The name of the 25th element comes from the Latin magnes, meaning magnet. It was discovered in 1774 by Scheele and isolated later that year by Johan Gahn. Manganese is one of the few elements that humans use on a daily basis. In 1774, a Swedish scientist named Johann Gottlieb Gahn was able to isolate manganese metal by reducing the compound of manganese dioxide. Remarkably enough, manganese has been used by humans throughout the centuries.

Introduction

In pure form Manganese is a hard, brittle, gray-white metal. It is best known as an alloying agent in steel. It enhances the ability to hot-work steel and increases resistance to impact. The Roman empire used manganese in their weapons and they were able to defeat their enemies. The hardness property of manganese helped them to create strong equipment for war. Furthermore, humans have been using manganese compounds centuries before human civilization began. The history of Manganese usage traces back to the stone age era, where nomads used it as a pigment to decorate their caves and sacred places. Manganese is an element that has helped and still helps humans to improve their personal lives in various ways.

History of Manganese

- 1771-Manganese recognized as an element by Swedish chemist Scheele
- 1774-First isolated by J.G. Gahn.
- 1799-patents granted in U.K. for using manganese in steelmaking
- 1808-Patents granted in U.k. for using manganese in steelmaking
- 1816-A German researcher observed that manganese increased the hardness of iron, without reducing its malleability or toughness.
- 1826-Prieger in Germany produced a ferromanganese containing 80% manganese in a crucible.
- 1841-Industrial-scale production of "spiegeleisen", a pig-iron containing a high percentage of manganese began.
- 1875-Commercial production of ferromanganese with a 65% manganese content. started
- 1860-Beginning of modern steel industry.
- 1868-Invention of dry cell using manganese dioxide

Where does it come from?

One may think of Manganese as initially being in metal form, however this is not the case. Manganese is not found in nature as the free metal we like to think of. Instead Manganese exists as minerals with the additions of oxides, silicates and carbonates added to the mix. Most Maganese is obtained from ores found in locations all over the world. Manganese is also known to to lie on the ocean floor in the form of nodules, which are large lumps of metallic ores.
Physical Properties

The atomic structure of Manganese includes four electron subshells.

- First subshell contains 2 electrons
- Second subshell contains 8 electrons
- Third subshell contains 13 electrons
- Four subshell contains 2 electrons

More properties of Manganese:

<table>
<thead>
<tr>
<th>Symbol:</th>
<th>Mn</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atomic Number:</td>
<td>25</td>
</tr>
<tr>
<td>Mass Number:</td>
<td>54.93805 amu</td>
</tr>
<tr>
<td>Electron Configuration:</td>
<td>[Ar]3d⁶4s²</td>
</tr>
<tr>
<td>Ionization Energy:</td>
<td>First: 717</td>
</tr>
<tr>
<td></td>
<td>Second: 1509</td>
</tr>
<tr>
<td></td>
<td>Third: 3248</td>
</tr>
<tr>
<td>Common Oxidation States:</td>
<td>+2, +3, +4, +7</td>
</tr>
<tr>
<td>Melting Point:</td>
<td>1245 C</td>
</tr>
<tr>
<td>Boiling Point</td>
<td>1862 C</td>
</tr>
</tbody>
</table>
Reactions of Manganese in the world around us

Manganese is very chemically active and it has the ability to react with various elements in chemistry which we see on a day to day basis that allow for its diversity in function and uses. Because of its valence electron configuration, it allows us to use it in different and unique ways that typically other elements cannot be used in. In biological systems manganese is a crucial component of vitamin \(B_{11}\).

The pure metal is produced from its most common compound (\(MnO_2\)--10\(^{th}\) most abundant compound in the earth's crust). It can be reduced chemically or refined electrolytically. The element has at least 5 stable oxidation states with distinctive colors (as is typical of transition metals). It is commonly encountered in the laboratory as the compound \(KMnO_4\) which is a strong oxidizing agent. \(MnO_2\) catalyzes the decomposition of \(H_2O_2\) and is sometimes used for the small scale production of oxygen gas in the lab.

