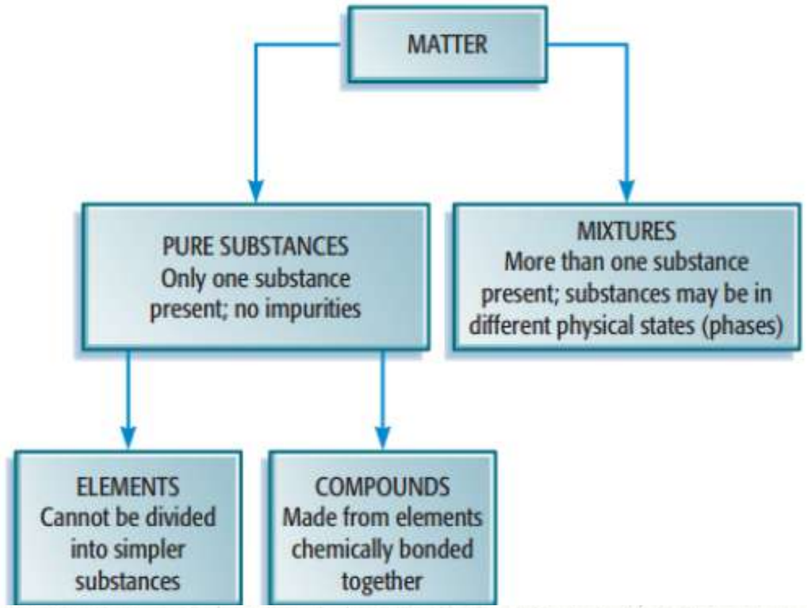
CHAPTER 3
ATOMS, ELEMENTS, COMPOUNDS

11C UNDARGA

ELEMENTS AND COMPOUNDS

There are two types of pure substance:

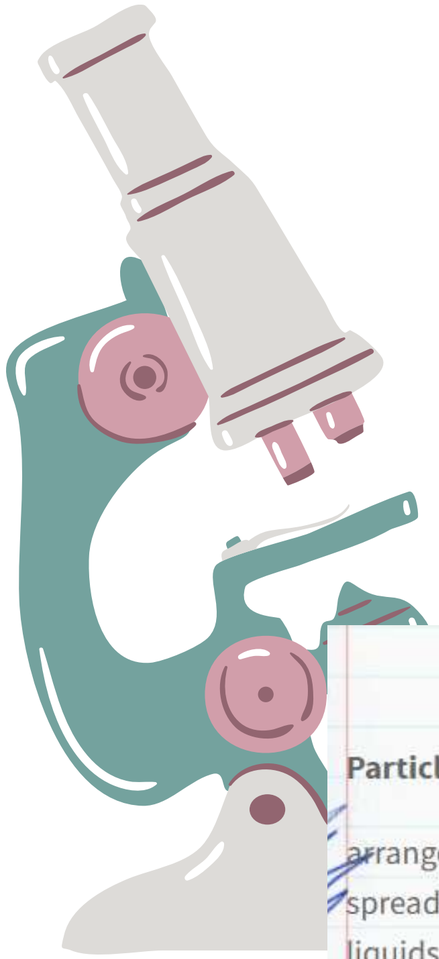
- **Elements** are substances that cannot be chemically broken down into simpler substances.
- **Compounds** are pure substances made from two, or more, elements chemically combined together



When a mixture forms	When a compound forms
the substances are simply mixed together; no reaction takes place	the substances chemically react together to form a new compound
the composition of the mixture can be varied	the composition of the new compound is always the same
the properties of the substances present remain the same	the properties of the new compound are very diff erent from those of the elements in it
the substances in the mixture can be separated by physical methods such as fi ltration, distillation or magnetic attraction	the compound cannot easily be separated into its elements

- **atoms** are the smallest particles that take part in a chemical reaction
- atoms of different elements can combine to make **molecules** of a compound

THE KINETIC THEORY OF MATTER



- ALL MATTER IS MADE UP OF VERY SMALL PARTICLES (DIFFERENT SUBSTANCES CONTAIN DIFFERENT TYPES OF PARTICLES)
- THE PARTICLES ARE MOVING ALL THE TIME (THE HIGHER THE TEMPERATURE, THE HIGHER THE AVERAGE ENERGY OF THE PARTICLES)
- THE FREEDOM OF MOVEMENT AND THE ARRANGEMENT OF THE PARTICLES IS DIFFERENT FOR THE THREE STATES OF MATTER

Particles in a gas are:	Particles in a liquid are:	Solid The particles in a solid are:
arranged totally irregularly	closely packed together	packed close together
spread very far apart compared to solids and liquids	in an irregular arrangement	in a regular arrangement or lattice
able to move randomly.	able to move around past each other.	not able to move freely, but simply vibr their fixed positions.

