CONCEPT BOOSTER

What can be better for us if it is a bag of sweet surprises!! & for each chemistry aspirant a sweet surprise cannot be better than shortcut techniques to learn & remember inorganic chemistry. My coming articles are going to be on important topics of inorganic chemistry with possibly the best shortcut tricks from my side. Stay tuned and keep your eyes on my article to enjoy essence of CHEMISTRY... ALL THE BEST!

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HEATING EFFECTS

Before we get into the detailed discussion, take a look into the following concepts :

1. Polarisation $(\phi) \propto$ covalent character

$$\propto \frac{1}{\text{ionic character}}$$

$$\propto \frac{1}{\text{thermal stability}}$$

2. $\sqrt{\phi} = 2.20$ to $3.21 \rightarrow$ oxide is amphoteric.

   $\sqrt{\phi} < 2.2 \rightarrow$ oxide is basic.

   $\sqrt{\phi} > 3.2 \rightarrow$ oxide is acidic.

METAL CARBONATES AND BICARBONATES

Let us take the thermal stability of alkaline earth metal carbonates and alkali metal carbonates.

$$BeCO_3 < MgCO_3 < CaCO_3 < SrCO_3 < BaCO_3$$

$$Li_2CO_3 < Na_2CO_3 < K_2CO_3 < Rb_2CO_3 < Cs_2CO_3$$

They are thermally quite stable. Therefore, they are not easily decomposed on heating. So, no question of getting CO_2 on heating these alkali metal carbonates.

Only Li_2CO_3 decomposes on heating to give CO_2.

$$Li_2CO_{3(s)} \xrightarrow{\Delta} Li_2O + CO_2$$

However, an alkaline earth metal carbonate decomposes on heating to give CO_2 where $BeCO_3$ requires least heat (least stable) and $BaCO_3$ requires high temperature or highest heat (most stable).

$$MCO_{3(s)} \xrightarrow{\Delta} MO + CO_2$$

(M = alkaline earth metal)

Now, coming to an unconventional thing, what happens when Ag_2CO_3 or $MgCO_3$ is heated?

Shortcut : Symbol of metals that ends with 'g' are Mg, Hg, Ag (mostly used these g).

Mg doesn't come under this shortcut as it is under alkaline earth metal category.

Hg Ag

'g' = get back to itself

So, when these metal carbonates will be heated, we'll get back metal. Therefore,

$$\underset{\text{(yellow)}}{Ag_2CO_3} \xrightarrow{\Delta} \underset{\text{(black)}}{2Ag} + CO_2 + \frac{1}{2}O_2\uparrow$$

$$HgCO_3 \xrightarrow{\Delta} Hg + CO_2 + \frac{1}{2}O_2\uparrow$$

(Not $HgO + CO_2$)

Carbonate part (CO_3^{2-}) will always give CO_2 and O_2.

Zn behaves as alkaline earth metal in this aspect. So,

$$\underset{\text{(white)}}{ZnCO_3} \xrightarrow{\Delta} ZnO + CO_2$$

yellow (hot), white (cold) → This phenomenon is due to defect in crystal.

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Now comes, two important concepts :

$$\underset{\text{Malachite or basic Cu(II) carbonate}}{CuCO_3 \cdot Cu(OH)_2} \xrightarrow{\Delta} 2CuO + CO_2 + H_2O \cdot \text{ Why?}$$

Remember it as simple decomposition.

$$CuCO_3 \cdot Cu(OH)_2 \xrightarrow{\Delta} 2CuO + CO_2 + H_2O$$

$$CuO \quad CO_2 \quad CuO \quad H_2O$$

But this is a bit different for white lead *i.e.* $2PbCO_3 . Pb(OH)_2$.

