Contributions of Ancient Arabian and Egyptian Scientists on Chemistry

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Abstracts

The modern chemistry is based on the findings and thinking of the people of historical age. If no one knows the base and work of the previous on a subject, he or she could mere develop a new thought or findings. For, a civilization must know its past. Hence, the present work is a small effort to find out the contribution of ancient Arabian and Egyptian scientists in the field of Chemistry. Different scientists of different school of thought, correlating different streams of science being Chemistry as a main subject, are described in the present work.

Chemistry deals with the composition and properties of substances and the changes of composition they undergo. It has been divided into Inorganic and Organic. The conception of this in modern Chemistry came from *al-Rãzi*'s classification of chemical substances into mineral, vegetable and animal. Inorganic Chemistry, deals with the preparation and properties of the elements, and their compounds, originally arose from the study of minerals and metals, whereas Organic Chemistry, which deals with carbon compounds, developed through the investigation of animal and plant products.

Prior to 1828 it was not possible to synthesize organic substances from their elements and, therefore, it was supposed that there existed fundamental difference between Organic and Inorganic Chemistry. In 1828 F. Wohler synthetically prepared urea, an organic substance; thereby revealing that there was no fundamental difference between these two branches of Chemistry. Since carbon compounds were numerous, their study separately made under Organic Chemistry, and study of elements and non-carbon compounds included in Inorganic Chemistry'. **(1)**

The earliest discoveries in Inorganic Chemistry were made in metallurgy, *Materia Medica*, painting, enameling, glazing, glass-making, arts, etc. These arts, and many metals, compounds and alloys were known to the Arabs. Similarly, the discoveries in Organic Chemistry were made in the arts of dyeing, tanning, the manufacture of paper, in the study of fats, both of plant and animal origin, in medicine, etc. Thus Chemistry had its sources in photo techniques, mineralogy, metallurgy, *Materia Medica* and decorative arts. It is the product of transmutation of baser metals into gold and philosophical thoughts of practical or theoretical interest. Finally, it is the result of the study of the properties of the substances.

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A Greek philosopher, Empedocles, held the view that all the four elements, air, water, earth and fire, were the primal elements, and that the various substances were made by their intermixing. He regarded them to be distinct and unchangeable. Aristotle considered these elements to be changeable i.e., one kind of matter could be changed into another kind. **(2)**

Jábir ibn Hayyãn (Liatinized as Geber), a great Arabian Chemist of the 8th century A.C., modified the Aristotelian doctrine of the four elements, and presented the so-called sulphur-mercury theory of metals. According to this theory metals differ essentially because of different proportions of sulphur and mercury in them. He also formulated the theory of geologic formation of metals.

Unlike his Greek predecessors, he did not merely speculate, but performed experiments to reach certain conclusions. He recognized and stated the importance of experimentation in Chemistry. He combined the theoretical knowledge of the Greeks and practical knowledge of the craftsmen, and himself made noteworthy advance both in the theory and practice of Chemistry.

Jâbir's contribution to Chemistry is very great. He gave a scientific description of two principle operations of Chemistry. One of them is calcinations which is employed in the extraction of metals from their ores. The other is reduction which is employed in numerous chemical treatments. He improved upon the methods of evaporation, melting, distillation, sublimation and crystallization. These are the fundamental methods employed for the purification of chemical substances, enabling the chemist to study their properties and uses, and to prepare them. The process of distillation is particularly applied for taking extract of plant material.

In the opinion of *Jàbir* the cultivation of gold was not the only object of a chemist. The preparation of new chemical substances was also regarded by him as the chief object of Chemistry. We owe to him for the first preparation of such substances as arsenic and antimony from their sulphides, and basic lead carbonate. He also did important work in the preparation of steel, and the refinement of metals. *Jàbir* also deals with such applications as the use of manganese dioxide in glass-making, varnishes to water-proof cloth and protect iron use of iron pyrites for writing in gold and distillation of vinegar to concentrate acetic acid.