ATOMIC STRUCTURE

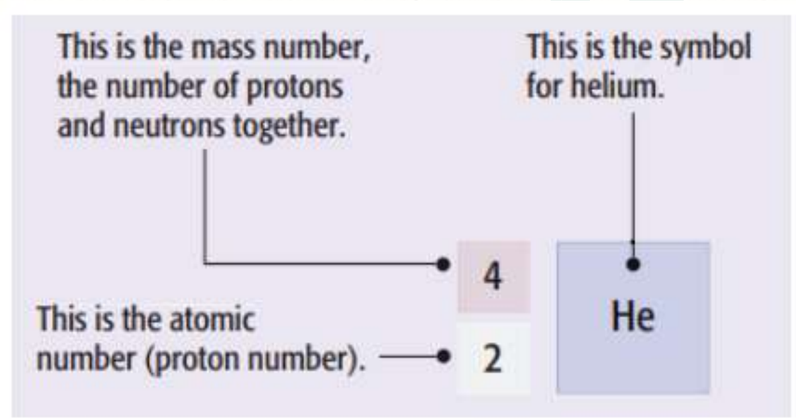
PROTON NUMBER: NUMBER OF PROTONS IN AN ATOM (AND NUMBER OF ELECTRONS IN AN ATOM)

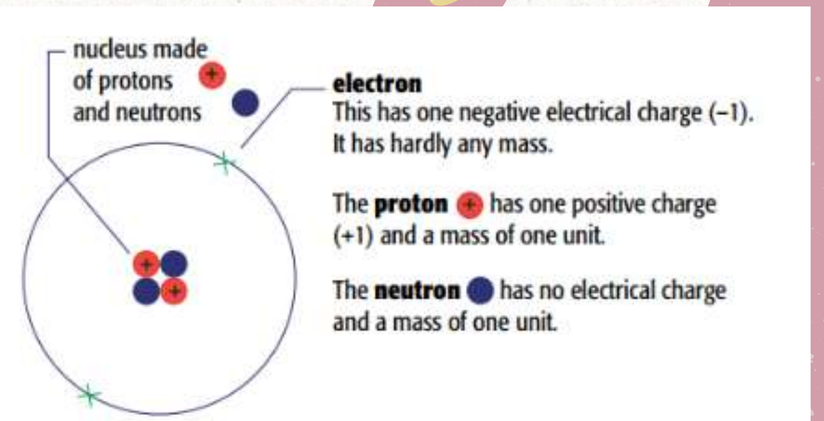
NUCLEON NUMBER: NUMBER OF PROTONS + NEUTRONS IN AN ATOM.

ISOTOPES: ATOMS OF SAME ELEMENT WITH DIFFERENT NO. OF NEUTRONS AND THE SAME NUMBER OF PROTONS AND ATOMIC NUMBER.

ATOM = NUCLEUS(POSITIVE CHARGE) + ELECTRON(NEGATIVE CHARGE)
NUCLEUS = PROTON (POSITIVE CHARGE) + NEUTRON (NEUTRAL)

Relative atomic mass : The masses of atoms of all other elements are compared to the mass of a carbon atom (12 unit = real mass of carbon-12)





BONDING

COVALENT BOND = NON METAL + NON METAL : COVALENT BONDING, WHICH INVOLVES SHARING ELECTRONS BETWEEN ATOMS.

