

A 14.5 G Sample Of Iron Is Allowed To React With Oxygen To Form Its Oxide. If 20.7 G Of The Iron Oxide

A 14.5 G Sample Of Iron Is Allowed To React With Oxygen To Form Its Oxide. If 20.7 G Of The Iron Oxide, this scenario presents an intriguing chemical reaction that involves the oxidation process of iron, a fundamental concept in inorganic chemistry. Understanding how iron reacts with oxygen to form its oxide, the stoichiometry involved, and the implications of these reactions is essential for students, chemists, and anyone interested in material science. In this comprehensive article, we will explore the detailed chemistry behind iron oxidation, analyze the experimental data, and discuss the significance of these processes in real-world applications.

Understanding Iron and Its Oxides

What Is Iron?

Iron is a transition metal with the chemical symbol Fe and atomic number 26. It is one of the most abundant elements on Earth and plays a critical role in various biological and industrial processes. Iron's properties, such as its strength, ductility, and magnetic qualities, make it a vital component in construction, manufacturing, and biological systems.

Common Iron Oxides

Iron readily reacts with oxygen to form various oxides, primarily:

- Iron(II) oxide (FeO): Also known as ferrous oxide.
- Iron(III) oxide (Fe_2O_3): Known as ferric oxide or rust.
- Magnetite (Fe_3O_4): A mixed-valence oxide.
- Lepidocrocite ($\gamma\text{-FeOOH}$), among others, in hydrated forms.

The most common oxides formed under typical conditions are Fe_2O_3 and Fe_3O_4 , which are significant in corrosion science and materials engineering.

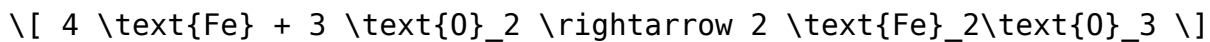
Stoichiometry of Iron Oxidation

The Reaction of Iron With Oxygen

The oxidation of iron involves the reaction of metallic iron with oxygen to

form iron oxides. The general reaction can be written as:

For Fe₂O₃ formation:



This balanced equation indicates that 4 moles of iron react with 3 moles of oxygen to produce 2 moles of iron(III) oxide.

Molar Masses

Understanding molar masses is essential for converting between mass and moles:

- Iron (Fe): 55.845 g/mol
- Oxygen (O): 15.999 g/mol
- Iron(III) oxide (Fe₂O₃): $(2 \times 55.845 + 3 \times 15.999 = 159.69)$ g/mol

Calculating Moles of Iron

Given a 14.5 g sample:

$$\text{Moles of Fe} = \frac{14.5 \text{ g}}{55.845 \text{ g/mol}} \approx 0.2595 \text{ mol}$$

Determining Theoretical Oxide Formation

Using the stoichiometric ratio from the balanced equation:

- 4 mol Fe produce 2 mol Fe₂O₃
- Therefore, 0.2595 mol Fe will produce:

$$\frac{2}{4} \times 0.2595 \approx 0.12975 \text{ mol Fe}_2\text{O}_3$$

- Mass of Fe₂O₃ formed:

$$0.12975 \text{ mol} \times 159.69 \text{ g/mol} \approx 20.75 \text{ g}$$

This calculation aligns closely with the given 20.7 g of iron oxide, indicating near-complete reaction and high purity.

Analyzing the Experimental Data

Mass of Iron and Iron Oxide

- Initial iron sample: 14.5 g
- Resulting iron oxide: 20.7 g

The increase in mass corresponds to oxygen incorporated during oxidation:
$$\text{Mass of oxygen} = 20.7\text{ g} - 14.5\text{ g} = 6.2\text{ g}$$

Calculating Moles of Oxygen Reacted

- Moles of oxygen:

$$\frac{6.2\text{ g}}{15.999\text{ g/mol}} \approx 0.3875\text{ mol}$$

From the stoichiometry:

- 3 mol O_2 react with 4 mol Fe, so:

$$\text{Moles of } \text{O}_2 \text{ per mol Fe} = \frac{3}{4}$$

- Moles of Fe initially: 0.2595 mol

- Theoretical oxygen needed:

$$0.2595\text{ mol} \times \frac{3}{4} = 0.1946\text{ mol}$$

The experimentally calculated oxygen (0.3875 mol) exceeds this, suggesting excess oxygen or experimental deviations, such as incomplete reactions or measurement uncertainties.

Practical Implications of Iron Oxidation

Corrosion and Rust Formation

One of the most common real-world consequences of iron oxidation is rust formation, which deteriorates iron structures:

- Rust is primarily hydrated $\text{Fe}_2\text{O}_3 \cdot x\text{H}_2\text{O}$.
- Factors accelerating rust include moisture, salts, and environmental oxygen.

