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CHEMISTRY

REVISION NOTES

GROUP - 2

Group 2

Atomic radius

As one goes down the group, the atomic radius increases because the atoms have more shells of electrons, making the atom bigger.

Melting points

The melting points of elements decrease as you move down the group. This is because the metallic bonding becomes weaker as the atomic size increases. As the distance between the positive ions and delocalised electrons increases, the electrostatic attractive forces between them weaken.

1st ionisation energy

The first ionisation energy is the energy required to remove the outermost electron from an atom. This energy is higher for atoms with a stronger attraction between the nucleus and the electrons. As the outermost electrons are located in shells that are successively further from the nucleus, they are held more weakly.

Additionally, the outer shell electrons are shielded from the attraction of the nucleus by the repulsive force of inner shell electrons.

Group 2 reactions

The reactivity of group 2 metals increases down the group.

The metals in group 2 react vigorously with oxygen. Magnesium burns with a bright white flame.

The reaction of 2Mg and O_2 produces 2MgO. MgO is a white solid with a high melting point due to its ionic bonding.

Mg will also react slowly with oxygen without a flame.

Mg ribbon will often have a thin layer of magnesium oxide on it formed by a reaction with oxygen.

$2Mg + O2 \longrightarrow 2MgO$

This needs to be cleaned off with emery paper before doing reactions with Mg ribbon.

If testing for reaction rates with Mg and acid, an uncleaned Mg ribbon would give a false result because both the Mg and MgO would react but at different rates.

$Mg + 2HCl \longrightarrow MgCl_2 + H_2$
$MgO + 2HCl \longrightarrow MgCl_2 + H_2O$

Exam point – learnt the difference between the reaction of magnesium with steam and warm water.

Reaction of Magnesium with Water and Steam

$$Mg(s) + 2H_2O(i) \longrightarrow Mg(OH)_2(aq) + H_2(g)$$

Magnesium Water — Magnesium Hydrogen Oxide

$$Mg(s) + H_2O(g) \longrightarrow MgO(s) + H_2(s)$$

Magnesium Steam — Magnesium Hydrogen Oxide

The other Group 2 metals react with cold water with increasing force as we move down the group, forming hydroxides. The general equations is as follows:

$$X_{(s)} + 2H_2O_{(l)} + X(OH) \rightarrow X(OH)_{2(aq\ or\ s)} + H_{2(g)}$$

Upon adding reactive metals to water, observations are as follows:

- One would observe fizzing.
- The metal dissolves more vigorously down the group.
- The solution heating up.

With calcium, a white precipitate appears, while less precipitate forms a down group with other metals.

Titanium Extraction

Titanium is a valuable metal due to its abundant nature, low density, and excellent resistance to corrosion. It is widely used to create strong and lightweight alloys, which are commonly found in aircraft and other applications.

Carbon isn't suitable for extracting titanium because it forms titanium carbide (TiC) instead of pure titanium. Similarly, electrolysis isn't a viable extraction method because the titanium has to be very pure, and it's usually extracted through a chemical reaction with a more reactive metal, such as magnesium (Mg).

Steps to extract titanium:

1. Convert TiO2 (solid) to TiCl4 (liquid) at 900C.
2. Purify TiCl4 by fractional distillation in an argon atmosphere.
3. Extract Ti using Mg in an argon atmosphere at 500C.

Titanium is expensive because

1. The expensive cost of the Mg.

2. This is a batch process which makes it expensive because the process is slower (having to fill up and empty reactors takes time) and requires more labour and the energy is lost when the reactor is cooled down after stopping.

3. The process is also expensive due to the argon and the need to remove moisture (because $TiCl_4$ is susceptible to hydrolysis).

4. High temperatures are required in both steps.

Solubility of Hydroxides

Group 2 metals, also known as alkaline earth metals, include beryllium (Be), magnesium (Mg), calcium (Ca), strontium (Sr), barium (Ba), and radium (Ra). The solubility of their hydroxides in water generally increases down the group.:

Beryllium Hydroxide ($Be(OH)_2$):

- Beryllium hydroxide is amphoteric but tends to form basic solutions. It is sparingly soluble in water.