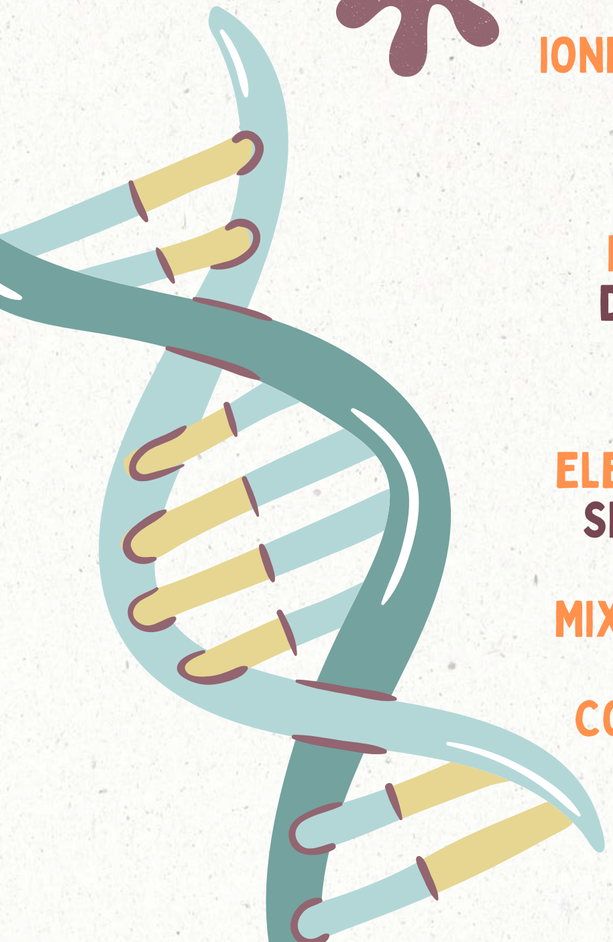
IONIC BOND = METAL + NON METAL : ELECTRONS ARE TRANSFERRED FROM ONE ATOM TO ANOTHER. THESE COMPOUNDS ARE HELD TOGETHER BY ELECTROSTATIC FORCES BETWEEN SEPARATE IONS.

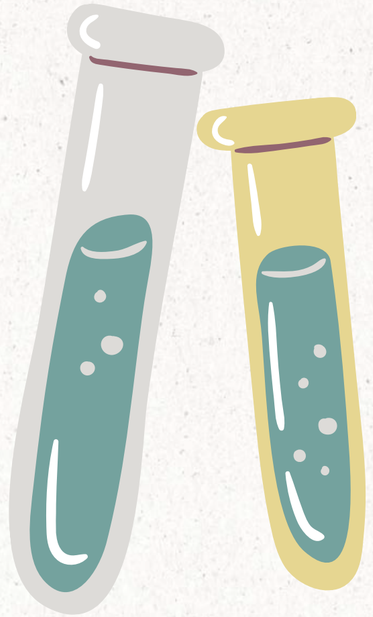
METALLIC BOND : CONSIST OF METALLIC ATOMS : FREE ELECTRONS ARE DELOCALISED AND FORM A KIND OF ELECTROSTATIC 'GLUE' HOLDING THE STRUCTURE.

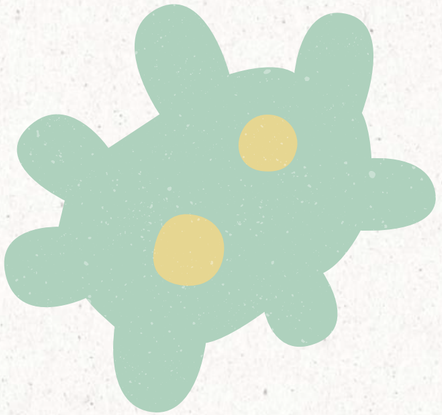
ELEMENT: SUBSTANCE THAT CANNOT BE SPLIT INTO ANYTHING SIMPLER, IN A CHEMICAL REACTION. EACH ELEMENT HAS A UNIQUE PROTON NUMBER.