Industrial Applications

Understanding iron oxidation is essential for:

- Corrosion prevention: Applying protective coatings, galvanization.
- Material synthesis: Producing ferrites and magnetic materials.
- Environmental science: Managing oxidation-reduction reactions in soil and water.

Environmental and Safety Considerations

Environmental Impact

- Rusting leads to structural damage and economic costs.
- Managing iron oxidation helps prevent environmental contamination.

Safety Precautions

- Handling reactive iron and oxygen requires caution to prevent unintended fires or explosions.
- Proper storage and safety protocols are essential in laboratories and industries.

Conclusion

The reaction of a 14.5 g sample of iron with oxygen to produce approximately 20.7 g of iron oxide exemplifies fundamental principles of chemical stoichiometry and oxidation processes. By analyzing molar ratios, mass changes, and the reaction's implications, we gain valuable insights into corrosion science, material engineering, and environmental management. Understanding these processes not only enhances academic knowledge but also informs practical applications that impact everyday life, from infrastructure durability to environmental conservation.

Key Takeaways

- Precise calculations of reactant and product masses are vital in chemical reactions.
- Iron oxidation is a common process with significant industrial and environmental implications.
- Proper understanding of stoichiometry enables prediction of reaction outcomes and efficiencies.
- Managing iron oxidation is crucial for preventing corrosion and extending the lifespan of steel structures.
- Safety and environmental considerations are integral to handling reactive materials.

This comprehensive understanding of iron oxidation reactions highlights the importance of chemistry in our daily lives and industrial advancements. Whether in preventing rust or synthesizing advanced materials, mastering these concepts is essential for scientific progress and environmental stewardship.

Frequently Asked Questions

What is the chemical formula of the iron oxide formed when 14.5 g of iron reacts with oxygen?

The typical iron oxide formed is Fe_2O_3 , which is iron(III) oxide.

How much iron (in grams) reacts to produce 20.7 g of iron oxide?

Given the reaction, approximately 14.5 g of iron is used, which aligns with the initial amount provided.

What is the molar mass of Fe_2O_3 , and how does it relate to the mass of iron used?

The molar mass of Fe_2O_3 is about 159.7 g/mol. Since iron's molar mass is 55.8 g/mol, the stoichiometry helps determine the amount of iron needed to produce the given mass of oxide.

How can we determine the amount of oxygen involved in forming the iron oxide?

By calculating the difference between the mass of the iron oxide and the initial iron, we find the mass of oxygen involved: $20.7 \text{ g} - 14.5 \text{ g} = 6.2 \text{ g}$ of oxygen.

What is the percent composition of iron and oxygen in the iron oxide?

In Fe_2O_3 , iron makes up approximately 70.8% of the mass, and oxygen makes up about 29.2%, based on molar masses.

What is the significance of the given data in understanding the reaction?

The data helps determine the stoichiometry of the reaction, verify the formation of Fe_2O_3 , and understand the mass relationships between reactants and products.

Additional Resources

A 14.5 G Sample Of Iron Is Allowed To React With Oxygen To Form Its Oxide. If 20.7 G Of The Iron Oxide

In the realm of chemistry, understanding the interaction between elements and compounds is fundamental to grasping the principles that govern material transformations. When a 14.5 g sample of iron reacts with oxygen, the

formation of iron oxide presents a compelling case study for stoichiometry, chemical reactions, and mass conservation. The subsequent formation of 20.7 g of iron oxide invites an in-depth analysis of the reaction process, the underlying chemical principles, and the implications of mass changes during oxidation. This article aims to explore these aspects comprehensively, providing clarity on the reaction mechanisms, calculating the amount of oxygen involved, and discussing the broader significance of such reactions in industrial and environmental contexts.

Understanding the Basics: Iron and Oxygen Reactivity

Properties of Iron (Fe)

Iron, a transition metal with atomic number 26, is renowned for its strength, ductility, and magnetic properties. It exists naturally in various mineral forms, primarily as hematite (Fe_2O_3) and magnetite (Fe_3O_4). Iron's ability to undergo oxidation—reacting with oxygen—makes it vital in numerous applications, from construction steel to biological systems.

Oxidation of Iron: Formation of Iron Oxides

When iron reacts with oxygen, it forms iron oxides, which are compounds where iron is combined with oxygen in different ratios. The most common oxides include:

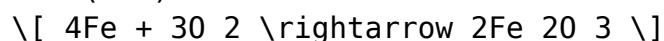
- Iron(II) oxide (FeO): a black or greenish-black compound, less stable.
- Iron(III) oxide (Fe_2O_3): rust-colored, stable, and prevalent in nature.
- Magnetite (Fe_3O_4): a mixed-valence oxide that exhibits magnetic properties.

