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ATOMISM OF NYĀYA-VAISEṢIKA *VS* JAINISM – A SCIENTIFIC APPRAISAL

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India is the oldest country of the world which believed in the reality of external material world (*pudgal*). The *pudgal* (matter) is made by the smallest particle and has a stable entity, known as *aṇu* and *paramāṇu*. Both the words mean only 'atom' unlike modern knowledge in physical science where '*aṇu*' means molecule and '*paramāṇu*' means atom. The *Nyāya-Vaiśeṣika* (of six systems of Indian philosophy, *Nyāya* School is linked with *Vaiśeṣika* school, therefore they are in pair as complementing each other, known as *Nyāya-Vaiśeṣika*), on one hand and Jains on other, had a glorious past of 2500 years of active participation in propounding a hypothetical model of 'atom', their origin, their position in space, their own energy, their various types of combinations in forming the matter of earth, water, fire and *ākāś'a* (ether). The word hypothesis has been used in the paper because our ancient thinkers had not proved the problems experimentally. *Nyāya-Vaiśeṣika* believes that atom can change from one form to another which is still not experimentally proved in the modern physical laboratories. This paper also throws light on the micro and macro similarities and dissimilarities in the concept of atom in two schools of Indian thoughts, simultaneously in the different levels of energy in the atom itself by which it moves and takes participation in combination, which is the basic theory of chemical combination (valency) in the modern science. What is the nature of matter? How was it formed? How was it stable and on what conditions was it unstable? How this stability and instability in the matter is effected by its atom. The present paper comprises all the cited facts, problems posed and discussed. Most of the hypothetical model propounded by twin school of Indian Philosophy connected with atom have been experimentally proved, but still some problems viz., changeability of atom is to be proved in the lab which the ancient Indian philosopher had hypothesized.

Key words: *Aṇu*, Atomism, Jain system, *Kaṇāda* theory, *Nyāya-Vaiśeṣika* system, *Paramāṇu*, *Pilu-pāka*, *Pilu-pilu*, *Pithara-pāka*, Valency

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It is a well-established fact that some of the prominent Indian logicians, especially non-Vedic, are realists and they believe in the reality of the external world and they also feel it necessary to offer a satisfactory explanation for its origin. It leads many of them to the atomic hypothesis in the form of *aṇu* and *paramāṇu*. The active confrontation of Jains and *Nyāya-Vaiśeṣika* on atomism had also developed an antithesis, found expression in the works of Vasubandhu (*c.* 5th century AD), a Buddhist theologist and Śaṅkara (*c.* 8th century AD), a prominent exponent of *Advaita* (no second, i.e. monism). Both these concepts remain a fundamental thesis for Vātsyāyana[1] (*c.* 5th century AD) and Uddyotkara[2] (*c.* 6th century AD), both belong to the *Nyāya School* of Indian philosophy. This dialectical confrontation of atomism with its anti-thesis of non-atomism result in Indian philosophy in the theoretical classification of various questions concerning the ancient atomic hypothesis.

The *Vaiśeṣika School* may be said to be the foremost champion among the atomists in Indian Philosophy. From a very early period of *c.* 7th century BC to the seventeenth century AD, through their numerous commentaries and independent works, they have tried to develop the atomic view and put it on a firm logical foundation, fighting against the onslaught of the anti-atomists. This school was based on a system of atomism, explaining the cosmic process in which the soul was involved. The *Vaiśeṣika*'s like the *Sāṅkhyas*, held that the soul was wholly different from the cosmos, and that its salvation lay in fully realising this difference. The first stage in this process was the recognition of the world's atomic character. The universe was an infinitely complex and endlessly changing pattern of atoms, more scientifically it is molecule (*aṇu*) combining and dissolving according to regular principles. At the end of the cosmic cycle the atoms[4] or molecules[5] reverted to a state of complete equilibrium from which they only emerge at the beginning of the next cycle, as the raw material of a new cosmos.

In modern science this phenomenon is explained by big bang theory, which was first developed in 1927 by A.G.E. Lemaitre (1894-1966) and revived and revised in 1946 by George Gamow (1904 1968). In this cosmological theory, it was explained that all the matter and energy in the universe originated in a super house agglomeration that exploded at a finite moment in the past. By this very fact it is also called as superdense theory of the origin of matter in the universe.

