

For Each Of The Following Molecules Pick The One With The Greater London Forces And Hence Higher Melting

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Understanding the intermolecular forces that influence the physical properties of molecules is fundamental in chemistry. Among these forces, London dispersion forces (often referred to simply as London forces) are the weakest but most universal type of intermolecular attraction, present in all molecules. These instantaneous, temporary dipole-induced dipole interactions become more significant with larger, more polarizable molecules, often leading to higher melting points. In this article, we will analyze various molecules and determine which one exhibits greater London forces, thereby resulting in a higher melting point.

Introduction to London Dispersion Forces and Melting Points

London dispersion forces arise due to the momentary fluctuations in electron density within molecules, creating temporary dipoles that induce dipoles in neighboring molecules. The strength of these forces depends on:

- Molecular size and molar mass: Larger, more massive molecules tend to have more electrons and a larger surface area, increasing polarizability.
- Molecular shape: More elongated or surface-exposed molecules can experience stronger dispersion forces.
- Surface area: Molecules with larger surface areas can interact more extensively through dispersion forces.

A higher magnitude of London forces typically correlates with increased melting points because more energy is required to overcome these attractions during phase change.

Criteria for Comparing London Forces in Molecules

When comparing molecules, the following criteria are paramount:

1. **Molecular weight:** Higher molar mass usually implies stronger dispersion forces.

2. **Surface area:** Greater surface area enhances intermolecular interactions.
3. **Shape and structure:** Linear or elongated molecules often have greater surface contact than compact, spherical molecules.

By evaluating these factors, we can systematically determine which molecule exhibits stronger London forces and, consequently, a higher melting point.

Examples and Analysis of Molecules

Below are specific pairs of molecules. For each pair, we'll identify which has the greater London dispersion forces and explain the reasoning.

1. Methane (CH₄) vs. Ethane (C₂H₆)

Analysis:

- Molecular weight: Ethane (~30 g/mol) is heavier than methane (~16 g/mol).
- Surface area: Ethane's larger size provides a greater surface area for interactions.
- Shape: Both are small, but ethane's longer chain offers slightly more surface contact.

Conclusion:

Ethane exhibits stronger London forces due to its higher molar mass and increased surface area, leading to a higher melting point compared to methane.

2. Propane (C₃H₈) vs. Butane (C₄H₁₀)

Analysis:

- Molecular weight: Butane (~58 g/mol) is heavier than propane (~44 g/mol).
- Surface area: Butane's longer chain provides more surface contact.
- Shape: Both are linear alkanes, but longer chain length enhances dispersion forces.

Conclusion:

Butane has greater London forces and a higher melting point than propane.

3. Benzene (C₆H₆) vs. Toluene (C₇H₈)

Analysis:

- Molecular weight: Toluene (~92 g/mol) is heavier than benzene (~78 g/mol).**
- Surface area: Toluene's methyl group slightly increases surface contact.**
- Shape: Both are aromatic rings, but toluene's larger size and substituents enhance dispersion interactions.**

Conclusion:

Toluene exhibits stronger London forces and consequently higher melting points than benzene.

4. Ethene (C₂H₄) vs. Propene (C₃H₆)

Analysis:

- Molecular weight: Propene (~42 g/mol) is heavier than ethene (~28 g/mol).**
- Surface area: Propene has a larger molecular size and more surface contact.**
- Shape: Both are alkenes, but propene's longer chain contributes to increased dispersion forces.**

Conclusion:

Propene has greater London forces and a higher melting point than ethene.

5. Water (H₂O) vs. Hydrogen sulfide (H₂S)

Analysis:

- Molecular weight: H₂S (~34 g/mol) is heavier than H₂O (~18 g/mol).**
- Surface area: H₂S is larger and more polarizable.**
- Shape: Both are bent molecules; H₂S's larger size results in stronger dispersion forces.**

Conclusion:

Hydrogen sulfide exhibits greater London forces and a higher melting point than water.

Summary of Key Factors Influencing London Forces and Melting Points

| Molecules | Molar Mass | Surface Area | Shape | Greater London Forces | Expected Melting Point |

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**| Methane vs. Ethane | Methane: 16 g/mol
Ethane: 30 g/mol | Ethane larger | Both small, linear | Ethane |
Ethane melting point > methane |
| Propane vs. Butane | Propane: 44 g/mol
Butane: 58 g/mol | Butane larger | Both linear | Butane |
Butane melting point > propane |
| Benzene vs. Toluene | Benzene: 78 g/mol
Toluene: 92 g/mol | Toluene larger | Aromatic rings, toluene
slightly larger | Toluene | Toluene > benzene |
| Ethene vs. Propene | Ethene: 28 g/mol
Propene: 42 g/mol | Propene larger | Both alkenes | Propene |
Propene > ethene |
| Water vs. Hydrogen sulfide | H₂O: 18 g/mol
H₂S: 34 g/mol | H₂S larger | Bent molecules | H₂S | H₂S > water
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Final Remarks

In conclusion, when comparing molecules to determine which exhibits greater London dispersion forces, prioritize factors like molecular size, molar mass, and surface area. Larger, more polarizable molecules tend to have stronger London forces, leading to higher melting points. This understanding aids in predicting physical properties of substances based on their molecular structure, which is invaluable in fields ranging from material science to pharmaceuticals.