MIXTURE: TWO OR MORE ELEMENTS MIXED TOGETHER BUT NOT CHEMICALLY COMBINED

COMPOUND: SUBSTANCE IN WHICH TWO OR MORE DIFFERENT ELEMENTS ARE CHEMICALLY COMBINED







IONS AND IONIC BONDS

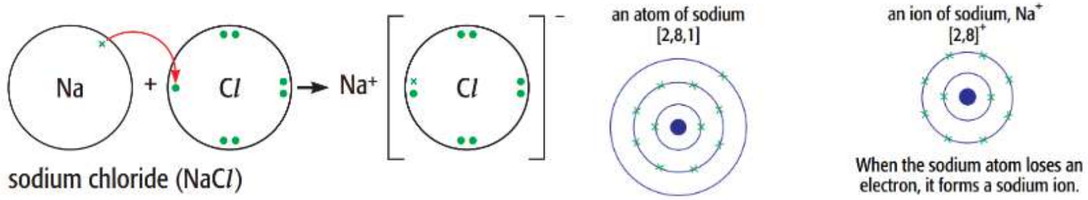
ION: CHARGED PARTICLE MADE FROM AN ATOM BY THE LOSS OR GAIN OF ELECTRONS

METAL ATOMS MOST EASILY LOSE ELECTRONS, SO THEY BECOME POSITIVE IONS. IN DOING SO THEY ACHIEVE A MORE STABLE ELECTRON ARRANGEMENT, USUALLY THAT OF THE NEAREST NOBLE GAS.
GENERALLY, ATOMS OF NON-METALS GAIN ELECTRONS TO BECOME NEGATIVE IONS. AGAIN, IN DOING SO THEY ACHIEVE THE STABLE ELECTRON ARRANGEMENT OF THE NEAREST NOBLE GAS.

IONIC BOND: INVOLVES THE TRANSFER OF ELECTRONS FROM ONE ATOM TO ANOTHER. THIS TRANSFER OF ELECTRONS RESULTS IN THE FORMATION OF POSITIVE AND NEGATIVE IONS. TH E OPPOSITELY CHARGED IONS ARE THEN ATTRACTED TO EACH OTHER BY ELECTROSTATIC FORCES.

PROPERTY	REASON
Form giant lattice	Cations and anions attract
High m.p. and b.p.	Strong bonds between ions
Don't conduct electricity when solid	Ions can't move
Conduct electricity when molten/aqueous	Ions can move
Usually soluble in water	Not required

A common example of a compound that involves ionic bonding is sodium chloride.



sodium chloride (NaCl)

$Na \rightarrow Na^+ + e^-$: positive charge ion → **cation**

$Cl + e^- \rightarrow Cl^-$: negative charge ion → **anion**

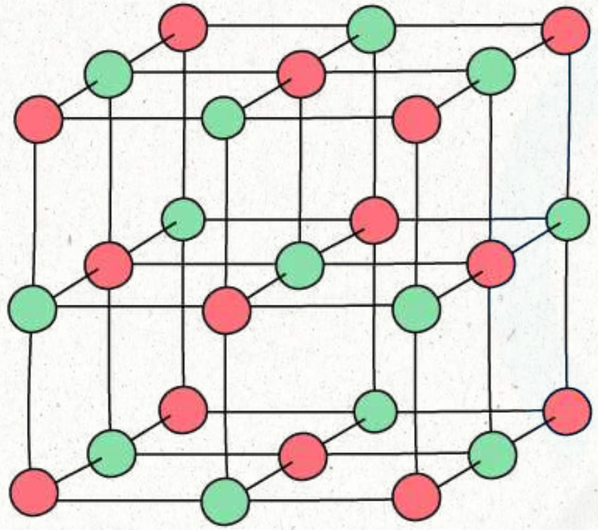
IONS AND IONIC BONDS

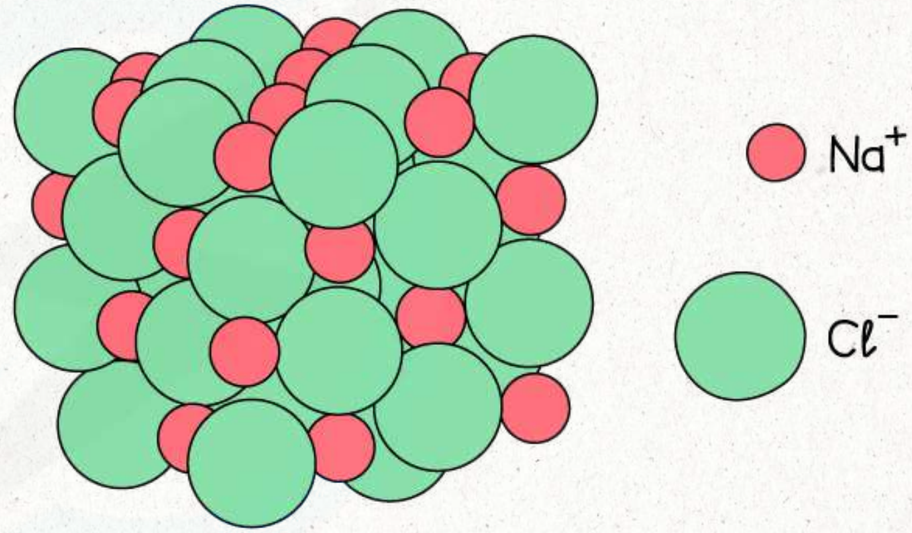
IONIC COMPOUNDS ARE SOLIDS AT ROOM TEMPERATURE.

