Is Selenium a metal, non-metal or metalloid?

Abstract

Is selenium(Se) a metal, non-metal, or a metalloid? There are various public opinions circulating around it. Since a long time from now, there are a lot of voices discussing this. Even until now, there is still no consensus about it. So, in this project, we are trying to find out whether selenium is a non-metal, metal or metalloids base on its physical and chemical properties which could be studied in the secondary school combining with the other information from the internet.

Principles and hypothesis

Studied from the secondary school chemistry, the general properties of metals include being good conductors of heat and electricity, having high melting and boiling points. Non-metals generally have a lower melting point and boiling point than metals and they being poor conductors of heat and electricity, etc. And the physical properties of metalloids are having extremely high melting/ boiling point, and having fair electrical conductivity.

On the other hand, the oxides of metal are generally basic whereas the oxide of non-metals and metalloids are generally acidic. We will define selenium's chemical category based on the above properties.

Besides, we would like to introduce the concept of displacement reaction in studying the chemical properties of the chalcogens(e.g. sulphur(S) and selenium(Se)), especially selenium such rarely mentioned element. We can assume selenium is a metal if selenium could displace a metal oxide or a metal could displace selenium (IV) oxide. If selenium is a non-metal, its oxide could be displaced by sulphur which is supposed to be more reactive than selenium in the chalcogen group. Like halogens, chalcogens are a group of non-metals(mostly). As the reactivity of halogens decreases down the group, We suppose chalcogens will show the similar trends of the reactivity.

Results

- Displacement reaction involving chalcogens and their oxides

When selenium (IV) oxide was mixed and heated with sulphur, the yellow fume produced can turn moist blue litmus paper red. This may be probably due to the presence of acidic sulphur dioxide produced. However, some of the pink fumes condense to form shiny grey solid which is believed to be selenium. This shows that sulphur can displace selenium from its compound. The related chemical equation of the displacement reaction is believed as:

$$S(s) + SeO_2(s) \rightarrow Se(s) + SO_2\ (g)$$

- Physical and chemical properties of chalcogens, metals and metalloids

	Selenium	Sulphur	Metals	Metalloids
m.p./b.p.	220.8℃/ 685℃ (*)	115.2℃/ 444.6℃	High	Very High
Reaction with water	No reaction(*)	No reaction(*)	Forming Bases	Not Found
Reaction with acid	No reaction(*)	No reaction(*)	H_2 Produced	Not Found
Electrical conductivity	Only conducts when molten(*)	Poor(*)	Good	Fair

The melting/ boiling point of selenium is closer to that of sulphur (a non-metal), compared with metals and metalloids. This shows selenium is more likely to be a non-metal, just like sulphur.

Moreover, there is no reaction between selenium and water/acid. This show differences between selenium and metals. Also, the electrical conductivity of selenium differs from metalloids.
This shows selenium is more likely to be a non-metal, just like sulphur.

- Physical and chemical properties of the oxides of chalcogens, metals and metalloids

	Selenium Dioxide SeO_2 (s)	Sulphur Dioxide SO_2 (g)	Metal oxides	Metalloid oxides
m.p./b.p.	Sublimes at 315℃(*)	-72℃ / -10℃	Generally High	Generally high
Acid-base behaviour	Acidic(*)	Acidic	Generally basic	Generally amphoteric

The melting/ boiling point of selenium(IV) oxide is much closer to that of sulphur dioxide(a non-metal oxide), compared with metal oxides and metalloid oxides.
This shows selenium(IV) oxide is more likely to be a non-metal oxide, just like sulphur dioxide.

Besides, selenium(IV) oxide behaves similarly as another non-metal oxide in the same group – sulphur dioxide is acidic. Like sulphur dioxide, selenium(IV) oxide dissolves in water to form selenious acid: $SeO_2 + H_2O \rightarrow H_2SeO_3$
This also shows selenium(IV) oxide is more likely to be a non-metal oxide.

- Physical and chemical properties of chlorides of chalcogens, metals and metalloids

	Selenium tetrachloride $SeCl_4$ (s)	Sulphur dichloride SCl_2 (l)	Metal chlorides	Metalloid chlorides
m.p./b.p.	Sublimes at 191.4℃(*)	-121.0℃/ 59℃	High	Very low
Acid-base behaviour	Acidic(*)	Acidic	Neutral/ acidic	Neutral/ acidic

The melting/ boiling point of selenium(IV) chloride is relatively closer to sulphur dichloride, compared with metal chlorides and metalloid chlorides.
This shows that selenium(IV) chloride is more likely to be non-metal chloride, just like sulphur dichloride.
Furthermore, similar to the results of the oxides, selenium(IV) chloride behaves similarly as another non-metal chloride in the same group- sulphur dichloride which gives acidic properties. Like sulphur dichloride, selenium(IV) chloride reacts with water and form hydrogen chloride gas and selenious acid: $SeCl_4 + 3H_2O \rightarrow 4HCl + H_2SeO_3$
This shows that selenium(IV) chloride is more likely to be non-metal chloride.

Discussions

From the above studies, we concluded that selenium is a non-metal owing to its moderately low melting and boiling points and electrical conductivities, moderately low sublimation point and acidic behaviour of its oxide and chloride, and finally the ability to be displaced by a non-metal rather than a metal which shows its chemical properties closer to those of non-metals.
In fact, there are a lot of limitations and error which causes the study needs a room of improvement. We should involve the oxygen in the comparison of the properties of the chalcogens as well as their oxides and chlorides but gaseous chemicals are difficult to handle in the secondary school laboratory. Some related compounds have very limited information from the internet and hence we did not involve them in this study. Displacement reactions of different metals, non-metals and metalloids related to the study should also be involved but unknown dangers exist especially when more reactive metals are used in the secondary school laboratory. We believe these interesting properties of chalcogens should be further studied for discovering more usages of the chalcogens especially selenium such seldom mentioned element. Nowadays selenium is usually mentioned in the field of its photoelectric properties as a solar cell. We believe defining the chemical category of selenium may influence the use of such materials.