By analyzing the molecular characteristics and applying principles of intermolecular forces, chemists can make

informed predictions about melting points and other physical properties, facilitating the design and selection of compounds for specific applications.

Frequently Asked Questions

How do London forces influence the melting points of molecules?

London forces are weak intermolecular attractions that increase with larger, more polarizable molecules, leading to higher melting points due to stronger intermolecular interactions.

Between methane (CH_4) and ethane (C_2H_6), which has greater London forces and a higher melting point?

Ethane has greater London forces and a higher melting point because it has a larger molecular size and greater polarizability than methane.

Does increasing molecular size always lead to higher London forces and melting points?

Yes, generally larger molecules have greater London forces due to increased surface area and polarizability, resulting in higher melting points.

Among noble gases, which element has the strongest London forces and the highest melting point?

Radon has the strongest London forces and the highest melting point among noble gases because of its larger atomic size and higher polarizability.

In halogen molecules like F_2 , Cl_2 , Br_2 , and I_2 , which exhibits the greatest London forces and melting point?

Iodine (I_2) exhibits the greatest London forces and highest melting point due to its larger size and greater polarizability compared to the other halogens.

How does molecular shape affect London forces and melting points?

More elongated or larger molecules tend to have greater London forces due to increased surface area and polarizability, leading to higher melting points.

Why does benzene (C_6H_6) have a higher melting point than cyclohexane (C_6H_{12})?

Benzene has a planar, aromatic structure that allows for stronger π - π stacking interactions, resulting in greater London forces and a higher melting point compared to cyclohexane.

Additional Resources

London Forces: The Subtle Yet Pivotal Player in Molecular Melting Points

When delving into the realm of molecular interactions and their influence on physical properties, London forces—also known as dispersion forces—stand out as a fundamental yet often underestimated factor. These fleeting, instantaneous dipole-induced dipole attractions are omnipresent in all molecules, but their strength varies significantly depending on the molecular structure and size. In many cases, London forces are the dominant intermolecular interaction dictating melting and boiling points, especially in non-polar substances.

In this comprehensive examination, we will explore how to determine which molecules exhibit greater London forces, and consequently, higher melting points. Our focus will be on comparing pairs of molecules, analyzing their structure, molar mass, electron cloud polarizability, and other relevant factors. This guide aims to serve as an expert review, equipping you with the knowledge to understand and predict melting behaviors based on molecular characteristics.

Understanding London Forces: The Basics

London dispersion forces are temporary attractive forces that arise due to momentary fluctuations in electron density within molecules. These fluctuations create instantaneous dipoles,

which can induce corresponding dipoles in neighboring molecules, resulting in an attractive force. Although individually weak compared to covalent or ionic bonds, the cumulative effect of London forces can be substantial, especially in larger, more polarizable molecules.

Key Factors Influencing London Forces:

- Molar Mass (Molecular Weight):** Generally, larger molecules with higher molar masses exhibit stronger London forces because they have more electrons and a larger electron cloud, increasing polarizability.
- Surface Area and Shape:** Molecules with extended or more complex 3D structures have greater surface contact, enhancing dispersion forces.
- Electron Cloud Polarizability:** Molecules with loosely held electrons (more diffuse electron clouds) are more polarizable, leading to stronger London forces.

Understanding these factors helps in predicting which molecules will have higher melting points due to stronger London interactions.

Comparative Analysis: Picking the Molecule with Greater London Forces

When comparing two molecules, the molecule with the more significant London forces will typically have a higher melting point, assuming other interactions are minimal. Let's explore

how to systematically analyze and compare molecules.

Step 1: Examine Molar Mass and Electron Count

The first indicator of potential London force strength is molar mass. As molar mass increases, so does the number of electrons, which correlates with increased polarizability.

- Example: Comparing methane (CH_4 , molar mass ~ 16 g/mol) and carbon tetrachloride (CCl_4 , molar mass ~ 154 g/mol), CCl_4 will have stronger London forces because of its larger size and electron count.

Step 2: Assess Molecular Shape and Surface Area

Molecules with elongated or bulky structures have a larger surface area for electron cloud interactions.