The most important discovery made by *Jabir* was the preparation of sulphuric acid. The importance of this discovery can be realized by the fact that in this modern age the extent of the industrial progress of a country is mostly judged by the amount of. sulphuric acid consumed in that country. Another important acid prepared by him was nitric acid which he obtained by distilling a mixture of alum (of Yemen) and copper sulphate (of Cyprus). Then by dissolving ammonium chloride into this acid, he prepared *aqua regia* which, unlike acids, could dissolve gold in it.

Jabir classified chemical substances, on the basis of some distinctive features, into bodies (gold, silver, etc.) and souls (mercury, sulphur, etc.) to make the study of their properties easier.

Jãbir is the author of a large number of books on chemistry and a book on astrolabe. About one hundred chemical works ascribed to him are extant. His fame chiefly rests on his chemical books preserved in Arabic. **(3)**

We find that the author recognized and stated clearly the importance of experimentation more clearly than any other early chemist. He remarkably sound views on methods of chemical research. It is impossible to reach definite conclusions regarding the extent of his contributions until all the Arabic writings ascribed to him have been properly edited and studied. But on the basis of our present knowledge, *Jabir* appears to be one of the greatest scientist whose influence can be traced throughout the whole period of the historical development of the Arabian and European chemistry. In the light of these facts it would not be improper to call *Jãbir* as the father of Chemistry.

Some of the chemical writings to which *Jãbir*'s name is attached were translated into Latin. The first such version, the *Book of the Composition of Alchemy* was made by Robert of Chester in 1144. The *Kitab al-Sab'in* (the book of the seventy) was translated by Gerard of Cremona in the 12th century'. The translation of the *Sum of Perfection* was made by Richard Russell. One of his books has been translated into French by Berthelot. **(4)**

Several technical terms have passed from *Jãbir*'s Arabic writings through Latin into the European languages. Among these are realgar (red sulphide of arsenic), tutia (zinc oxide), alkali, antimony, and alembic for distillation Vessel. The Arabic equivalents for the last three words are *alqali, ithmad,* and *al-'anbiq* respectively. **(5)**

Before *Jãbir Ibn Hayyan*, the Umayyad prince *Khalid Ibn Yazid*, who was a philosopher, poet and chemist, encouraged Greek philosophers in Egypt to translate Greek scientific works into Arabic. These were among the earliest translations in Arabic from other languages. He was himself deeply interested in medicine, astrology and chemistry. Many chemical works are ascribed to him. One of them is entitled *Firdaus al-Hikmah fi'Ilm al-Kimiya.* This work was in verse, and contained 2,315 couplets. **(6)**

An encyclopaedic scientist, and philosopher, *Abu Yusuf Ya'qub al-Kindi* considered the art of transformation of one metal into the other as an imposture. A few of 'his numerous works dealing with many sciences are extant. One of his works is on pharmacy, a branch of applied chemistry. **(7)**

Chemistry was usually mixed up with mineralogy and geology. The oldest Arabian lapidary which may serve as an important source of chemistry was written by '*Utärid Ibn Muhammad al-Hãsib* who flourished in the ninth century. It deals with the properties of precious stones. **(8)**

In the same century *Jãbir*'s work was further advanced by *al-Räzi* who wrote many chemical treatises, and described a number of chemical instruments. One of his treatises consists of 25 pieces of chemical apparatus. He made investigations on specific gravity. One of his important works is on the art of transformation of baser metals into the noble ones. He applied his chemical knowledge for medical purposes, thus laying the foundation of Iatrochemistry. **(9)**

Other important chemists of this century were *Dhu'l-Nün* and *al-Jàhiz*. The former mostly dealt with the art of transmutation of metals. **(10)** The latter prepared ammonia from animal offals by dry distillation. **(11)**

In the tenth century *Ibn Wahshiyah* wrote on chemistry, His work may help to understand chemical symbolism. *Maslamah Ibn Ahmad*, an astronomer, mathematician and oculist of this century wrote two chemical works entitled, *Rutbat al-Hakim* and *Ghãyat al-Hakim.* The second is well known in the Latin translation made in 1252 by the order of King Alfonso under the title *Picatrix.* **(12)**

A Persian pharmacologist *Abü Mansür Muwaffaq Ibn 'Ali al-Harawi* who flourished in Herat in the tenth century, was apparently the first to think of compiling a treatise on *Materia Medica* in Persian. He travelled extensively in Persia and India to obtain necessary information. He wrote, between 968 and 977, a book entitled *Kitab al-Abniyah 'an Haqã'iq al-Adwiyah.* It contains Greek, Syrian, Arabian, Persian, and Indian knowledge. It deals with 585 remedies (of which 466 are derived from plants, 75 from minerals, and 44 from animals). He classified them into four groups according to their action, and gave the outline of a general pharmacological theory.

