Ionic Bonding

Content

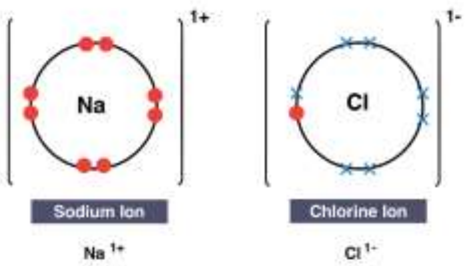
Common Complex Cations and Anions (Examples)

Ion name	Chemical Formula	Cation/Anion
Sulfate	$SO_4{}^{2-}$	Anion
Nitrate	NO_3-	
Carbonate	$CO_3{}^{2-}$	
Hydroxide	OH^-	
Dichromate (VI)	$Cr_2O_7{}^{2-}$	
Manganate	$MnO_4{}^{2-}$	
Phosphate	PO_4^{3-}	
Silver	Ag^+	Cation
Zinc	Zn^{2+}	
Chromium	Cr^{3+}	
Tin	Sn^{2+}	
Aluminium	Al^{3+}	
Copper	Cu^{2+}	

General Rules when writing Chemical Formulae (Ionic Compounds)

Rule no.	Rule
1	A compound made from 2 elements has a name that ends with -ide
2	The oxidation state of an ion will tell the charge of the ion
3	A compound that contains a polyatomic ion containing oxygen has a name ending in-ate, however when that anion has one less Oxygen atom, it ends with -ite
4	Metallic element first, then non-metallic element (Except for Organic Compounds)
5	A compound that has more than 1 polyatomic ions must have brackets between it

Sample 'Dot-and-Cross' Diagram for an Ionic compound



Structure of Physical Properties of Ionic Compounds

Structure of Ionic Compounds

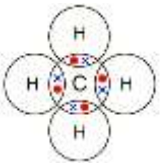
- Called giant ionic lattice structures
- 3 dimensional and held in place by ionic bonds
- Held together tightly as oppositely charged ions attract one another strongly

Physical Properties of Ionic Compounds

No.	Property	Explanation
1	Most ionic compounds have high melting points and high boiling points	- Ionic compounds have very strong electrostatic forces of attraction between oppositely charged ions - A lot of thermal energy is required to overcome these electrostatic forces of attraction between oppositely charged ions
2	Ionic compounds are usually soluble in water and insoluble in organic solvents	
3	Ionic compounds are good conductors of electricity when molten or in aqueous solution	- There must be free and mobile ions in order for the compound to conduct electricity. - In aqueous solution/molten state, the cations and anions are free and mobile and can act as charge carriers and can carry electrical charge - In solid state, there are no free-moving ions to conduct electricity since the ions are vibrating in fixed positions

Covalent Bonding

Sample 'Dot-and-Cross' Diagram of a Covalent Molecule



Common prefixes for naming compounds

Prefix	Number of atoms
mono	1
di	2
tri	3
tetra	4

Structure and Properties of Covalent Substances

Note:
Do not confuse yourself, intra- means within. And they are not weak Covalent bonds are in fact the strongest bonds. Inter- means between molecules

Section A: Structure and Properties of Simple Covalent substances

- Held by strong Intramolecular forces of attraction
- Held by weak Intermolecular forces of attraction

Properties of Simple Molecular Substances

No.	Property	Explanation
1	Low melting and boiling points	- Between molecules, they are held by weak intermolecular forces of attraction - Little Thermal Energy is required to overcome these weak intermolecular forces of attraction between molecules - Therefore, they have low melting and boiling points
2	Insoluble in water but soluble in organic solvents	- However, a certain group of compounds called hydrogen halides can dissolve in water forming acids (See Acids and Bases Notes)
3	Do not conduct electricity in the solid, liquid or gaseous state	- Simple Covalent Molecules do not have any mobile ions or delocalized electrons that can act as charge carriers to carry electrical charge

Section B: Structure and Properties of Giant Molecular Structures (Macromolecules)

Structure of Giant Molecular Structures

- Giant network of atoms covalently bonded together
- Examples include: Boron Nitride, Silicon Dioxide, Diamond, and Graphite
- Diamond and Graphite are allotropes (different forms of the same element) of carbon

Properties of Giant Molecular Structures

No.	Property	Explanation
1	Very high melting and boiling points	- A giant molecular structure consists of a large number of atoms that are held together by strong covalent bonds - To melt or boil these substances, these strong covalent bonds must be broken. - A lot of thermal energy is required to break these covalent bonds
2	Do not conduct electricity (Except for Graphite)	- All valence electrons in giant molecular structures are used for bonding (except graphite) - Therefore, no free and mobile delocalized electrons that can act as charge carriers to carry electrical charge
3	Insoluble in both water and organic compounds	- Water cannot weaken the strong covalent bonds to attract the atoms to therefore dissolve it