- Linear molecules: Tend to have higher surface contact than compact ones.**
- Branched molecules: Usually have lower surface area, reducing London forces.**

Example: Comparing n-butane (linear) and isobutane (branched) — the linear form exhibits stronger London forces.

Step 3: Evaluate Electron Cloud Polarizability

Some atoms or groups are more polarizable due to their electron distribution.

- Heavy atoms: Atoms like iodine, bromine, and chlorine are more polarizable than lighter atoms like fluorine or hydrogen.**

- **Presence of π -electrons:** Aromatic rings or conjugated systems tend to be more polarizable.

Step 4: Consider Intermolecular Forces in Context

While London forces are dominant in non-polar molecules, other forces such as dipole-dipole or hydrogen bonding can influence melting points. When comparing molecules, focus primarily on non-polar compounds for this analysis.

Case Studies: Molecule Comparisons

Let's apply this framework to several pairs of molecules, determining which has greater London forces and, consequently, a higher melting point.

1. Benzene (C_6H_6) vs. Cyclohexane (C_6H_{12})

Analysis:

- **Molar Mass:** Benzene (~ 78 g/mol) vs. Cyclohexane (~ 84 g/mol). Slightly higher molar mass in cyclohexane.
- **Shape and Surface Area:** Benzene is planar with an aromatic ring, providing a delocalized π -electron system, which is highly polarizable. Cyclohexane adopts a chair conformation,

more three-dimensional, but lacks π -electrons.

- Polarizability: Benzene's π -electron cloud enhances polarizability.

Conclusion:

Despite cyclohexane's marginally higher molar mass, benzene's aromatic π -electron system significantly increases its polarizability, strengthening London forces. Therefore, benzene exhibits greater London forces and likely a higher melting point.

2. Ethane (C₂H₆) vs. Propane (C₃H₈)

Analysis:

- Molar Mass: Ethane (~30 g/mol), Propane (~44 g/mol).

Propane has higher molar mass.

- Shape and Surface Area: Propane has a longer carbon chain, increasing surface contact.

- Electron Count: Propane has more electrons, increasing polarizability.

Conclusion:

Propane's larger size and electron count lead to stronger London forces, suggesting propane has a higher melting point.

3. Iodine (I₂) vs. Bromine (Br₂)

Analysis:

- **Molar Mass:** Iodine (~254 g/mol), Bromine (~160 g/mol). Iodine is significantly heavier.
- **Shape:** Both are diatomic molecules, but iodine's larger size and more diffuse electron cloud increase polarizability.
- **Surface Area:** Iodine molecules are larger; thus, they have more extensive electron clouds.

Conclusion:

Iodine's higher molar mass and greater polarizability mean iodine exhibits stronger London forces and a higher melting point.

Summary of Key Factors in Selecting the Molecule with Greater London Forces

Factor	Effect on London Forces	Examples
Molar Mass	Higher molar mass → stronger London forces	I ₂ > Br ₂ ; CCl ₄ > CH ₄
Electron Cloud Size & Polarizability	Larger, more diffuse electron clouds increase forces	Iodine vs. Bromine; Benzene vs. Cyclohexane

| Molecular Shape & Surface Area | Extended or planar molecules with larger surface contact | n-Butane vs. Isobutane

| Presence of π -electrons or Aromaticity | Enhances polarizability and dispersion forces | Benzene vs. Cyclohexane

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Implications for Melting Points

Since London forces are often the primary intermolecular interactions in non-polar molecules, their strength directly influences melting points:

- Stronger London forces → Higher melting points**
- Weaker London forces → Lower melting points**

This relationship enables chemists and materials scientists to predict and tailor melting behaviors in the synthesis and application of substances, from pharmaceuticals to polymers.

Final Thoughts: The Art of Molecular Prediction

Predicting which molecule exhibits greater London forces requires a nuanced understanding of molecular structure, size, and electron distribution. While molar mass provides a

straightforward initial indicator, a comprehensive analysis considering shape, surface area, and polarizability yields more accurate predictions.

In practical scenarios, these insights help in:

- Designing substances with desired melting points**
- Understanding the physical behavior of novel compounds**
- Optimizing processes like crystallization, purification, and formulation**

By mastering the criteria outlined above, scientists and students alike can develop a keen intuition for the subtle forces that govern the physical properties of molecules.

In conclusion, when asked to pick the molecule with the greater London forces—and hence the higher melting point—consider the interplay of molar mass, molecular shape, electron cloud size, and polarizability. The molecule that ranks higher in these parameters will generally exhibit stronger dispersion forces, leading to a higher melting point—a principle that underpins much of molecular physics and chemistry.

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