# U1 / Planet earth

Elements in air

|  |  |  |  |
| --- | --- | --- | --- |
| **Element** | **Percentage** | **Test** | **Observation results** |
| N | 78% |  | |
| O | 21% | 1. Burning splint 2. Glowing splint | Burns brighter  Relights |
| CO2 | .03% | Lime water | Solution changes from colorless to milky |
| He, Ne, Ar | .9% |  | |
| Water vapour | Varies | 1. Dry cobalt(ii) chloride paper 2. Anhydrous copper(ii) sulphate | Changes from blue -> pink  Changes from white -> blue |

Hydrogen → Test with burning splint → pop sound can be heard

Elements in sea water with **flame test**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Element** | **Formula** |  | **Observation results** | **Color** |
| Magnesium chloride | MgCl2 |  |  |  |
| sSodium sulphate | Na2SO4 |  | Golden yellow flame |  |
| Calcium chloride | CaCl2 |  | Brick-red flame |  |
| Copper(II) chloride | CuCl2 | Salts | Bluish green flame |  |
| Potassium chloride | KCl | Lilac flame |  |
| Sodium chloride | NaCl |  | Golden yellow flame |  |

Obtain noble gases from fractional distillation of liquid air

### IMG_256Displacement of Water

As the gases cannot dissolve in water and are lighter in density than water, they would rise to the top of the gas jar and be collected there. Some examples of gases collected via this way include H2 O2.

### IMG_256Upwards delivery

This method is used to collect gases which are soluble in water and has a lighter density as compared to air. Some examples of gases collected this way include Cl2, HCl and SO2. Downwards delivery is the opposite to this setup.

## Common definitions

**Reactivity**

How easily atoms can lose / gain electrons & so react with other atoms

**Melting & boiling points**

Determined by the strength of the bonds holding that substance together, the more the strength the more energy is required to break the bonds (higher)

More reactive

**Conduction of electricity**

Determined by if there are any charged particles that can move, if it’s an ionic substance → determined by it’s physical state

# U2 / Microscopic world I

**Isotopes** - Isotopes are atoms with the same number of protons, but different numbers of neutrons.

**Relative atomic (formula) mass** - the average weighted mass of the isotopes of an element

Properties of elements by type

|  |  |
| --- | --- |
| **Metals** | **Non-metals** |
| Solid in r.t.p  Shiny  High m.b.p /1  Malleable & ductile  High density  Good conductors of heat & electricity /2 | Gases in r.t.p except Br -> solid  Not shiny  Low m.b.p. /3 Some are high like diamond & graphite  Brittle  Low density  Poor conductors of heat & electricity except graphite |

/1 - metals have strong ionic bonds, so they have high m.b.p

/2 - electrons are delocalized

/3 - non-metals have strong covalent bonds between atoms ; weak intermolecular forces between molecules, resulting in a low m.b.p..

Graphite & diamonds have giant lattice structures, they have huge numbers of atoms & the structure makes it stronger, resulting in a higher m.p. b.p

|  |  |  |
| --- | --- | --- |
| 1. Mass number   [Z] Atomic number (p) |  | n = A - Z  e- = n  p+ = Z |

## Groups, properties & reactivity

1. **Why is group 1 more reactive down the group?**

Only one e- must be **lost** to be stable, radius gets bigger, outermost shell distance to nucleus increases, weakens the attractive force, easier to **lose** electron

1. **Why is group 7 less reactive down the group?**

One e- must be **gained** to be stable, radius gets bigger, weakens the attractive force, harder to **attract** e- to complete shell

1. **Why is group 0 unreactive?**

Since group 0 elements already have a full shell, they don’t tend to loose / gain e-.

