VERIFICATION OF THE EMPIRICAL RELATIONSHIP BETWEEN THE MASS NUMBER AND SOME PHYSICAL PROPERTIES OF HALOGENS

Supported by tetfund

C. E. Mokobia[1]*, O. Edomi[2] and C. A. Oduah[1]
[1]Department of Physics, Delta State University, Abraka, Nigeria
[2]Department of Science and Technology (Physics option), Delta State School of Marine Technology Burutu, Nigeria
*Corresponding author: ovieedomi2@gmail.com

Received: June 16, 2020 **Accepted:** October 12, 2020

Abstract: The halogen and its compounds occupy group VII in the periodic table, and they display an almost perfect gradation in physical properties. The halogens constitute fluorine, chlorine, bromine, iodine and the more recently discovered radioactive element astatine. These halogens are used in the building up of quenching vapours which comprised of different types of detectors, such as the Geiger Muller Counter (GMC) used for measurement of all types of radiation; alpha, beta and gamma radiation. This work verified the relationship between the mass number and some other physical properties of halogens using a scatter graph to show the relationship between mass number against each of the respective halogens. All the properties of the halogens compound verified were obtained from literatures. The results show that the proton number, boiling and melting point, temperature and density at STP each have a linear relationship with the mass number. On the other hand, the heat of fusion shows a logarithmic dependence on the mass number. The obtained results from the verification were tested statistically and found to be reliable and accurate.

Keywords: Geiger Muller counter, halogens, mass number, verification, radiation

Introduction

The element of group VII; fluorine chlorine, bromine, iodine and astatine which is radioactive in nature are known as the halogens. The name was derived from two Greek words meaning “to make salt”. Indeed, all the halogens react with group I metals to make ionic salt, such as sodium chloride NaCl, sodium fluoride NaF, potassium bromide KBr and so on (Philip, 2004). The family relationship of the halogen is illustrated also by the similarity in the chemical properties of the elements, a similarity in the chemical properties of the elements, a similarity which is associated with the arrangement of seven electrons in the outer shell of the atomic structure of each of the elements in the group. All the members form compounds with hydrogen and the readiness with which union occurs decreases as the atomic weight increases. In like manner, the heats of formation of the various salt decreases with the increasing atomic weight of the halogens. The properties of the halogens acids and their salts show as striking a relationship; the similarity is apparent in organic halogens compounds, but as the compound becomes chemically more complex, the characteristics and influences of other components of the molecule may mask or modify the gradation of properties (International Labour Organization, ILO, 2011).

These halogens are used in the chemical, water and sanitation, plastic, pharmaceutical, pulp and paper, textile, military and oil industries. Bromine, fluorine, chlorine and iodine are chemical intermediates, bleaching agent and disinfectants. Both bromine and chlorine are used in the textile for bleaching and shrink-proofing wool. Bromine is also used in gold mining extraction processes and in oil and gas- well drilling. It is a fire retardant in the plastics industry and an intermediate in the manufacture of hydraulic fluid, refrigerating and dehumidifying agents, and hair-waving preparation. Bromine is also a component of military gas and fire extinguishing fluids (Lee, 2013).

Chlorine is used as a disinfectant for refuse and in the purification and treatment of drinking water and swimming pools. It is a bleaching agent in laundries and in the pulp and paper industries, also used in manufacture of special batteries and chlorinated hydrocarbons and in the processing of meat, vegetable, fish and fruit.

Fluorine, fluorine monoxide, bromine pentafluoride and chlorine trifluoride are oxidizers for rocket fuel systems. Fluorine is also used in the conversion of uranium tretrafluoride to uranium hexafluoride, and chlorine trifluoride used in nuclear reactor fuel for cutting oil-well tubes (Skoog *et al.*, 2001).

Despite the useful applications of the halogens, if not properly managed posed some hazardous effects; for instance, the gases (fluorine and chlorine) and the vapours of bromine and iodine are irritant of the respiratory system; inhalation of relatively low concentrations of these gases and vapours gives an unpleasant, pungent sensation, which is followed by a feeling of suffocation, coughing and a sensation of constriction in the chest. The damage to the lung tissue which is associated with these conditions may cause the lungs to become overloaded with fluids, resulting in a condition of pulmonary oedema which may well prove fetal (ILO, 2011). Based on this scenario, verifying the empirical relationship between the mass number and some other physical properties of the halogens is now of paramount interest in this study.