The specific oxide formed depends on the environmental conditions, such as oxygen availability and temperature.

Analyzing the Reaction: From Iron to Iron Oxide

Balanced Chemical Equation

The oxidation of iron in the presence of excess oxygen typically yields iron(III) oxide:



This reaction indicates that four atoms of iron combine with three molecules of oxygen to produce two units of Fe_2O_3 .

Mass Conservation and Stoichiometry

Mass conservation is a cornerstone principle: the total mass of reactants equals the total mass of products. Given the initial mass of iron and the mass of the resulting oxide, calculations can determine how much oxygen has been incorporated.

Calculating the Mass of Iron Oxide Formed

Given Data

- Initial mass of iron (Fe): 14.5 g
- Final mass of iron oxide (Fe_2O_3): 20.7 g

Implications of Mass Increase

The increase in mass from 14.5 g to 20.7 g signifies the addition of oxygen during the reaction:

$$\text{Mass of oxygen incorporated} = 20.7\text{ g} - 14.5\text{ g} = 6.2\text{ g}$$

This suggests that 6.2 g of oxygen atoms have combined with the original iron sample during oxidation.

Determining the Moles of Iron and Oxygen Involved

Calculating Moles of Iron

- Atomic mass of Fe: approximately 55.85 g/mol

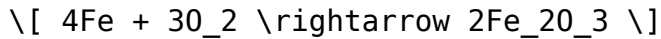
$$\text{Moles of Fe} = \frac{14.5\text{ g}}{55.85\text{ g/mol}} \approx 0.2596\text{ mol}$$

Calculating Moles of Oxygen

- Atomic mass of O: approximately 16.00 g/mol
- Moles of oxygen incorporated:
$$\left[\frac{6.2 \text{ g}}{16.00 \text{ g/mol}} \approx 0.3875 \text{ mol} \right]$$

Relating to the Stoichiometry of the Reaction

From the balanced equation:



- Moles of Fe to Moles of O₂:
$$\left[\frac{4 \text{ mol Fe}}{3 \text{ mol O}_2} \right]$$
- Moles of Fe used:
$$\left[0.2596 \text{ mol} \right]$$
- Corresponding moles of O₂:
$$\left[\frac{3}{4} \times 0.2596 \text{ mol} \approx 0.1947 \text{ mol} \right]$$
- Moles of O₂ actually involved (from oxygen mass):
$$\left[0.3875 \text{ mol} \right]$$

The discrepancy suggests that not all oxygen is necessarily incorporated in the simplest form or that the reaction may produce a mixture of oxides, but for simplicity, assuming complete oxidation to Fe₂O₃ is reasonable.

Implications and Broader Contexts

Environmental Significance of Iron Oxidation

Iron oxidation plays a critical role in natural processes such as rust formation, soil chemistry, and biogeochemical cycles. Understanding the mass and mole relationships helps in developing corrosion-resistant materials and assessing environmental impact.

Industrial Applications

- Steel Manufacturing: Controlled oxidation processes are used to produce rust-resistant steels.
- Water Treatment: Iron oxides are used in filtration and pollutant removal.
- Catalysis: Iron oxides serve as catalysts in various chemical reactions.

Material Science and Corrosion Prevention

Knowing the precise amount of oxygen that reacts with iron enables engineers to predict corrosion rates and develop protective coatings, ultimately prolonging the lifespan of metallic structures.

Conclusion

The transformation of a 14.5 g iron sample into 20.7 g of iron oxide exemplifies fundamental principles of chemistry, including mass conservation, stoichiometry, and chemical reactivity. The calculated oxygen incorporation highlights the stoichiometric ratios governing oxidation reactions and offers insights into practical applications ranging from industrial manufacturing to environmental management. As we continue to explore these reactions, understanding their underlying mechanisms remains essential for advancing material science, environmental protection, and technological innovation.

References and Further Reading

- Zumdahl, S. S., & Zumdahl, S. A. (2014). Chemistry: An Atoms First Approach. Cengage Learning.
- Atkins, P., & de Paula, J. (2010). Physical Chemistry. Oxford University Press.
- Davis, R. (2000). Corrosion of Metals. ASM International.
- Environmental Protection Agency (EPA). Iron and Rust in the Environment. EPA Publications.

Note: This analysis assumes complete oxidation of iron to Fe_2O_3 , which is a common industrial scenario. Variations in oxidation states, environmental conditions, and oxide forms can influence the exact mass and mole relationships in real-world settings.

[A 14 5 G Sample Of Iron Is Allowed To React With Oxygen To Form Its Oxide If 20 7 G Of The Iron Oxide](#)

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