Diamond – Its Special Properties and Structure

No.	Property	Explanation based on its Structure
1	Hard and has a high melting point	- Each carbon atom is covalently bonded to 4 other carbon atoms, forming a tetrahedral arrangement - A lot of thermal energy is needed to break these strong covalent bonds between Carbon atoms
2	Does not conduct electricity	- All valence electrons in of carbon atoms used in bonding - No free and mobile delocalized electrons that move throughout the structure that can act as charge carriers to carry electrical charge

Graphite – Its Special Properties and Structure

No.	Property	Explanation based on Structure

1	High Melting and Boiling Point	- Each carbon atom is covalently bonded to three other atoms, in a hexagonal arrangement in layers - A lot of thermal energy is required to break these strong covalent bonds
2	Soft and Slippery	- Layers of carbon atoms are held loosely by weak intermolecular forces of attraction - These layers of carbon atoms can slide over one another when a force is applied.
3	Conducts Electricity	- Each carbon atom has one valence electron that is not used to form covalent bonds - These delocalized electrons can move freely along the hexagonal layers and act as charge carriers, therefore able to carry electrical charge

Silicon Dioxide

No.	Property	Explanation based on Structure
1	High melting and boiling point	- Each Silicon atom is bonded to four oxygen atoms and each oxygen atom is bonded to two silicon atoms, forming a tetrahedral arrangement - A lot of thermal energy is needed to break these strong covalent bonds
2	Does not conduct electricity	- All valence electrons are used for bonding - No free and mobile delocalized electrons that can act as mobile charge carriers to carry electrical charge

Metallic Bonding

Physical Properties of Metals

No.	Property	Explanation

1	Good Conductors of electricity	- Presence of free and mobile delocalised electrons to carry electrical charges
2	Good Conductors of Thermal Energy	- Due to the movement of the delocalized electrons within the metal lattice - Thermal Energy is transferred easily by the delocalized electrons in the structure
3	Usually have high densities, melting points, and boiling points	- Atoms in a metal are packed tightly and held together by strong metallic bonds - Large amount of energy required to break these strong metallic bonds between positively charged metal cations and sea of delocalised electrons
4	Malleable and ductile	- When a force is applied, the layers of metal atoms can slide over each other easily in their orderly arrangement

Alloys

Why are alloys used?

No.	Reason	Example
1	To make metals harder and stronger	Brass (alloy of copper and zinc) is harder than pure copper or pure zinc
2	Improve the appearance of metals	Pewter (Alloy of Tin and Antimony) used to make ornaments as it looks more aesthetically pleasing than pure tin
3	Lowering the melting points of metals	Solder (Alloy of Tin and Lead) has a lower melting point than most metals. Used for joining circuit boards to electronic parts
4	Increase Corrosion Resistance	Cupronickel (Alloy of Copper and nickel) does not corrode easily

How are Alloys stronger than constituent Metals?

- In an alloy, atoms of the different metals or elements have different sizes, the orderly arrangement of atoms in the pure metal is disrupted
- Layers of atoms cannot slide over each other easily when a force is applied

Test yourself

1. Define *cations* and *anions*
2. What are ionic bonds?
3. Explain why Ionic Compound have

   i. Good electrical conductivity in molten or aqueous state but Poor electrical conductivity in solid state
   ii. High melting and boiling point
   iii. Solubility in water (generally)
4. Define *covalent bonds*
5. Explain why simple covalent molecules such as Carbon Tetrachloride have
   i. Low melting and boiling points
   ii. Poor conductivity in any state
   iii. Insoluble in water generally
6. Explain why Diamond is
   i. Very hard and has a very high melting point
   ii. Insoluble in water
   iii. A poor conductor of electricity
7. Explain why Graphite
   i. High Melting and Boiling Point
   ii. Soft and Slippery
   iii. Conducts Electricity
8. Explain why Silicon Dioxide is
   i. Very hard and has a very high melting point
   ii. Insoluble in water
   iii. A poor conductor of electricity
9. Define *Metallic bond*
10. Explain why metals are
    i. Good Conductors of electricity
    ii. Good Conductors of Thermal Energy
    iii. Usually have high densities, melting points, and boiling points
    iv. Malleable and ductile
11. What are alloys?
12. With references to 2 examples, suggest how alloys are used and why are they used as such?
13. Explain how alloys are harder than their constituent metals

Glossary of Terms

Cations	Defined as positively charged ions formed by the loss of electrons
Anions	Defined as negatively charged ions formed by gain of electrons

Ionic bonds	Defined as the strong electrostatic forces of attraction between positively charged and negatively charged ions
Covalent Bonds	Defined as the bond formed by the sharing of electrons between two atoms to form a stable noble gas electronic configuration
Metallic Bonds	Defined as the strong electrostatic forces of attraction between positive metal ions and the 'sea of delocalized electrons' in a giant metallic lattice structure
Alloys	Alloys are defined as a mixture of a metal with one or more other elements