Materials and Methods

Six physical properties of the halogens; Fluorine (F), chlorine (Cl) bromine (Br), iodine (I) and astatine (At) were obtained from literatures (Bentor, 2019). These properties are mass number (A), proton number (Ƶ), boiling point temperature (Θ_B), melting point temperature (Θ_M), the heat of fusion (HF) and density (*e*) at STP. Graphs of each of the other fine properties against “A” were plotted and their respective verified empirical relationships with the latter properties were obtained from the appropriate trend line equations. These equations are as follows;

$$Ƶ = 0.392A + 2.6632 \quad (1)$$

$$\Theta_B = 2.5.326A - 166.98 \quad (2)$$

$$\Theta_m = 2.5717A - 224.77 \quad (3)$$

$$H_F = 2.8795\ln(A) - 9.258 \quad (4)$$

$$\rho = 0.1121A + 0.8602 \quad (5)$$

Where A, Ƶ, Θ_B, Θ_m, H_F and *e*are the mass number, proton number, boiling point temperature, heat of the fusion and density for all respective halogens.

These equations were statistically tested for fitness using appropriate fitness graphs and error bars.

Results and Discussion

In Table 1, the six properties of the five identified halogens are presented. In Figs. 1–5, graphs are used to verify the dependence of Ƶ, Θ_B, Θ_m, H_F and *e* on “A” are presented, while the testing of the fitness of the respective equations is presented in Figs. 6 to 10. The Figures (1, 2, 3, 4 and 5) indicates that Ƶ, Θ_B, Θ_m, H_F and *e*are each linearly depends on A. These linear dependencies have the equation Ƶ = 0.392A + 2.6632, Θ_B = 2.5.326A – 166.98, Θ_m = 2.5717A - 224.77, and ρ = 0.1121A + 0.8602. On the other hand, the dependence of H_F on A is logarithmic having the equation H_F= 2.8795ln (A) – 9.258. The implication is that the physical properties mentioned in the study varies with an increase or decrease in the mass number, that is s slight deviation in the mass number will automatically affects all the physical properties considered.

Table 1: Halogens and some of their properties A: mass number, Z: proton number

Halogen		A	Z	Bp (θ_B °C)	Mp (θ_M °C)	H_F ($kJmol^{-1}$)	ρ (kgm-3)
Fluorine	F	19	9	-188.10	-219.60	0.001696	0.820
Chlorine	Cl	35	17	-34.04	-101.50	0.002898	6.406
Bromine	Br	80	35	58.80	-7.20	3.102800	10.571
Iodine	I	127	53	184.30	113.70	4.933000	15.520
Astatine	At	210	85	337.00	302.00	6.350000	23.800

B_P/M_P: boiling/melting point, HF: heat of fusion, ρ density (Bentor, 2019)