1. **What is displacement reactions?**

An atom taking place of another atom upon a reaction. Cl2 + 2KBr > Br2 + 2KCl (More reactive halogens will always displace less reactive ones)

|  |  |  |  |
| --- | --- | --- | --- |
| **Group 1** | **Group 2** | **Group 7** | **Group 0** |
| 1. Soft metals 2. Low density   Reactivity ▲ down the group   1. Reacts with air so must be stored under oil 2. Reacts with non-metals to form ionic compounds 3. Reacts vigorously w/ water   **M + H2O → MOH + H2**  Metal + Water → Metal Hydroxide + Hydrogen  [\*] produce H2 [2+] rapidly  [2+] melts to silvery ball  [2+] move quickly on surface  [3+] H2 catches fire  [4+] vigorously | 1. Low density; > g1 2. Reactivity < < g1   Reactivity ▲ down the group   1. Reacts with nonmetals to form ionic compounds 2. Reacts vigorously w/ water < g1   **M + H2O → MOH + H2**  ss   1. doesn’t react w/ H2O 2. no reaction w/ cold water   [2+] reacts with steam, produce H2  [3+] reacts w/ cold water  [4+] vigorously | 1. All have colors 2. Reactive   Reactivity ▼ down the group   1. Reacts with metals to form ionic compounds 2. Reacts with non-metals to form covalent compounds 3. Reacts w/ hydrogen   **H2 + M2 → 2HM**  Hydrogen + Metal → Hydrogen Metal-ide   1. explosively in the dark 2. explosively in sunlight; dark ↓ 3. only sunlight 4. No reaction | 1. Colorless gases 2. Very unreactive   No trend (unreactive) |

## Chemical bonds

1. **Ionic bonding - Donating electrons**

➔ Metal & non-metal

Atoms are attracted with electrostatic forces → makes up ionic bond

Oppositely charged ions

Example: NaCl

1. **Metallic bonding**

➔ Metals only

Strong electrostatic attraction holds everything together in a regular structure → makes up metallic bond

Metals: giant structure of atoms arranged in a regular pattern → giant metallic structure

Metals: Form +ve ions when they react [Ca2+]

Electrons becomes delocalized

• Strength

• High m.p. b.p.

• Good conductors of electricity & heat

1. **Covalent bonding - Sharing electrons**

➔ Non-metals only

Electrostatic attraction between shared electrons & the nuclei

## Chemical structures

Comparison:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Giant metallic** | **Giant ionic** | **Simple molecular** | **Giant covalent** |
| Examples | Na Cu Zn Al | NaCl | H2 F2 I2 H2O NH3 CCl4 | C (Diamond, graphite)  SiO2 (Silicon dioxide, quartz) |
| Structure | WhatsApp Image 2021-08-18 at 4.33.59 PMSodium | WhatsApp Image 2021-08-18 at 4.33.59 PM  Sodium chloride | WhatsApp Image 2021-08-18 at 4.33.59 PM  Iodine | WhatsApp Image 2021-08-18 at 4.33.59 PM  Diamond |
| Bonds | Strong metallic bonds | Strong ionic bonds | Strong covalent bonds between atoms  Weak intermolecular forces between molecules | Strong covalent bonds |
| State @ r.t.p | Solids except mercury | Solids | Gas or liquids | Solid |
| m.b.p | ▲ | ▲ | ▼ | ▲ |
| hardness | ▲ | ▲ | ▼ | ▲ |
| Water soluble? | no | yes | no | no |
| Non-aqueous solvent soluble? | no | no | yes | no |
| Electrical conductivity | Good conductors  (delocalized e-) | Conducts electricity when melted or dissolved in water | No | No except graphite |

Graphite shows lower shearing strength under friction force, so it’s a good lubricant

### Predicting structure of substance

low mp (g, l ) simple molecular

conduct electricity (s) metallic

conduct electricity (m, aq) ionic

high mp (s) giant covalent

# U3 / Metals

## Extraction of metals

The more easily a metal can be extracted the **earlier it was discovered in history**