Remember in this way : Due to higher stability of +4 state in comparison with +2 state, in case of Pb, where there is a scope, Pb will give +4 state along with +2 state. If not +4, then at least something higher than +2. So,

$$3[PbCO_3 \cdot Pb(OH)_2] + O_2 \xrightarrow{350\,°C} 2Pb_3O_4 + 3CO_2 + 3H_2O$$

In a combined form, the reaction can be shown as below :

$$3Pb_2CO_3(OH)_2 + O_2 \xrightarrow{350\,°C} 2Pb_3O_4 + 3CO_2 + 3H_2O$$

In this context, remember that when an oxide where Pb is at its higher oxidation state is heated, it gets down to its lower oxidation state.

$$2Pb_3O_4 \xrightarrow{\Delta} 6PbO + O_2$$

$$2PbO_2 \xrightarrow{\Delta} 2PbO + O_2$$

Ammonium carbonate on heating as obvious will give NH_3, H_2O and CO_2

$$(NH_4)_2CO_3 \xrightarrow{\Delta} 2NH_3 + H_2O + CO_2$$

Now, coming to bicarbonate salts. For bicarbonates, following general reaction is followed:

$$2HCO_3^- \longrightarrow CO_3^{2-} + H_2O + CO_2$$

So, all bicarbonates on heating decompose and give CO_3^{2-} and CO_2.

$$2NaHCO_3 \xrightarrow{\Delta} Na_2CO_3 + CO_2 + H_2O$$

In this context, do remember that as per thermal stability,

$$\underbrace{LiHCO_3}_{\text{liquid}} < \underbrace{NaHCO_3 < KHCO_3 < RbHCO_3 < CsHCO_3}_{\text{ionic solids}}$$

$$Be(HCO_3)_2 < Mg(HCO_3)_2 < Ca(HCO_3)_2 < Sr(HCO_3)_2 < Ba(HCO_3)_2$$

All in liquid state due to higher degree of polarisation.

METAL NITRATES

Some good tricks and twists are here. All bivalent metal nitrates decompose in the following manner :

$$2M(NO_3)_2 \longrightarrow 2MO + 4NO_2 + O_2$$

$$\begin{matrix} M \cdot NO_2 \cdot O \cdot NO_2 \cdot O \\ M \cdot NO_2 \cdot O \cdot NO_2 \cdot O \end{matrix}$$

This is an illustration of complete decomposition. But, as you know it is always very tough to decompose alkali metal products. So, for alkali metal nitrates, decomposition at first will be half way :

$$\underset{(M' = \text{alkali metal})}{M'NO_3} \xrightarrow{\Delta} \underset{\text{(nitrite)}}{M'NO_2} + \frac{1}{2}O_2$$

On applying more heat, nitrites will further decompose as below :

$$2M'NO_2 \xrightarrow{\Delta} M'_2O + N_2 + \frac{3}{2}O_2$$

e.g., $2NaNO_3 \xrightarrow{\Delta} 2NaNO_2 + O_2$

$$2NaNO_2 \xrightarrow{\Delta} Na_2O + N_2 + \frac{3}{2}O_2$$

[**Shortcut:** Why on heating alkali metal nitrites we do not get any oxide of nitrogen like NO, NO_2, N_2O, etc ?
Ans.: *Arunava Sarkar's Shortcut*]

$NaN^{+3}O_2^{-2}$ O_2 production is inevitable due to bond cleavage.

$$[O \text{---} N \text{---} O]^{-1}$$

So for oxygen, change is from –2 to 0. So for nitrogen, oxidation number can't increase. So, NO_2 is ruled out. Now look at three oxygen atoms :

$$\begin{matrix} Na \cdot NO \cdot O \\ Na \cdot NO \cdot O \end{matrix}$$

As per the structure of nitrite ion, oxygen atoms are equivalent. So, disparity is ruled out here. All oxygen atoms will be going together. [Moreover, NO was not possible. Because the minimum decrease should be 2 units for nitrogen and there is 2 units increase in oxygen $\rightarrow$ a shortcut]. So, only possibility was for N_2O but that is too ruled out.

Solution Senders of Chemistry Musing

Set - 47

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Set - 46

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