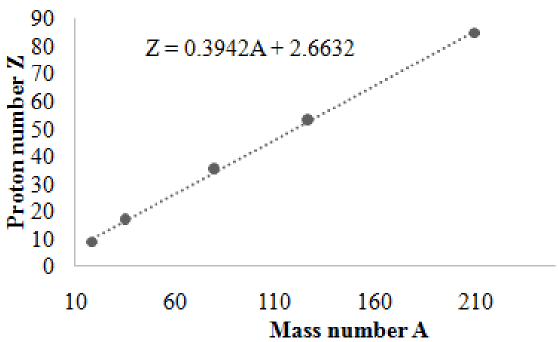

Fig. 1: Variation of Z with A for halogens

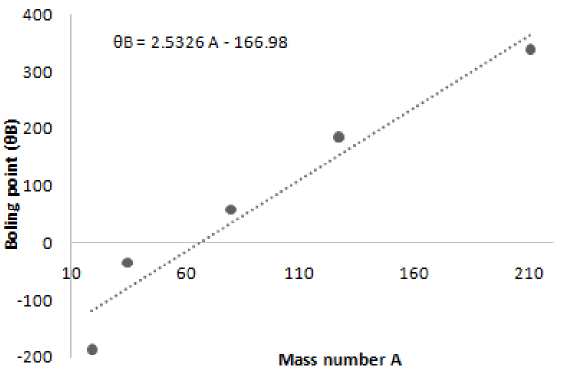

Fig. 2: Variation of θ_B with A for halogens

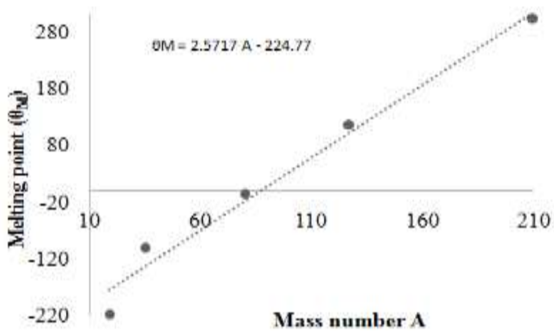

Fig. 3: Variation of θ_M with A for halogens

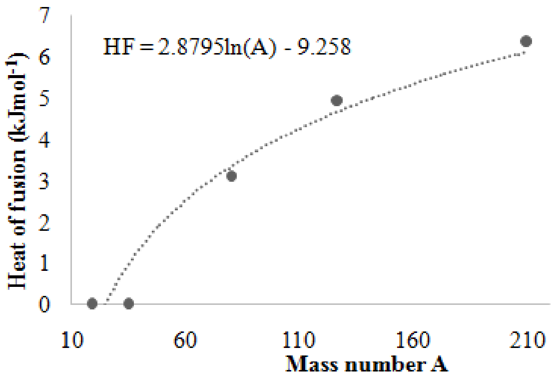

Fig. 4: Variation of H_F against A for halogens

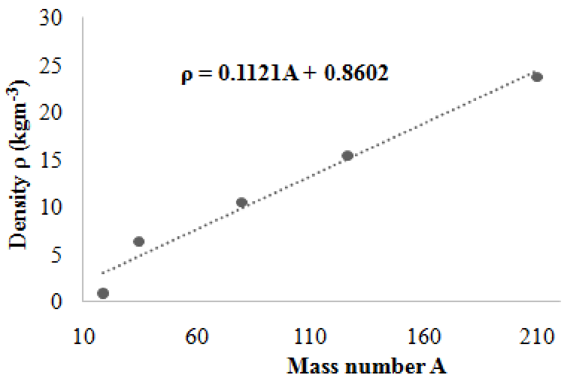

Fig. 5: Variation of ρ against A for halogens

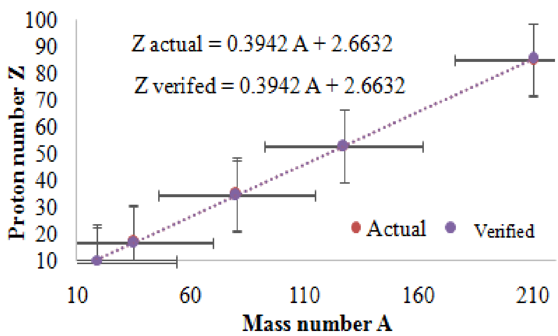

Fig. 6: Testing of the correctness of verified relationship between Z and A

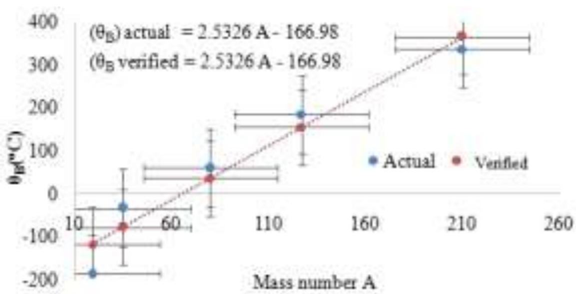

Fig. 7: Testing of the correctness of verified relationship between θ_B and A

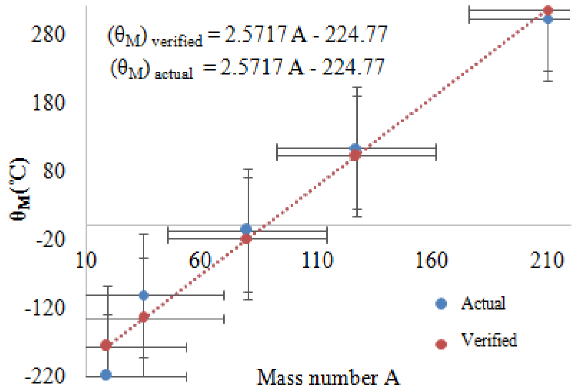

Fig. 8: Testing of verified relationship between θ_M and A

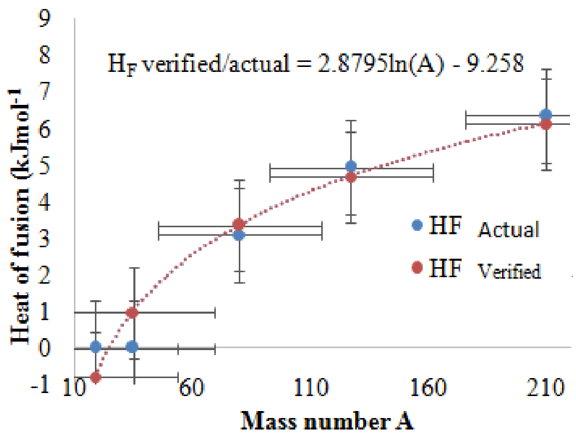

Fig. 9: Testing of correctness of the verified relationship between H_F and A

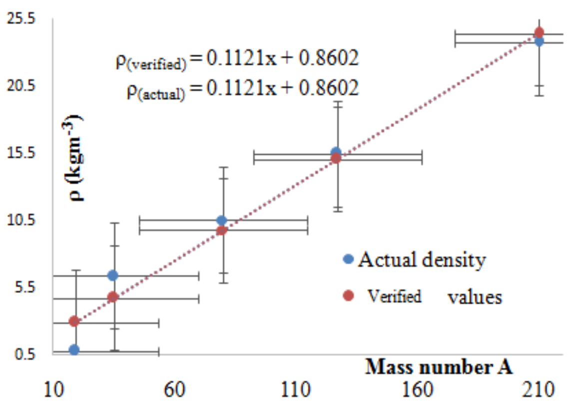

Fig. 10: Testing of the correctness of verified relationship between ρ and A

From Figs. 6–10, it is observed from the nature of their error bar that the verified values of each of the parameters whose dependence on "A" are determined and their corresponding actual values from the literatures clumped about the mean values (Gilliam, 2019). Thus is can be inferred that there is no variability between the values of the parameters obtained using the derived semi-empirical relationships and their actual values in the literature and that thus the difference between the former and latter values are statistically insignificant hence the verified relationship obtained in this work are precise and accurate (Gilliam, 2019). The known relationship between Ƶ and A is Ƶ = A – N (Gordon, 2019), where N represent Newton number. This is also linear. The respective values of N obtained using verified equation Ƶ = 0.3942A + 2.6632 for the elements F, Cl, Br, I and At are 9, 18, 46, 74, and 125. These within the limits of experimental error compare favourably with their corresponding actual values 10, 18, 45, 74 and 125 in their order of periodicity, respectively. This is further confirmation that the empirical relationship between Ƶ and A established in this study is reliable and accurate.