STRUCTURE: IONS ARRANGE THEMSELVES INTO A REGULAR LATTICE, IN THE LATTICE EACH ION IS SURROUNDED BY IONS OF THE OPPOSITE CHARGE. (GIANT IONIC STRUCTURE)

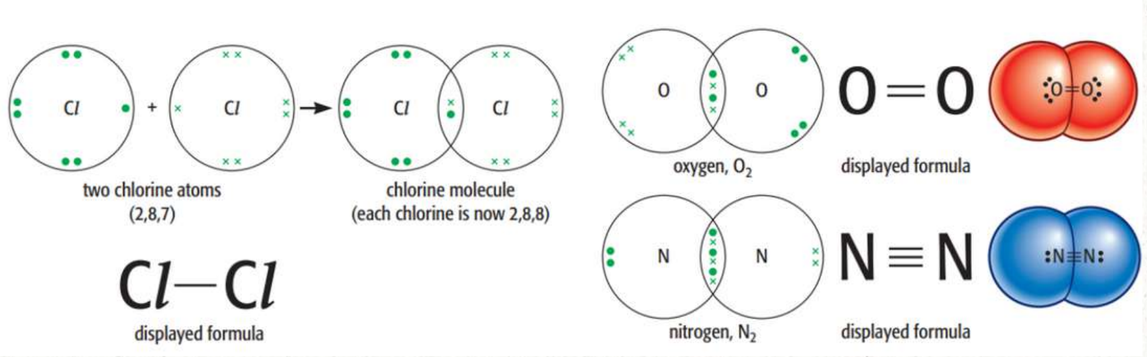
MELTING AND BOILING POINTS: LARGE AMOUNTS OF ENERGY ARE NEEDED TO BREAK STRUCTURE.

- OFTEN SOLUBLE IN WATER: WATER IS ATTRACTED TO CHARGED IONS AND SO MANY IONIC SOLIDS DISSOLVE.
- CONDUCT ELECTRICITY WHEN MOLTEN OR DISSOLVED IN WATER (NOT WHEN SOLID): IN THE LIQUID OR SOLUTION, THE IONS ARE FREE TO MOVE ABOUT. THEY CAN MOVE TOWARDS THE ELECTRODES WHEN A VOLTAGE IS APPLIED.





MOLECULES AND COVALENT BONDS



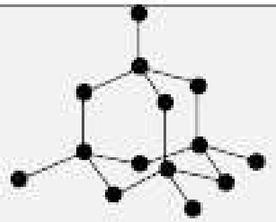
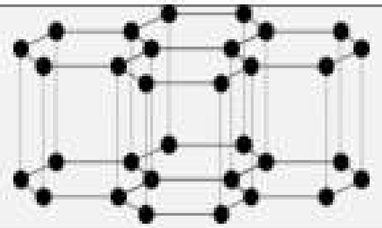
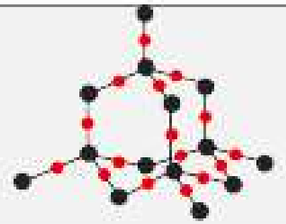
COVALENT BONDING, WHICH INVOLVES SHARING ELECTRONS BETWEEN ATOMS.

COVALENT BONDING RESULTS IN SIMPLE MOLECULES OR GIANT MOLECULAR LATTICES.

IN SIMPLE MOLECULES, THE ATOMS COMBINE TO ACHIEVE A MORE STABLE ARRANGEMENT OF ELECTRONS, MOST OFTEN THAT OF A NOBLE GAS.

- OFTEN LIQUIDS OR GASES AT ROOM TEMPERATURE: SUBSTANCES ARE MADE OF SIMPLE MOLECULES. THE ATOMS ARE JOINED TOGETHER BY COVALENT BONDS.
- LOW MELTING AND BOILING POINTS: TH E FORCES BETWEEN THE MOLECULES ARE ONLY VERY WEAK. NOT MUCH ENERGY IS NEEDED TO MOVE THE MOLECULES FURTHER APART.
- SOLUBLE IN ORGANIC SOLVENTS SUCH AS ETHANOL OR METHYLBENZENE (VERY FEW ARE SOLUBLE IN WATER): COVALENT MOLECULAR SUBSTANCES DISSOLVE IN COVALENT SOLVENTS
- DO NOT CONDUCT ELECTRICITY: NO IONS PRESENT TO CARRY THE CURRENT.

