3. From Structure to Properties

King

考点一：Atomic structure

3.1 investigate materials and describe them in terms of their physical properties
3.2 describe changes in the properties of materials that result from some common chemical reactions
3.3 use models in describing the structure and components of atoms and molecules
3.4 identify examples of common elements, and compare their characteristics and atomic structure
3.5 identify and write chemical symbols or molecular formulae of common elements or compounds
3.6 state the relative masses and charges of the three fundamental particles of the atom (proton, neutron and electron)

1. Matter

Matter can be defined as anything that has mass and occupies space. Matter can be identified by its physical and chemical properties.

Physical properties are easily observable and include characteristics *such as melting point, density, colour, and state.*

A **physical change** occurs when matter changes its shape or state but retains its physical properties, or identity.

- State - melting, freezing, boiling, or condensing
- Shape - cutting, breaking, or crushing
- Colour - Dying or painting

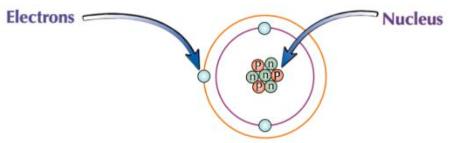
Chemical properties refer to how the substance reacts with other substances. *For example, iron is a reddish solid (physical properties) that reacts with oxygen to form rust (chemical property).*

A **chemical change** is a change in matter that produces one or more new substances.

- A gas is produced.
- A substance disappears
- A solid is formed.
- Heat is given off.
- A smell is produced.

2. STRUCTURE OF AN ATOM

Atoms are made up of 3 types of **subatomic** particle — **protons**, **neutrons** and **electrons**

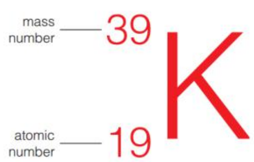


Subatomic particle	Relative mass	Relative charge
Proton	1	+1
Neutron	1	0
Electron, e^-	0.0005	–1

考点二：Atomic number

3.7 identify different isotopes of an element given the atomic number and the mass number
3.8 calculate relative atomic mass from the abundances of the isotopes of an element
3.9 differentiate between atomic number, mass number and relative atomic mass
3.10 illustrate and explain the electronic configurations of the elements using the Bohr model and the orbital and quantum mechanical models

1. ATOMIC NUMBER, MASS NUMBER AND ISOTOPES



Atomic number = number of protons(= number of electrons)
Mass number = number of protons - number of neutrons
isotopes atoms of the same element that have the same atomic number but different mass number

Isotopes have the* ***same configuration of electrons**, so they've got the* ***same*** *chemical properties.*

2. RELATIVE ATOMIC MASS

Relative isotopic mass is the mass of an atom of an isotope, compared with 1/12th of the mass of an atom of carbon-12.

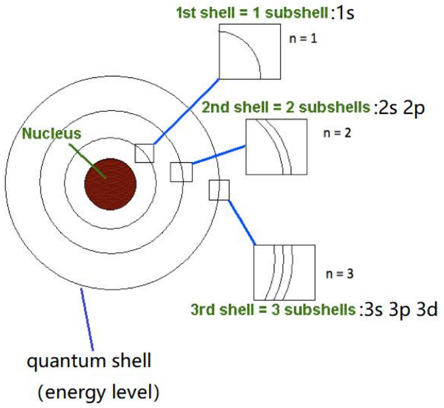
Relative atomic mass, Ar,is the weighted mean mass of an atom of an element, compared to 1/12th of the mass of an atom of carbon-12.

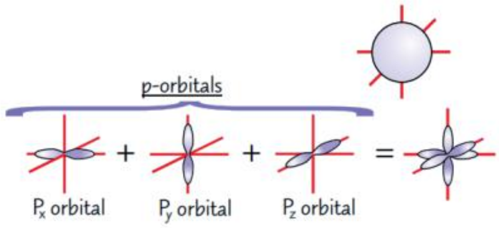
Relative Molecular Masses** are Masses of **Molecules

E.g. $M_r(CaF_2) = 40.1 + (2 \times 19.0) = 78.1$

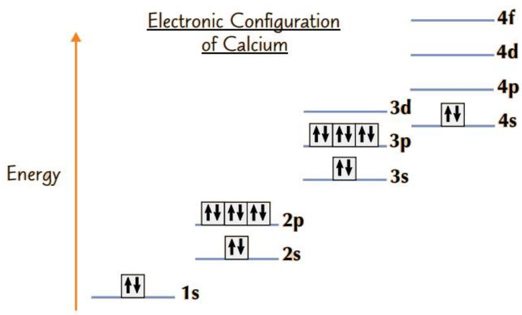
3. QUANTUM SHELLS

Electron Shells** are Made Up of **Subshells** and **Orbitals





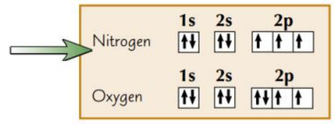
4. Electronic Configurations



两个原则:

***Lowest** Energy Levels First*

Singly before they start pairing up （to avoid repulsion）



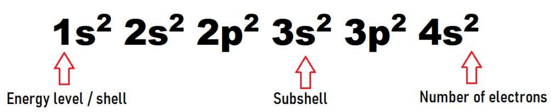
Subshell notation

Two exceptions(more stable)

Cr atom (24 e^-): $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^5\ 4s^1$ Cu atom (29 e^-): $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^1$

Half filled full fill

5. **IONISATION ENERGY**



"当空轨道的时候 4s 能级比 3d 低，一旦有了电子，3d 能级会"下沉"，也就是说比 4s 低。

The first ionisation energy is the energy needed to remove 1 electron from each atom in 1 mole of gaseous atoms to form 1 mole of gaseous 1+ ions

$O(g) \rightarrow O^+(g) + e^-$ 1st ionisation energy = +1314 kJ mol^{-1}

Endothermic process（因为要克服原子核对电子的吸引力）

Factors Affect Ionisation Energy

1. *Shell number→shielding→attraction*
2. *Nuclear charge→attraction*

First Ionisation Energies Decrease Down a Group

*when going down the group, the **shell number** increases, more **shielding** from the inner electrons. So there is a **less attraction** between nucleus and outmost electron*

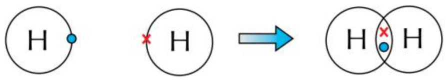
First Ionisation Energies Increase Cross a Period(in general)

*when crossing the poriod, electrons removed from the same **shell**, but the **nuclear charge** increases. So there is a **greater attraction** between nucleus and outmost electron*

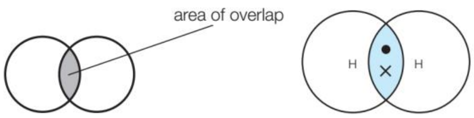
考点二：Chemical bond and shapes of molecule

3.11 illustrate and explain the formation of ionic, covalent, polar covalent and metallic bonds
3.12 predict the shape of polyatomic ions and molecules from their Lewis diagrams using the VSEPR theory
3.13 predict the polarity of molecules from their Lewis diagrams and VSEPR shapes
3.15 write and name the formulas of ionic and molecular compounds, following simple IUPAC rules
3.16 identify and describe the properties of ionic and molecular compounds and metallic substances
3.17 describe how intermolecular forces account for the properties of ionic and molecular compounds and metallic substances
3.18 classify ionic, molecular, and metallic substances according to their properties
3.19 relate the properties of a substance to its structural model
3.20 explain the structural model of a substance in terms of the various bonds that define it

1. COVALENT BONDS A covalent bond is the **strong electrostatic attraction** between the two **positive nuclei** and the **shared electrons** in the bond.

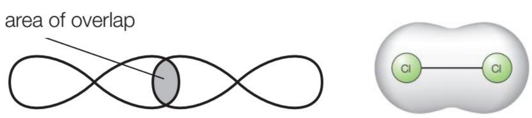


1.1 "**end on end**" of two s-orbitals: **σ bond**



H_2 $1s^1$

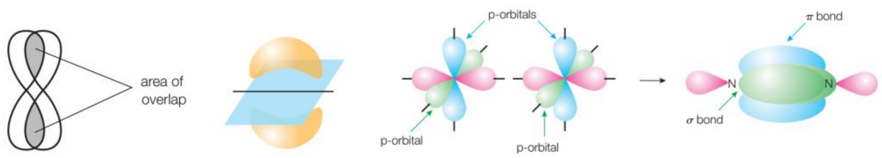
1.2 "end on end" of two p-orbitals: **σ bond**



Cl_2：$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3px^2\ 3py^2\ 3pz^1$.