Abu Mansür distinguished between sodium carbonate (natrum) and potassium carbonate *(qali).* He had some knowledge of arsenious oxide, cupric oxide, silicic acid, antimony and so on. He knew the toxicological effects of copper and lead compounds, the depilatory virtue of quicklime, the composition of plaster of Paris and its surgical use. **(13)**

The greatest Arabian surgeon, *Khalaf Ibn 'Abbäs al-Zahrãwi* (d. 1013) wrote a great medical encyclopaedia, *al-Tasrif* in 30 sections, which contains interesting methods of preparing drugs by sublimation and distillation, but its most important part is the surgical one. **(14)**

Abü Rayhan Muhammad al-Birüni (973—1048) took a great interest in the determination of the specific gravity of eighteen precious stones and metals. A voluminous unedited lapidary by *al- Biruni* is extant in unique manuscript in the Escorial Library. It contains a description of a great number of stones and metals from the natural, commercial, and medical point of view. Moreover, he composed a pharmacology *(saydalah).*Important information could certainly be obtained from his unedited works, on the origin of Indian and Chinese stones and drugs, which appeared in early Arabic scientific works. **(15)**

Ibn Sinà wrote a treatise on minerals, which was very important and one of the main sources of geological knowledge, also a source of chemistry in Western Europe until the Renaissance.

As mentioned before, mineralogy stood in close relation to chemistry. Nearly fifty Arabic lapidaries have been named. The best known of them is. the 'Flowers of Knowledge of Stones', by *Shihàb al-Din al-Tifãshi* (died in Cairo in 1154). It gives in 25 chapters extensive information on the subject of the same number of precious stones, their origin, geography, examination, purity, price, application for medicinal and magical purposes, and so on. Except for Pliny and the superior Aristotelian lapidary, he quotes only Arabic authors. **(16)**

The output of the books on Chemistry was very great after the eleventh century. Thus, there are known books of about forty Arabic and Persian chemists. *Ibn Khaldun*, (d. 1406) the talented Arabian philosopher of history and the greatest intellect of his century, was a violent opponent of the idea of transmutation of metals by chemical means. **(17)**

Some chemists thought that one metal can be transformed into another by artificial methods. For such transformation they followed different procedures depending on the character and form of the chemical treatment and the substance chosen for this purpose; the substance being called the 'Noble Stone' or 'Philosopher's Stone'. This may be excrements, or blood, or hair, or eggs, or anything else. After the substance has been specified, it is treated along certain lines mentioned in their books. The result is an earthen or fluid substance which is called *Elixir.* These chemists think that if *Elixir* is added to silver which has been heated in a fire, the silver turns into gold. If added to copper which had been heated in a fire, the copper turns into silver.

The question arises whether the metals are of specific differences, each constituting a distinct species, or whether they differ in certain properties and qualities and constitute different kinds of one and the same species?

Abü Nasr al-Färabi and his followers held the opinion that the difference in metals is caused by certain conditions such as humidity and dryness, softness and hardness, and colours such as yellow, white and black. According to him the metals are different kinds of one and the same species.

On the other hand, *Ibn Sina* and his followers believed that metals have specific differences and belong to different species, each of which has its own differential and genus, like all other species.

According to *Abü Nasr al-Färãbi*, it is possible to transform one metal into another, because it is possible to change their conditions.