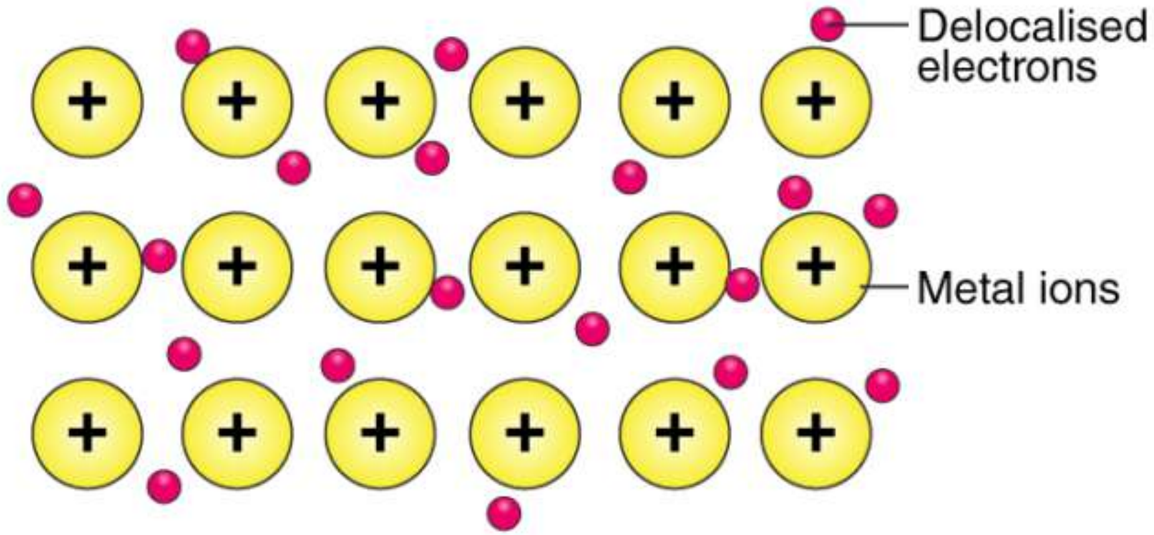
MACROMOLECULES

DIAMOND	GRAPHITE	SILICON DIOXIDE
		
• Four bonds • High m.p. • Doesn't conduct • Used for cutting as is srongest known substance	• Three bonds • Made of flat sheets • Held together by weak forces so is soft ∴ used as a lubricant • Conducts electricity as it has one free e^-	• Makes up sand • Each Si is bonded to 4 oxygen atoms, and each oxygen is bonded to 2 silicon atoms • ∴ it has a high m.p. and is hard, like diamond

ATOMS THAT SHARE ELECTRONS CAN FORM GIANT COVALENT STRUCTURES CALLED **MACROMOLECULES**. THESE HAVE VERY HIGH MELTING POINTS BECAUSE THEIR ATOMS ARE LINKED TOGETHER WITH STRONG COVALENT BONDS.

METALS CONDUCT HEAT AND ELECTRICITY BECAUSE THEIR STRUCTURES CONTAIN DELOCALISED (FREE) ELECTRONS. THE LAYERS OF ATOMS IN METALS ARE ABLE TO SLIDE OVER EACH OTHER. THIS IS WHY WE CAN BEND AND SHAPE METALS.

METALLIC BONDING



- THE STRUCTURE OF A METAL IS MADE UP OF POSITIVE IONS PACKED TOGETHER.
- THESE IONS ARE SURROUNDED BY ELECTRONS(DELOCALISED FREE ELECTRONS), WHICH CAN MOVE FREELY BETWEEN THE IONS. FORM A KIND OF ELECTROSTATIC 'GLUE' HOLDING THE STRUCTURE TOGETHER.
- IN AN ELECTRICAL CIRCUIT, METALS CAN CONDUCT ELECTRICITY BECAUSE THE MOBILE ELECTRONS CAN MOVE THROUGH THE STRUCTURE, CARRYING THE CURRENT.

IN AN ALLOY, SLIPPAGE IS PREVENTED BECAUSE THE ATOMS OF DIFFERENT SIZE CANNOT SLIDE OVER EACH OTHER.