Manganese and Air

By its location on the periodic table, Manganese is a little less electronegative than its neighbors which makes it a little less reactive to air. Manganese metal has the ability to burn in the presence of oxygen to form Mn\(_3\)O\(_4\).

\[
\ce{3Mn(s) + 2O2(g) \rightarrow Mn_3O_4(s)}
\]

Manganese and Nitrogen

Manganese can react in the presence of nitrogen, which is also found in the air, to form \(Mn_3N_2\).

\[
\ce{3Mn(s) + N2(g) \rightarrow Mn3N2(s)}
\]

Manganese and Water

When everything is considered under normal conditions, Manganese is not reactive with water

Manganese and Acids

Manganese dissolves readily in acidic solutions

Manganese and Halogens

Manganese reacts with the halogens of group 17 to form Manganese (II) halides. An example would be if manganese reacted with chlorine, manganese (II) chloride would form. A few example reactions are shown below, but reactions with other halogens such as with fluorine are similar.
\[ \text{Mn(s)} + \text{Cl}_2(g) \rightarrow \text{MnCl}_2(s) \]  
\[ \text{Mn(s)} + \text{Br}_2(g) \rightarrow \text{MnBr}_2(s) \]  
\[ \text{Mn(s)} + \text{I}_2(g) \rightarrow \text{MnI}_2(s) \]  

### Nuclear chemistry of Manganese

Just like many other elements in the periodic table, specifically metals, manganese is also able to form isotopes. More isotopes than the ones listed exist. However those not shown in the table are isotopes whose half-life occur to quickly to be easily found.

<table>
<thead>
<tr>
<th>Isotope</th>
<th>Half-life</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mn51</td>
<td>46.2 min</td>
</tr>
<tr>
<td>Mn52</td>
<td>5.591 days</td>
</tr>
<tr>
<td>Mn53</td>
<td>370,000 years</td>
</tr>
<tr>
<td>Mn54</td>
<td>312.3 days</td>
</tr>
<tr>
<td>Mn55</td>
<td>stable</td>
</tr>
<tr>
<td>Mn56</td>
<td>2.57</td>
</tr>
<tr>
<td>Mn57</td>
<td>1.45 min</td>
</tr>
</tbody>
</table>

### Uses of Manganese in our world today

#### Health and biology

The use of manganese in the personal health of humans and in medicine today is still as important as ever. Although many people may be wary of the importance to consume important minerals along with vitamins, many are not too familiar with the importance of the consumption of Manganese in the human diet. The existence of Manganese in the body is vital to processes on the cellular level. Without it, enzymes that are vital to life are disrupted and can cause complications in health. For example, manganese aids in the formation of connective tissue in our bodies, without it or with minimal amounts, ligaments and muscles for example are less flexible and injuries can occur more readily. However, if too much manganese is consumed then health problems such as weakness, drowsiness and even paralysis may occur. Luckily, consuming too much manganese is very rare and usually occurs to those working in mines or factories that may inhale manganese dust.
Industry and technology

The presence of Manganese in industries such as the steel industry is crucial to the success of this industry in specific. If we look back to the history of manganese presented in the beginning of this module, we can see that the use of Manganese in steel is not something recent but something from the late 1700’s. Nevertheless it is still a method used today for its effects on the quality and properties of steel. Manganese is used to form an alloy in the steel which in turn results in better properties such as toughness, stiffness, wear resistance, hardness and most important strength. Manganese also helps improve the rolling and forging qualities of steel. Manganese is also responsible for coloring glass a shade of purple and can also be used in industries where glass impurities evolve due to iron impurities as Manganese can return the glass back to its normal color.

In technology, although not modern technology and as was done in 1868, Manganese is used in the invention of dry cells. It is the dioxide formed by Manganese that is used to depolarize.

Problems

1. Write out the chemical reaction between manganese and the halogen fluorine.
2. How reactive is manganese with water?
3. What is one of manganese’s main uses in technology?
4. What is the electron configuration of manganese?
5. What oxidation states can manganese take?

Answers

1. \( \text{Mn}(s) + \text{F}_2(g) \rightarrow \text{MnF}_2(s) \)
2. Manganese is not reactive with water under normal circumstances.
3. Manganese is known for its use in the steel industry. It is used to enhance the properties of steel to make alloys that are stronger and tougher.
4. [Ar]\(^5d^54s^2\)
5. +2, +3, +4, +5, +6, +7

References


Contributors

- Marisol Ahumada & Abel Silva
• David Jin (UCD)