“*Ibn Sinà* thought that such transformation was impossible. His assumption is based on the fact that specific differences in metals cannot be changed by artificial means. He believed that since the metals are created by the Creator and Determiner of things, God Almighty, and the mystery of their real character was utterly unknown and could not be perceived, any attempt for transformation would be meaningless”. **(18)**

Ancient Arabs’ art of transformation of metals was based upon Hellenistic and Iranian traditions, but apparently the main principles and the main operations were already established long before the 12th century. Before this century the Arabs had not only made many experiments, and produced several works on this art, but they had begun to doubt and criticise the most advanced theories concerning it. This proves that the standard of their chemical thinking was advanced.

The 12th and 13th centuries added very little to their knowledge about the transformation of metals, but their research continued in various fields. The main chemical writer of this age was *Abu‘l-Qãsim Muhammad al-Iraqi* who flourished in the second half of the 13th century. He was an experimenter and a theorist. His works represent the full development of the Arabic doctrine. **(19)**

The 14th century was an enlightened period when a group of intelligent writers began to reject the idea of transformation of metals by chemical means. One of such person was a historian, *Rashid al-Din* who described such chemical practice in Mongol Persia and expressed his distrust of such chemists. The large encyclopaedic work *Nukhbat al-Dahr* of *al-Dimashqi* contains, in part second, much information on metal, their properties, and influences. **(19)** As usual in Arabic treatises, chemistry is mixed up with mineralogy and geology. **(20)**

Even in their purely chemical researches on transformation of metals, the Arab chemists achieved by no means unimportant results. In their efforts to discover *Elixir* they often discovered new chemical processes, and hit upon the catalytic properties of various substances. The pains, which they took in the search of gold, ultimately resulted in their great contribution to the development of modern chemistry.

The last important chemist of the 14th century was ‘*Izz al-Din ‘Ali Ibn al- Jildaki*. Some twenty treatises are ascribed to him. The list shows *al-Jildaki*’s great activity as a chemical writer. A complete study of his vast writings is necessary to know what he actually tried to establish. To some extent, this study was made by Ruska, Stapleton, Holm yard, and their disciples.

One of *al-Jildaki*’s important books entitled *Nihâyat al-Talab fi Sharh al-Muktasab* contains many quotations from the earlier works, and some novelties, as the use of nitric acid to extract silver out of the gold-silver alloy. *Al- Jildaki* remarked that the substances do not react except by definite weights. **(21)** This is one of the four fundamental laws of modern chemistry.

The ancient chemists applied their chemical knowledge to a large number of industrial arts. Only three such arts are mentioned here, which will enable the readers to estimate the extent of their knowledge of Applied Chemistry.

Paper:

Paper was invented by the Chinese who prepared it from the cocoon of the silkworm. Some specimens of Chinese paper extant date back to the second century A.C. The first manufacture of the paper outside China occurred in Samarqand (757). When Samarqand was captured by Arabs the manufacture of paper spread over the whole Arab world including the Maghrib. (Tunis, Morocco, Algiers).

By the end of the 12th century there were four hundred paper mills in Fasalone. In Spain the main centre of manufacture of paper was Shatiba which remained a ancient Arab city until 1239. Cordova was the centre of the business of paper in Spain.

The Arabs developed this art. They prepared paper not only from silk, but also from cotton, rags and wood.In the middle of the 10th century the paper industry was introduced in Spain. In Khurasan paper was made of linen.

There is an early treatise dealing with paper-making, the *Umdat al-Kuttab wa 'Uddatu dhawi'l-Albãb* which is ascribed to the *Amir al- Mu'izz' Ibn Badis*, a ruler of the Zayri dynasty (1015—61) in Tunis. The 11th chapter of this treatise, dealing with paper, has been edited, translated and elaborately discussed by the foremost student of Arabic paper, Josef Karabacek. This work explains how to prepare the pulp, make the sheets, wash and clean them, colour, polish and paste them, and give them an antique appearance. No text comparable to this in any other language of so early a date is known.

The preparation of pulp involves a large number of complicated chemical processes, which shows the advancement of the chemical knowledge of the Arabs and Egyptians at that time.