（只要有两个以上的 bond，其中一个是σ，其他的都是Π bond）

1.3 "side by side" of two p-orbitals=π **BOND**

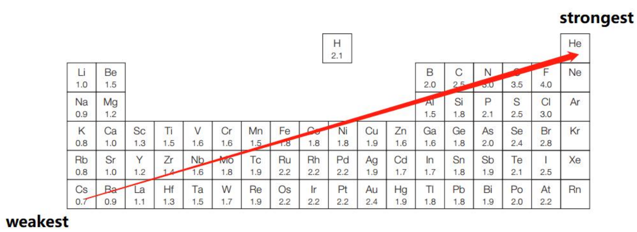


electron density above and below the molecule

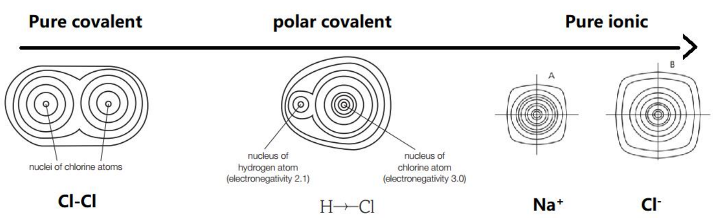
Bond	C–C	C=C	C≡C
Average Bond Enthalpy (kJ mol⁻¹)	+347	+612	+838
Bond length (nm)	0.154	0.134	0.120

2. ELECTRONEGATIVITY

Electronegativity is the ability of an atom to attract a bonding pair of electrons.



Electron density map



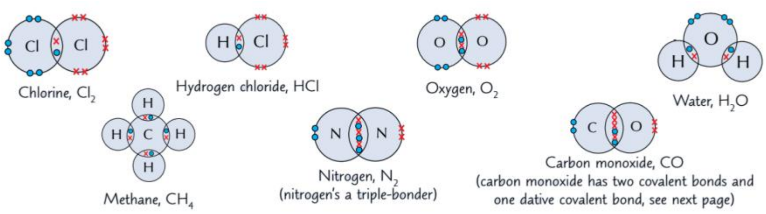
电负性差（EN difference 越大，越 ionic，反之亦然！

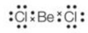
The larger electronegativity difference, the more ionic character.(electron cloud tend to separate)

The smaller electronegativity difference, the more covalent character.(electron cloud tend to share electron)

3. DOT-AND-CROSS DIAGRAMS

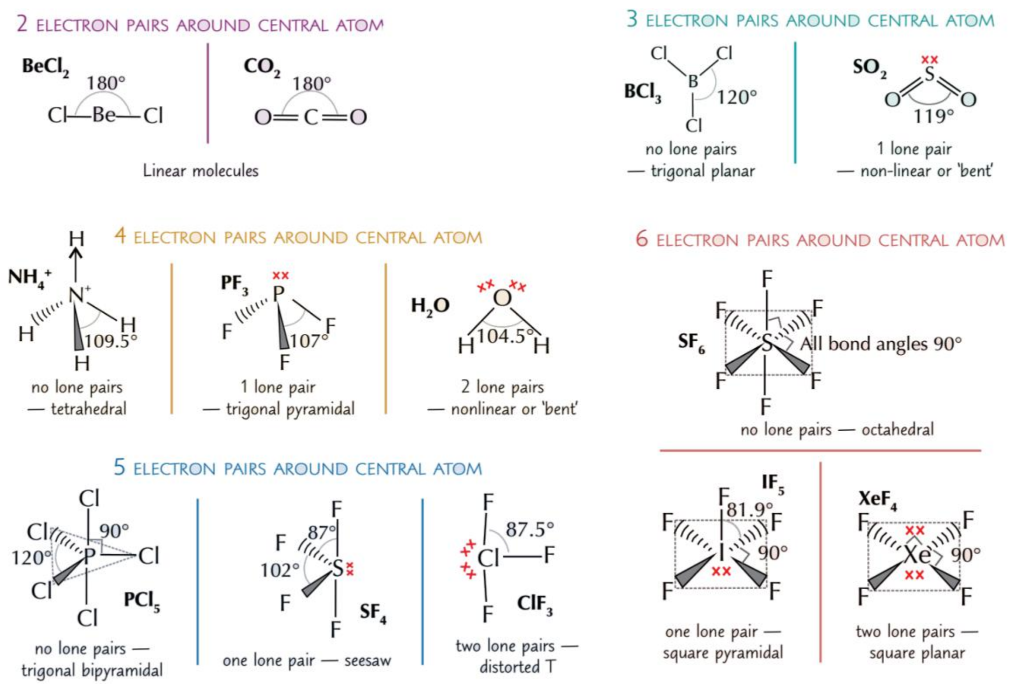
THE OCTET RULE



Beryllium chloride, $BeCl_2$	
Boron trichloride, BCl_3	
Phosphorus(V) chloride, PCl_5	
Sulfur hexafluoride, SF_6	