Magnesium Hydroxide ($Mg(OH)_2$) – Medical use :

- Magnesium hydroxide is sparingly soluble in water. However, it has low solubility, and its solid form is often used as a suspension (milk of magnesia) for medicinal purposes to treat excessive acidity in the stomach.

Calcium Hydroxide ($Ca(OH)_2$):

- Calcium hydroxide is sparingly soluble in water. It does dissolve to some extent, and the resulting solution is known as **lime water which can used to test for Carbon dioxide.**

$$Ca(OH)_{2(aq)} + CO_{2(g)} \longrightarrow CaCO_{3(s)} + H_2O_{(l)}$$

Strontium Hydroxide ($Sr(OH)_2$):

- Strontium hydroxide is slightly more soluble than the hydroxides of the preceding elements but is still considered sparingly soluble.

Barium Hydroxide ($Ba(OH)_2$):

- Barium hydroxide is more soluble than the hydroxides of the previous elements in the group. It is still considered sparingly soluble but is more soluble than strontium hydroxide or calcium hydroxide.

When mixed with water, Barium hydroxide dissolves easily, and the solution becomes strongly alkaline due to the presence of hydroxide ions. The chemical equation for the reaction is

$$Ba(OH)_2\,(s) + H_2O\,(l) \rightarrow Ba^{2+}\,(aq) + 2OH^-\,(aq).$$

Solubility of Sulphates:

The solubility of sulfates of Group 2 elements, also known as alkaline earth metals, generally decreases as we move down the group.

Here's a general trend in the solubility of sulfates for Group 2 elements:

- Beryllium sulfate ($BeSO_4$) is not able to dissolve in water.
- Magnesium sulfate ($MgSO_4$) is able to dissolve in water.
- Calcium sulfate ($CaSO_4$) is only able to dissolve sparingly in water.
- Strontium sulfate ($SrSO_4$) is only slightly able to dissolve in water.
- **Barium sulfate ($BaSO_4$) is almost completely insoluble in water.**

Medical use of Barium Sulphate:

$BaSO_4$, also known as barium sulfate, is a chemical compound used in the medical field to help diagnose gastrointestinal problems. It is given to patients as a 'Barium meal' before taking x-ray images of their intestines. The barium in the compound absorbs the X-rays, allowing the gut to show up clearly on the X-ray image. Although barium compounds are generally toxic, it is safe to use in this case because the low solubility of $BaSO_4$ means it is not absorbed into the bloodstream.

Barium reaction with sulphuric acid

When barium metal is reacted with sulfuric acid, the reaction will happen slowly due to the formation of an insoluble compound called barium sulfate. This compound will be produced on the surface of the metal, preventing further reaction with the acid.

The chemical equation for this reaction is:

$$Ba + H_2SO_4 \rightarrow BaSO_4 + H_2.$$

A similar effect occurs with metals that are higher up the group because their solubility increases. However, this effect is less pronounced.

It's worth noting that this reaction doesn't happen with other acids like hydrochloric or nitric acid because they form soluble group 2 salts.

Test for Sulphate ions:

To test for the presence of sulfate ions (SO_4^{2-}), a barium chloride ($BaCl_2$) solution can be used. When barium chloride reacts with sulfate ions, it creates a white precipitate of barium sulfate ($BaSO_4$).

$$Ba^{2+} + SO_4^{2-} \rightarrow BaSO_4(s)$$

False result

Hydrochloric acid is necessary to react with carbonate impurities that are frequently found in salts. These impurities can cause a white barium carbonate precipitate and lead to inaccurate results. Sulfuric acid cannot be used because it contains sulfate ions, which could result in a false positive outcome.

Exam Questions

State **one** observation when magnesium reacts with steam.

Give an equation, including state symbols, for this reaction.

Give an equation to show how magnesium is used as the reducing agent in the extraction of titanium.

Explain, in terms of oxidation states, why magnesium is the reducing agent.

Give the full electron configuration for the calcium ion, Ca^{2+}

What is a use for barium sulfate?

A In agriculture to act as a fertiliser ⬭

B In agriculture to neutralise acidic soil ⬭

C In medicine to produce an X-ray image ⬭

D In medicine as an antacid to treat indigestion ⬭

Which compound is used to treat the symptoms of indigestion?

A MgO ⬭

B $Mg(OH)_2$ ⬭

C CaO ⬭

D $Ca(OH)_2$ ⬭

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