**Harder extraction** = **more reactive**

|  |  |  |
| --- | --- | --- |
| **Metal** | **Extraction** | **Properties** |
| **K** | **Electrolysis:** metal oxide → metal + oxygen  mO → m + O2 |  |
| **Na** |  |
| **Ca** |  |
| **Mg** |  |
| **Al** | [Strong] [Malleable] [Cheap] [Conductor] [Corrosion resistant] [Non-poisonous] [Low density] |
| **Zn** | **Heating w/ C:** metal oxide + carbon → metal + carbon dioxide  Heat in air // mO + C → m + CO2  Iron(III) oxide + carbon monoxide → iron + carbon dioxide |  |
| **Fe** | [Strong] [Hard] [Malleable] [Cheap] |
| **Pb** |  |
| Cu | **Heat in air:** metal sulphide + oxygen → metal + sulphur dioxide  mS + 2O → m + SO2 | [Strong] [Conductor] [Malleable] [Corrosion resistant] [Non-poisonous] |
| Hg Mercury |  |
| Ag Silver | **Heating:** 2Ag2O → 4Ag + O2 | [Conductor+] [Malleable] [Corrosion resistant] |
| Pt Plat | Panning / Mechanical separation |  |
| Au | [Malleable] [Corrosion resistant] [Soft] [Shiny] |

## Reactions of metals

Metals which reacts with air are **stored under paraffin oil, reactivity can not be measured**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **React with air:** metal + oxygen → metal oxide | | | | | | | | | | | | |  | **Metal** | **Color of flame when burnt** |
| Burn bool | K | Na | Ca | Mg | Al | Zn | Fe | Pb | Cu | Hg | Ag | Pt | Au |  | K | Lilac |
|  | **React with H2O:** metal + H2O(l/g) → metal ((OH)2 / O) + hydrogen | | | | | | | | | | | | |  | Na | Golden yellow |
| l/g | K | Na | Ca | Mg | Al | Zn | Fe | Pb | Cu | Hg | Ag | Pt | Au |  | Ca | Brick-red |
|  | **React with dilute acid:** metal + acid → metal acid[0] + acid[1] (HCl / H2SO4) | | | | | | | | | | | | |  | Mg | Bright white |
| Size | K | Na | Ca | Mg | Al | Zn | Fe | Pb | Cu | Hg | Ag | Pt | Au |  | Fe | Yellow sparks |

**Displacement reactions:** (Mr1 > Mr2) ? (M2 displace M1 : no reaction)

**Trends for metals in pTable:** ← ↓ increase in reactivity, the more difficult

|  |  |  |  |
| --- | --- | --- | --- |
| **Common -ium -ide** | | **Uncommon ions -ate** | |
| NH4+ | Ammonium | CO32- | Carbonate [3] |
| H3O+ | Hydronium | HCO3- | Hydrogen carbonate [3] |
| OH- | Hydroxide |  |  |
| CN- | Cyanide |  |  |
| OCN- | Cyanate |  |  |
| O22- | Peroxide |  |  |
| **Common -ite[pt]** | |  | |
| NO2- | Nitrite |  |  |
| ClO2- | Chlorite (Hypo, ite, ate, per) | MnO4- | Permanganate |
| BrO2- | Bromite | C2H3O2- | Acetate |
| IO2- | Iodite | C2O42- | Oxalate |
| SO32- | Sulfite | CrO42- | Chromate |
| PO33- | Phosphite | C2O72- | Dichromate |

## Mole & stuff

Full: // particles can be number of e- or atoms ...