The *Nyāya-Vaiśeṣika* atomic system, in many respects anticipating the theories of modern physics, was the result not of experiment and observation but rather of logical thought. Since an endless regress was logically and philosophically unsatisfactory, it was believed that there must be a final stage in the subdivision of any piece of matter, beyond which further subdivision was impossible, that is the concept of atom in modern physics. Hence the universe must be atomic in structure. Further developments of the theory led to a doctrine of molecules to account for multifarious variety of the world. The *Vaiśeṣika* philosophers had somewhat agreed to modern scientific physics; they did not however, hit on a realistic theory of elements, which would have demanded practical investigation and experiment. Like most other Indian philosophers they maintained the existence of five atomic element, 1) Earth, 2) Water, 3) Fire, 4) Air and 5) *Ākāśa*, which filled all space, *ākāśa* is generally translated as 'Ether'[6] in the sense in which this term was used in western pre-relativity physics.

The *Vaiśeṣika sūtra* of Kaṇāda[7], the earliest basic text in the whole gamut of the *Nyāya-Vaiśeṣika*, literature, which dates back to the dawn of the Christian era. There we find the word *aṇu* but not the word *paramāṇu* in the sense of an 'atom' as well as 'very small', but not molecule. Though, in the absence of any early commentary, it is difficult to work out exactly the implications of the *sūtras,* there is no doubt that we have in the *Vaiśeṣika sūtra* a fairly developed form of the atomic theory. Thus, for instance, *Kaṇāda* offers indirect arguments to prove the importance of atom, enumerates their qualities, specifies their dimension as globular *(parimaṇḍala),* points out that the qualities of earth-atoms are changeable by heat (*pākaja*) and also distinguishes the various uses of the word *aṇu*. In modem physics, atom is characterized by its atomic number, which is the number of protons in the nucleus of an atom. The atomic number is equal to the number of electrons orbiting the nucleus in a neutral atom. It is also governed by the periodic law[8] i.e. the principle that the physical and chemical properties of elements (*aṇu*) are in a periodic function of their proton number. One of the major successes of the periodic law was its ability to predict chemical and physical properties of undiscovered elements and unknown compounds that were later conformed experimentally. Therefore, atom is the fundamental constituent of all the matter in the universe. Until the discovery of the electron by J. J. Thomson[9] in 1898, it was assumed that atoms were the

fundamental constituents of matter. This discovery[10] and Rutherford's discovery of the atomic nucleus and the proton in 1914 made it apparent that atoms were not themselves elementary in the sense that they have an internal structure.Chadwick's discovery of the neutron in 1932 completed the atomic model based on an atomic nucleus consisting of protons and neutrons surrounded by sufficient number of electrons to balance the nuclear charges. It did not however explain the great stability of the nucleus, which clearly could not be held together by an electromagnetic interaction, as the neutron has no electric charge. But the concept of *Kaṇāda* of the changeability of one atom to another atom by heat is still not experimentally proved by modern science. Because in modern concept heat is a type of energy by which state of a matter can be changed from solid to liquid and from liquid to gas but not the nature of atom. Therefore in *Kaṇāda* concept, heat is different from modern heat. Then what was the concept of heat in *Kaṇāda theory,* which was able to change the nature of an atom i.e. it could change the atomic number of an atom, is not invented as yet.

Praśastapāda (c. 5th century AD), the author of *Padārthadharma-saṅgraha* which is claimed by some to be a *bhāṣya* on the *Kaṇāda sūtra,* uses both the word *aṇu* and *paramāṇu* for an atom and develops the theory further by clarifying some of the main tenets. He devotes a separate section to explain the origin and distraction of the physical world, how things are gradually produced out of atoms after creation starts and how they are dissolved into atoms ultimately at the time of the *pralaya*. The allied theory of *pilu-pāka*[11] that the chemical change due to heat takes place not in the thing as a whole, but in every individual atom- is also treated in a separate section[12]. Therefore it is clear that *Praśastapāda* was the first to introduce the *dyad* or *dvyaṇuka,* the first product out of the atoms.