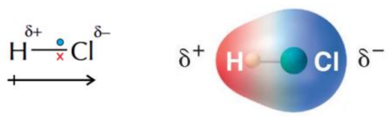
Exceptions

4. Shapes of Molecules (ELECTRON PAIR REPULSION THEORY)

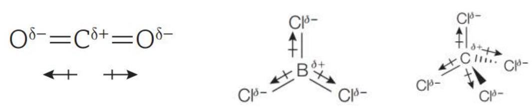


5. NON-POLAR AND POLAR MOLECULES

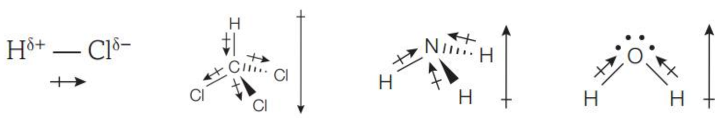
Dipole--the unequal distribution of electron



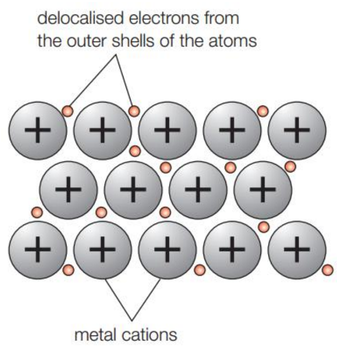
1) The molecule is symmetrical and the diploles cancel out



2) The molecule is asymmetrical and the diploles do not cancel out



6. **METALLIC BONDING** --The positive metal ions are **electrostatically attracted** to the delocalised negative electrons.



1) **high melting points** :

*The **higher** the melting point; the smaller size the stronger bonding, the **higher** the melting point*

2) **Malleable** (can be **shaped**) and are **ductile** (can be drawn into a wire).

1) **Good thermal conductors**. *The delocalised electrons can pass kinetic energy to each other.*

4) **Good electrical conductors**. *because the **delocalised electrons** are free to move .*

5) **Insoluble**, *because of the strength of the metallic bonds.*

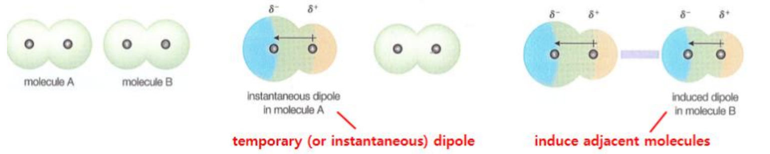
考点三 Intermolecular force

3.14 illustrate and explain hydrogen bonds and van der Waals' forces

1. **Intermolecular forces---**forces between molecules.

*--They're much weaker than **covalent**, **ionic** or **metallic bonds**(intramolecular force).*

1) London forces are also called instantaneous dipole-induced dipole bonds.

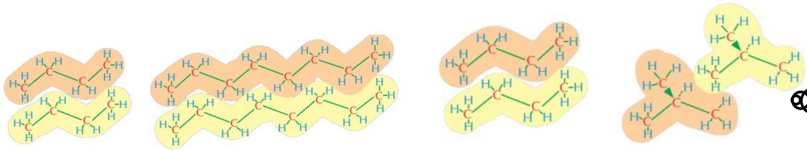


London forces are present among all molecules.

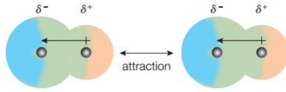
The strength of London forces is determine by the **size** and **shape** of molecules.

i. **Size**: the larger molecules(Mr), the more electrons number, the stronger London force.

ii.**Shape**: the more branching in the molecule, the fewer contact surface area, the weaker London force.



分叉越多越，熔沸点越低(high volatility)！



2) Dipole-dipole interactions

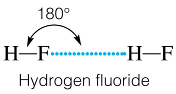
The δ+ and δ– charges on polar molecules cause weak electrostatic forces of attraction between molecules.

3) Hydrogen bonds

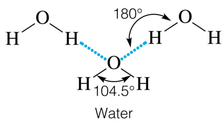
Hydrogen bonding only happens when hydrogen is covalently bonded to fluorine, nitrogen or oxygen.

Think: "H-FON"

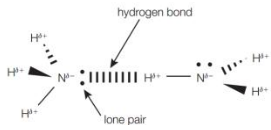
Fluorine, nitrogen and oxygen are very electronegative, creating large difference in EN.



1 H-bond



2 H-bond

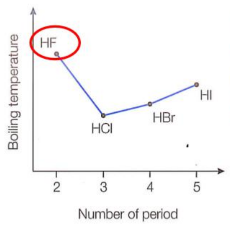


1H-bond

The strengths of the hydrogen bonds increase with the electronegativity of the element hydrogen attached(F>O>N).

The boiling points of Group 7 hydrides

Hydrogen bonds in HF, so HF has a high boiling point



From HCl to HI, although the *permanent dipole-dipole interactions* decreases, the *number of electrons* in the molecule increases, so the strength of the *London forces* also increases.