Mem:

For (A as compound) & (B as asked compound) in Q do

1. n = n in mol of A
2. r = mol ratio A : B
3. n / r \* gmol of B

For Q with **limiting reactant** & (AB as compounds) & (C as asked compound) do

1. n[AB] = n in mol of AB
2. r = mol ratio A : B
3. n[AB] change → r
4. print(“n[A] mol of A would react with n[B] mol of B”) // optional
5. Find limitedReactant, compound\_in\_excess // optional
6. r = mol ratio limitedReactant : C
7. n[limitedReactant] / r \* gmol of C

## Corrosion of metals

**Rusting** is the corrosion of iron

**hydrated iron(III) oxide** *(2Fe2O3•nH2O)* is known as rust - reddish brown solid

**O2 & H2O** are necessary for rusting, air contains O2 & little moisture → very little rusting

**Rust indicator** changes from green to blue in presence of rust

### Increase rate of rusting

|  |  |
| --- | --- |
| Presence of acids / salts | Increase electrical conductivity |
| High temperature | Increased rate of chemical reaction |
| Attachment to less reactive metal | Iron is easier to lose electrons (more readily) |
| Sharp of bent surface | // |

These can be studied by placing nails in petri dishes containing rust indicator in gel

### Preventing rusting

|  |  |
| --- | --- |
| Painting | When scratched becomes ineffective |
| Greasing / oiling | Must be reapplied frequently |
| Glavanisation /Zinc | Can’t be applied to cans due to toxicity, damaged still effective due to Zn being more reactive |
| Tin-plating | Not poisonous |
| Electroplating /Chromium | Expensive |
|  |  |
| Sacrificial protection | Attach to a more reactive metal → metal will lose e- more readily than iron → prevent iron from forming iron(II) ions |
| Alloying /combining metals | Expensive to create **stainless steel** |
| Cathodic production | Connect Fe to **negative terminal** of battery → losing e- can be prevented |

### Corrosion resistance of aluminium + Anodisation

Al is exposed to air → thin layer of **Aluminium oxide Al2O3** is formed on it’s surface, which is impermeable to O2 & H2O

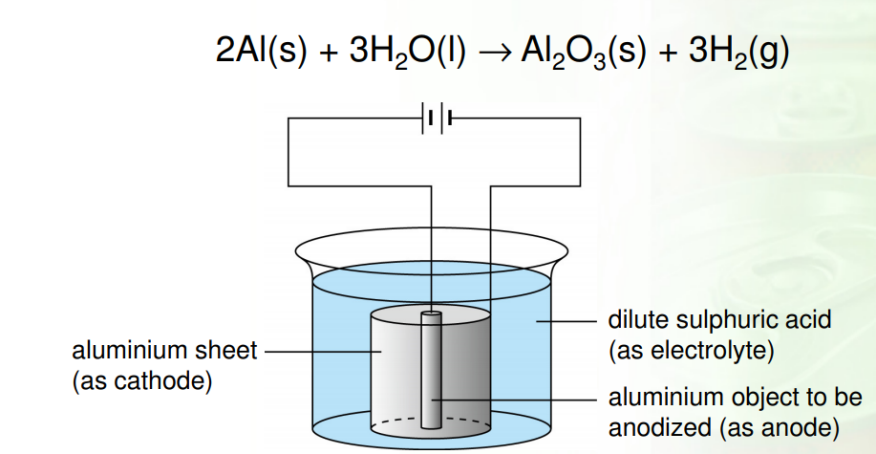
→ protects Al from further corrosion

Fe2O3 formed on Fe’s surface is permeable to O2 & H2O → can’t protect Fe from rusting

**Anodisation** process to ↑ thickness of oxide layer by **electrolysis**

Anodised Al is **more corrosion resistant** & can be dyed

Experimental set-up for anodisation:



## Recycling metals

Recycling is collecting used metal items and producing new metal from them

# U7 / Redox reactions

Ox. n → Charge of ion

Reduction (Red) - ↓O [Ox. n] | ↑e- - Oxidising agent

Oxidation (Ox) - ↑O [Ox. n] | ↓e- - Reducing agent

|  |  |
| --- | --- |
| **Example:**  2ZnO(s) + C(s) → 2Zn(s) + CO2(g) | Zn2+ O2- → Oxidation number = (2)+(-2) = 0 |
|  |