Further this theory has certain modifications made by Udayana[13] in the *Vyomavatī* and the *Kiraṇāvalī*, the *Nyāyakandalī* of Srīdhara, the *Setulikā* of Padmanābha Miśra, all commentaries on the work of *Praśastapāda,* the first one being the earliest and the *Upāskara Saṅkara Miśra,* a commentary on the *Kaṇāda sūtra.*

The *Nyāya sūtra* (*c.* 200-500 AD) of Gautama mainly concerns itself with the atom as such. In no less than 10 *sūtras* comprising the whole of one separate section and the concluding portion of another, Gautama hints at how

the atom is arrived at and strongly defends its reality as a partless entity against the onslaught of the opponents. The view that the world is produced out of atoms and not from a single ultimate principle called *avyakta*[14], the *Sāṅkhya* claims, and is also pointed to *Pitharapāka* that the chemical change due to heat takes place also in the thing as a whole.

The *Nyāya sūtra* found a very able exponent in *Vātsyāyana,* who in his commentary, called the *Nyāyabhāṣya,* faithfully brings out and substantiates the implications of *Gautama* and also advances his own ideas and arguments to silence the anti-atomists. Thus, for instance, he clearly explains with an illustration the process of arriving at the impart-atom, justifies etymologically the use of the term *paramāṇu*[15] for it and provides a clue generally referred to absurdity which the non-admission of the atom would lead to, namely that of the seed and the mountain being equal in magnitude, that's why it was *avyakta* (inexpressible).

After *Vātsyāyana,* the task of defending the *Nyāya* position was taken up by Uddyotakara and Vācaspatī, who undoubtedly were successful to a great extent in their mission. Especially, *Uddyotakara* started a relentless tirade against the strong attack of the *Mahāyana Buddhists*[16] on the conception of the micro atom. He explained and examined the opponent's view in minute details and subjected them to a vigorous criticisms and in this task he was ably assisted by Vacaspatī. Although the atomic theory is dealt with briefly or elaborately, and is referred to in various context in almost each and every later work of the *Nyāya-Vaiśeṣika* school it was fully developed in the writing of Vacaspatī. The later author's novelty mainly lies in the way of presentation and the clarification of ideas already current. There were however two exceptions *Padmanābha Miśra* of *c.* 13th century AD and Raghunātha Śiromaṇi of *c.* 16th century who did not subscribe to the generally accepted *Nyāya-Vaiśeṣika* view of atom. Raghunātha argues that the visible triad (*tryaṇuka*) can very well be accepted as the ultimate unit of matter; the admission of the *dvyad* and the atom is unnecessary. *Padmanābha,* slightly differing maintains that the ultimate unit should be either the *dvyad* or the *triad.* However, both agree that such a unit is indivisible.[17]

According to the *Vaiśeṣika sūtra* in *Nyāya-Vaiśeṣika* there are four kinds of atoms corresponding to four material elements, namely earth

(VS.I.i.5;II.i.1;II.ii.1), water (VS.II, i.2; II.ii.5), fire (VS.II.i.3-4;II.i. 9-17; V.i.14) and air or ether (VS.II.i.5; II.i.20-27;II.i.28-31). These are not homogenous, as the Jains hold but differ qualitatively. The *Nyāya-Vaiśeṣika* admits twenty-four qualities in all, which are divided into two groups, *sāmānyaguṇas* or general qualities that reside in more than one substance and *viśeṣaguṇas* or specific qualities that reside in one substance only. The qualities of conjunction, disjunction, number, magnitude etc come under the first group (physical properties) and the qualities of colour, taste, smell etc. belong to the second group (chemical properties). The atoms differ so far as the specific qualities are concerned. Thus, through all the atoms quality share the globular *(parimaṇḍala)* magnitude of the various specific qualities, an earth-atom has colour, taste, smell and touch (temperature); a water-atom has colour, taste and touch (cool); a fire-atom has colour, and touch (hot), and lastly, an air-atom has touch (temperate) only. All the qualities of the atoms are eternal excepting the four-colour taste, smell, and touch- as located in the earth atoms, for they are changeable by heat.

This type of changeability in a substance by heat is also accepted by modern science in which it is a type of energy in the course of being transferred from one body or system to another as a result of a difference in temperature. The energy in the body or system before or after transfer is also sometimes called heat but this leads to confusion, especially in thermodynamics.[18] A body in equilibrium with its surroundings contains energy (the kinetic and potential energies of its atoms and molecules), but this is called internal energy (U) rather than heat. When such a body changes its temperature or phase, there is a change in internal energy (ΔU), which (according to the first law of thermodynamics) is given by $\Delta U = Q - W$, where Q is the heat absorbed by the body from the surroundings and W is the work done simultaneously on the surroundings. To use the word heat for both U and Q is clearly confusing.[18a]