Conclusion

Verification of the empirical relationship between the mass number and some other physical properties of the halogens have been investigated using a scatter graph to show the relationship between the mass number and some other physical properties of the halogen respectively. The results revealed that the proton number, boiling point and melting point temperatures and density at STP each have a linear relationship with the mass number. But the heat of fusion shows a logarithmic dependence on the mass number. The obtained results from the verification were tested statistically and found to be reliable and accurate. The respective values of N obtained using verified equation Ƶ = 0.3942A + 2.6632 for the elements F, Cl, Br, I and At are 9, 18, 46, 74, and 125.
These within the limits of experimental error compare favourably with their corresponding actual values 10, 18, 45, 74 and 125 in their order of periodicity, respectively. This is further confirmation that the empirical relationship between Ƶ and A established in this study is reliable and accurate.

Conflict of Interest

Authors have declared that there is no conflict of interest reported in this work.

References

Bentor Y 2014. Chemical element. Chemical Elements.com.www.chemicalelements.com. Retrieved 2019-01-09.

Gilliam T 2019. Error bar. Wikipedia. https://en.m.wikipedia.org. Retrieved 28/08/19

Gordon E 2019. Atomic Mass and Atomic Number. Chemistry libre Texts. https://chem.libretexts.org. Retrieved 02/09/19

ILO 2011. https://www/ILOencyclopedia.org/part-xviii-10978/guide-to-chemical lite and 1047-halogen-and-thier-compounds. Retrieved 27-07-2020.

Lee JD 1996. Concise Inorganic Chemistry. 5th edn. Blackwell Science Ltd, Ibadan Nigeria, pp. 599-605

Philip M 2004. Advance chemistry. Published 1978; reprinted 2004. Cambridge University Press, United Kingdom, pp. 645-655.

Skoog DA, West DM, Holler FJ & Grouch E 1997. Fundamental of analytical chemistry. 8th edn. Gengage Heaving Publisher, India, pp. 438-565.