The manufacture of writing-paper in Spain is one of the most beneficial contributions of Arabs to Europe. Without paper the scale on which popular education in Europe developed would have not been possible. The preparation of paper from silk would have been impossible in Europe due to the lack of silk production there. The Arabs method of producing paper from cotton could only be useful for the Europeans. After Spain the art of paper-making was established in Italy (1268—76). France owed its first paper mills to ancient Spain. From these countries the industry spread throughout Europe.

Another type of paper; marbled paper, which was common upon end-papers, paper covers and edges of books, was prepared in the East, and exported to the West. About the preparation of marbled paper Roger Bacon tells us: “The Turks have a pretty art of chamoletting of paper, which is not with us in use. They take diverse oiled colours, and put them severally (in drops) upon water; and stirr the water lightly and then wet their paper (being of some thickness) with it, and the paper will be waved, and veined, like Chamolet or Marble’.

Books bound in the West towards the end of the 16th century are found with end-papers brought from the East, but it was not until about a century later that European binders began to make them themselves. Hand-made marbled papers are now rarely used, but more or less clumsily reproduced imitations still serve various purposes.

There is an Arabic word ‘*rizma*’ meaning a bundle of merchandise, which had been adopted in almost every Western language with slight variations to mean a bundle of paper (English: ream). This also testifies to the Arabic origin of that business in the West. **(22)**

Tiles:

The industry of tile-making which involves a large number of complex technical and chemical processes, was highly developed by Arabs. The earliest treatise, a Persian text, dealing with the manufacture of faience, was unique of its kind in world literature until the 16th century. It has been written by ‘*Abd Allah Ibn ‘Ali Kàshàni* in the 13th century. This book entitled *Jawahir* al-*‘Arã’is Wa Aja’ib al-Nafä’is* was written on precious stones and perfumes. It explains the manufacture of Faience, the ingredients (as clay, borax, feldspar, cobalt, lapis lazuli, lead, manganese, tin etc.), their mixtures, the kiln processes and implements, the methods of glazing and decorating. This treatise is similar to the various other treatises on precious stones written in Arabic and Persian. The final chapter deals with the art of enamelled pottery. This account is specially valuable because it is based on actual and traditional practice. The maker of the beautiful lustre ‘*mihrab*’ (arch) of the tomb of *Imam Yahyã* (now in the Hermitage, Leningrad), dated 1305 A.C., *Yusuf Ibn ‘Ali Ibn Muhammad*, was possibly a brother of the author. **(23)**

Ceramics:

The early history of Arabian and Egyptian ceramics has not so far been written. Many interesting specimens have been discovered in recent years which throw much light on the development of this industry in the Arab world. The centers of this industry were situated in Persia, Mesopotamia, Syria, Egypt and Valencia from where various types spread rapidly throughout the Islamic Caliphate.

Under Arabian influence the potters in these Centers revived old technical processes, developed new ones and began to experiment with decorative and ornamental schemes. The Arabian potters readily absorbed progressive ideas but at the same time maintained great originality. Two types of pottery were in common use; enamelled and lustered. In enamelled pottery (the glazed earthenware) the Ancient s, from an early period, were expert masters. In lustered pottery also they made great progress. “In this the design is painted in a metallic salt on a glazed surface and fixed by firing in smike in a way that gives it a metallic gleam, which varies in different specimens from a bright copper-red to a greenish- yellow tint, and in some cases throws off brilliant iridescent reflections. **(24)**

In the last chapter of the Persian text *Kitab al-Jawähir’ al-’Ara’is Wa ‘Ajã’ib al-Nafa’is,* the author describes the techniques of glazing with two fires (lustres), leaf building, over glaze decoration fired in a muffle kiln. (i.e., separated from the flame, the source of heat being outside), *haf’t rang,* a Persian term referring to the seven colours of the planets. There may be a reference to the polychrome over glaze technique, the so called *minai* ware (another Persian term; *mina-wash* means lustre; *mina* coloured). The author indicates differences between the art as practiced in Kashan, Baghdad and Tabriz. In Baghdad and Tabriz other kinds of firewood and potash were used.

In the 15th century the Arabian ceramic art was followed by Italian potters, who obtained much of the mature technical knowledge from Arab sources. This technical knowledge proved to be helpful in the revival of ceramic art during the Renaissance. **(25)**

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