By virtue of motion in the atoms, the beginning of a new creation started motion that unites one atom with another to form the countless varieties of things by the mathematical principle of permutation-combination or by the force of *adṛṣṭa* or merit and demerit. According to the *Nyāya-Vaiśeṣika*, the production of two atoms combine to form a *dvyads* or *dvyaṇu* and then three *dvyads* combine to form a *triad* or *traṇuka* and in which six atoms (2 x 3 = 6)

are present. As per *Vaiśeṣika, dvyad* is the smallest visible substance. It is to be noted that each and every conjunction between atoms does not give rise to a new substance and accordingly the conjunction of atoms may be either productive (*ārambhaka*) or non productive (*anārambhaka*). A productive conjunction can occur only between atoms of the same kind and never between atoms of a dissimilar kind. Thus, for instance, two earth-atoms or two water atoms may combine to form an earth-*dvyad* or or a water *dvyad*, but an earth atom conjoined to another water atom will not produce a new substance. In modern chemistry this phenomenon is known as valency, which is the combining power of an atom or radical, equal to the number of hydrogen atoms that the atom could combine with or displace in a chemical compound (hydrogen has a valency 1). In similar type of atoms it occurs in the form of covalency[19] (by sharing of electrons in their outermost orbit) or in co-ordinate valency (by displacing as well as sharing of electrons in their outermost orbit), but in different atoms it occurs in electrovalency[20] (by giving and taking of electrons in their outermost orbit), or in covalency or in co-ordinate valency. Therefore, it is clear that *Nyāya-Vaiśeṣika* scholars of India perhaps knew the principle of covalency, but they had no knowledge of the principle of electrovalency and coordinate valency of the combination of atoms to form stable molecule.[21]

Perhaps the most challenging problem that the atomists in Indian philosophy are confronted with is the problem of the combination of atoms why should one atom be combined with another atom? Is it some property located in the atoms themselves or something external to them that brings the atoms together?

According to the *Nyāya-Vaiśeṣika* in the production of composite things, conjunction of the parts plays an indispensable role. Thus, at the beginning of creation, initially conjunction between the two atoms must come about so that the fast product out ot the atoms-the *dvyad*[22] may be produced and the process of creation may start. But conjunction is generally brought about by movement (*karman*). But the question is why should there be movement in atoms at the beginning of creation? From what Kaṇāda repeatedly asserts, by early *Vaiśeṣika* position was: "The cause of creative motion is believed to be *adṛṣṭa*[23], unseen moral force, which guides the destiny of souls, according the equipped bodies, an appropriate objective world for the experience of pleasure and pain. It is due to the operation of this net empirical force that atoms start

moving to get together in order that they may be integrated into countless varieties of things". *Praśastapāda* adds later two more conditions, the will of god (maheśvara) and conjunction of the atoms with the individual selves *(ātmaṇu-saṅyoga).*

In the *Nyāya sūtra* itself we do not find any reference in this regard. But, the later Naiyāyikas like Uddyotakara and others though accepting *adṛṣṭa* as the cause of the said movement, brings in the agency of god also. In fact, *Udayana* takes it to be an invincible proof for the existence of God. His implications come to this. The atoms as well as the *adṛṣṭa* causing movement in them are all nonsentient. But, as is borne out by common experience such things cannot themselves produce effects; they must be guided by some conscious intelligent agent, who is none other than almighty. The above is how the *Nyāya-Vaiśeṣika* position is generally represented and there is no doubt that it is true so far as the later representatives are concerned.

However, it would 'also be unjust to overlook the fact that the real implication, as regard movement due to *adṛṣṭa* of the early *Nyāya-Vaiśeṣika* might have been something different. In later work *adṛṣṭa*, is invariably explained in the sense of *dharmādharma* (merit and demerit), belonging to the category of quality. It is moreover a specific quality (*viśeṣaguṇa*) of the individual itself, that it belongs to the self-only and not to any other substance. But it appears that this was a later modification and originally it meant, considering the literal meaning of the world, the 'unseen'. As Kaṇāda himself illustrate this 'unseen force' may operate in the physical as well as the non-physical spheres. Thus, in the physical sphere, *adṛṣṭa* is the cause of the upward motion of fire, the oblique motion of air etc., and Kaṇāda repeatedly asserts that, at the start of a fresh creation, movement in the atom is due to *adṛṣṭa.*

