Topic 4 – Giant Molecular Structure and its Physical Properties

Differences:

Aspects		**Simple molecular structure**	**Giant molecular structure**
Structure		Simple molecules	Giant network of atoms
Bonds		1. **Weak intermolecular forces** of attraction between *molecules* 2. **Strong covalent bonds** between *atoms* in molecule	**Strong covalent bonds** between *atoms* throughout structure
Melting & boiling point		Low	High
Solubility	Water	Insoluble	Insoluble
	Organic solvent	Soluble	Insoluble
Electrical conductivity		×	×

4.1 Physical Properties – Simple Molecular Structure and Giant Molecular Structure

Giant molecular structure: giant network of atoms bonded together by covalent bonds

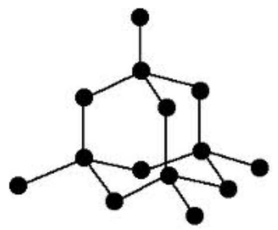
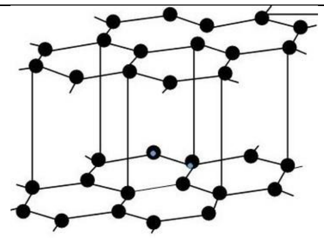
- Examples:
  1) Diamond (C)
  2) Graphite (C)
  3) Silicon dioxide (SiO_2)
- Allotropes (different types) of carbon:
  1. Diamond
  2. Graphite

Physical properties

Properties	Explanation
1. Melting & boiling point: high	• Large number of atoms held by **strong covalent bonds** • **Large amount of energy** → break strong bonds
2. Solubility • Water: insoluble • Organic solvent: insoluble	• All atoms held together by strong covalent bonds • Force between **structure & solvent molecule**: too weak to break strong bonds
3. Electricity conductivity: × (except graphite)	• All valence electrons: form **covalent bonds** • **No free moving / mobile electrons** to conduct electricity

4.2 Giant Molecular Structures of Carbon

Carbon: Group IV (4 valence electrons)

Allotrope		Diamond	Graphite
Force of attraction between carbon atoms		Strong covalent bonds	Strong covalent bonds
Valence electron	bonding	4	3
	non-bonding	0	1
Arrangement of carbon atoms		• 1 carbon atom: bonded to 4 carbon atoms	• 1 carbon atom: bonded to 3 carbon atoms
		• Tetrahedral arrangement	• Hexagonal arrangement
		• Atoms held by strong covalent bonds	• Layers held by weak intermolecular forces
Structure			

4.3 Melting and boiling points

Melting and boiling point

Deduction	Structure of element	
	Simple molecular structure (N_2, O_2, F_2)	Giant molecular structure (diamond, graphite)
Melting point Boiling point	Low	High
Energy – overcome forces of attraction	Small amount	Large amount
Forces of attraction between particles	Weak intermolecular forces between molecules	Strong covalent bonds between atoms

4.4 Electrical Conductivity

Electrical conductivity

Allotrope	Diamond	Graphite
Valence electrons used to form covalent bonds	4	3 (1 non-bonding)
Free moving / mobile electrons	0	1 per atom
Conduct electricity	×	√

4.5 Hardness

Hardness

Allotrope	Diamond	Graphite
Forces of attraction holding atoms	Strong covalent bonds	Strong covalent bonds
	4 other carbon atoms	3 other carbon atoms
Energy – overcome	Large amount	Small amount
	Strong covalent bonds between carbon atoms	Weak forces of attraction between layers of carbon atoms (layers slide past easily)
Hardness	Hard	Soft & slippery
Appearance	Hardest naturally occurring substance	Soft & slippery greyish-black solid
Usages	Cut almost all known substances 1. Drill bits 2. Saw blades	1. Pencil lead 2. Natural lubricant in machine parts

Typical questions

1. Explain, in terms of bonding and structure, why oxygen has low melting and boiling point while diamond has high melting and boiling point.

   Oxygen has a **simple molecular structure**. There are **weak forces of attraction**[1] between oxygen molecules. **Little amount of energy**[2] is needed to overcome weak intermolecular forces **between molecules**[3]. Hence, oxygen has low melting and boiling point.
   Diamond has a **giant molecular structure**. The carbon atoms in diamond are held by **strong covalent bonds**[1] in a tetrahedral arrangement. **Large amount of energy**[2] is needed to overcome strong covalent bonds **between carbon atoms**[3]. Hence, diamond has high melting and boiling point.