it does not have any mobile electrons to conduct electricity.<br><br><u>Graphite</u><br>① Graphite has a giant covalent structure.<br>② Each carbon atom uses only 3 out of 4 of its valence electrons to form covalent bonds with 3 other carbon atoms in a giant covalent network.<br>③ Hence, each carbon atom has 1 mobile valence electron that is delocalised between the layers to conduct electricity. | ① (metal) has a giant metallic structure.<br>② It is held together by strong electrostatic forces of attraction between the positively charged cations and the 'sea' of delocalised electrons.<br>③ Hence, (metal) has mobile electrons that allows it to conduct electricity. | <u>Solid state</u><br>① (substance) has a giant ionic structure.<br>② In solid state, the oppositely charged ions can only vibrate about their fixed positions due to the strong electrostatic forces of attraction.<br>③ Thus, the ions are not mobile to conduct electricity.<br><br><u>Aqueous / Molten state</u><br>① (substance) has a giant ionic structure.<br>② In aqueous/molten state, the electrostatic forces of attraction between oppositely charged ions are weakened.<br>③ Thus, the ions become mobile and can conduct electricity. |
| | Hardness | NA | <u>Diamond</u><br>*Same explanation as mp & bp*<br><br><u>Graphite</u><br>① Graphite has a giant covalent structure.<br>② Each carbon atom is covalently bonded to 3 other carbon atoms in a giant covalent network.<br>③ Graphite is soft and slippery because the layers of carbon atoms are held by weak intermolecular forces of attraction and thus, can slide over each other easily. | Pure metals are malleable/ ductile because the orderly layers of same-sized atoms can slide over each other easily. | *Same explanation as mp & bp* |

## Simple Molecular Structure

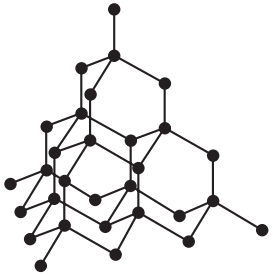


## Giant Metallic Structure

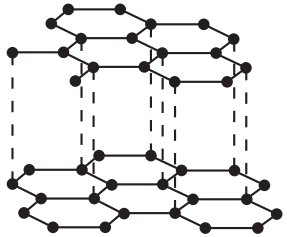


## Giant Covalent Structure

Diamond



Graphite



## Giant Ionic Structure