So far the Jains were concerned, there is no scope for doubt that they were definitely atomists; the atoms in a most scientific way has been defined and its qualities have been enumerated in some of their early texts. The Jains maintain that everything in this world, except souls and space, produced from matter is known as *pudgala*[24] and that all *pudgala* (matter) consists of *paramāṇu*[25] (atom). Each *paramāṇu* (atom) occupies one *pradeśa*[26], (point of space). Matter in Jain's view, however, may be either in the firm state *(sthula)* or in the subtle (*sukṣma*) state. When it is in the subtle state, innumerable atoms

of it occupy the space of one gross atom. Therefore, *sukṣma* state of atom is more micro in contrast with the *sthula* position of atom. When it is in the subtle state, innumerable atoms of it occupy the space of one gross atom, which means in modern concept it is a type of multi atomic structure of a molecule.

In Jain's atomicity, the *pudgalas*[27] (atom) are eternal as regards their substance; each atom has one kind of taste, smell and colour, and two kinds of touch. These qualities however are not permanent and fixed for the several atoms, but they may be changed and developed in them.The figures formed by the arrangement of the atoms into groups are manifold and the atoms may develop a motion of its own, and this motion may become so swift that by means of it an atom may traverse in one moment the whole universe from one end to the other. This moment in the atom by its own energy were not explained by *Nyāya-Vaiśeṣika* scholars and this is the cause of atomic combination in the space. The Jains, claming that their view is corroborated by common experience e.g., particles of barley-meal (*saktu*) come together and form one lump when drop of water fall upon them, maintain that generally a viscid *(snigdha)* atom combine with dry (*rukṣa*) atom. Some atoms are by nature viscid and some atoms are by nature dry. A combination may take place everywhere. The exact degrees that are capable of combination and the one that are not discussed in the *Tattvārtha-sūtra.* Here it would perhaps be interesting to note the difference of the Jain view from that of *Nyāya-Vaiśeṣika.* A product resulting from the combination of a viscid and a dry atom would be impossibility in the latter's view. It is only possible in the Jain view because they consider all atoms to be homogeneous and not heterogeneous in a particular *pudgala.* According to them, even the four-fold distinction of earth, water, fire and air is derived as secondary, not primary and eternal, as believed by the followers of the *Vaiśeṣika* school of Hindu Philosophy. According to the *Nyāya-Vaiśeṣika,* the division of the elements is fundamental and the four kinds of atoms are qualitatively different from one another. Thus viscidity (*sneha*) being a property of the element of water alone, would be present in water atoms only and the other three kinds of atoms (earth, fire and wind) will all be dry. Moreover, they argue that a productive conjunction can occur only between two atoms of a similar kind, but never between two atoms of a dissimilar kind (earth + fire/ earth + wind/fire + water/water+ wind/.....and so on). Thus the combination of viscid and dry atoms, which are productive in the Jain view, would be

non-productive in the *Nyāya-Vaiśeṣika* view. Again the combination of two viscid atoms (e.g. two water atoms) or that of two dry atoms (e.g. two fire atoms) is productive according to the latter (forming water *dvyads* or fire *dvyads*), but would not be non-productive according to the formers. Therefore, according to Jains an atom is the smallest unit of matter, but it never occurs alone, means atom as such is very unstable, which is matching with modern concept of atom too. Then what is the smallest aggregate of the atoms? The *Sautrāntikas*[28] seem to have regarded the aggregate of seven atoms as the smallest compound (*aṇu*). These globular atoms did not touch one another completely, but that there was an interval between them. According to the *Abhidharmakoś'a,* the smallest aggregate seems to be composed of not less than eight atoms[29], but there is no hint as to their relative position. There is reference to a variety of very small aggregates, the number of their constituent atoms ranging from 9 to 11. Such aggregate[30] may first be divided into two groups non-sounding *(as'abda)* and sounding *(sas'abda)* and each of them again may be of three varieties, therefore, their total number is six[31] which is as follows:-

1. An aggregate, non-sounding and without any sense organ: 4 atoms of 4 elements + 4 atoms of the derived properties = 8 atoms.
2. An aggregate, non-sounding but with sense-organ: 8 atoms of (1) + 1 atom of the cutaneous organ = 9 atoms.
3. An aggregate, non-sounding, but with a sense organ: 9 atoms as in (2) +(1) atom of the sense organs (visual or auditory or olfactory or gustatory) = 10 atoms.
4. An aggregate sounding but without any sense organ: 8 atoms as in (I) + (1) atom of *s'abda* = 9 atoms.
5. An aggregate, sounding and with a sense-organ: 9 atoms as in (2) +(1)atom of *s'abda* = 10 atoms.
6. An aggregate, sounding and with sense organ : 10 atoms as in (3) + (1)atom of *s'abda* = 11 atoms.

Therefore, the aforesaid combination of 8, 9, 10 and 11 atoms by Jain atomist clearly indicates that they were well aware of various probability of chemical combinations or valency by which molecular compounds are formed in the nature.

It is now clear that Indian atomism was much more than a somewhat passing episode as it was in Greece not to speak of the ancient-Chinese tradition where the atomic hypothesis never took any real root at all. By contrast beginning from a very ancient time, it played an imaginatively long innings in *Nyāya-Vaiśeṣika* and Jain schools of Indian thought.The outstanding idealist philosopher like *Vasubandhu*[32] (*c.* 5th century AD) and others did their best to refute and reject it with sharp and sophisticated logics. But these could not annihilate the enthusiasm for atomism without any experimental background, only because highly talented logic with a commitment of naturalistic explanation of the material world went on defending it with amazing tenacity and counter sophistication. The defence of atomism therefore specially in the nature philosophy of *Nyāya-Vaiśeṣika* and Jain *Ajīvakas*[33] stretched over many centuries seems to be a unique feature of a scientific tradition of ancient India. In a sense this continued upto the latest representation of traditional Indian ethos. One is tempted to mention in this connection a legend about the famous philosopher Gadādhar of 17th century AD, who was in this death bed, and his followers wanted him to remember God as the world-cause, for according to Indian orthodoxy this would have ensured heaven for his soul. But Gadādhar refused to do so and his dying words said to be *pilu pilu* means--atoms, atoms.

NOTES AND REFERENCES

1. He was an Acārya of *Taittīreya Āraṇyaka,* who wrote a commentary on *Nyāya sūtra* of Gautama. As per Hemaclandra, he was contemporary to Cāṇakya, but it is unsubstantiated, therefore scholars are of opinion that he belonged to 5th Century AD.

2. He was the commentator of *Vātsyāyana* on *Nyāya sūtra* of Gautama. He contradicted the thought of Buddhist philosopher Diṅnāga, author of *"Pram ānsā muchāya".*

3. The *Nyāya* School was essentially a school of logic maintaining the view that clear thinking was an essential preliminary of salvation. This school evolved, about the beginning of the Christian era, a system of syllogistic logic which seems to have been quite independent of the Aristotelian system which conditioned the thoughts of Europe. Aristotle (384-322 BC) was a Greek philosopher, pupil of Plato, after whose death in 347 BC. he left Athens to become tutor of the young prince Alexander of Macedonia. In six systems of Indian philosophy, Nyāya (logic) school in linked with *Vaiśeṣika* school, therefore they are in pairs as complementing each other known as *Nyāya-Vaiśeṣika* school. The *Vaiśeṣika* school was based on a system of atomism, explaining cosmic process in which the soul was involved.

4. In modern physics, atom is the smallest part of an element that can exist and possesses its physical and chemical properties. Atoms consist of a small dense nucleus of protons (positive charge) and neutrons (electrically, uncharged) surrounded by moving electrons (negative charge). The number of electron equals to the number of protons so the overall charges of the atom is zero.

5. Molecule is one of the fundamental units forming a chemical compound; the smallest part of a chemical compound that can take part in a chemical reaction. It can be divided into ion - atoms both of +ive and -ive charges.

6. Ether is a hypothetical medium once believed to be necessary to support the propagation of electro magnetic radiation in space. It is now regarded as unnecessary and in modern theory, electromagnetic radiation can be propagated through empty space. The existence of the ether was first called into question as a result of the Michel -Morley experiment.

7. Kaṇāda, whose Gotra was Kāś yapa, propounded the *Vaiśeṣika* philosophy and also propounded the theory a *kaṇā* , not molecule but atom, in modern concept, which is the basic material of a matter whose physical and chemical character varied from one to another matter.

8. The concept of periodic law was first proposed in 1896 by the Russian chemist Dimitri Mendeleev (1834-1907) using relative atomic mass rather than proton number as a culmination of efforts to rationalise chemical properties by I.W. Doberiner (18 17), J.A.R. Newlands (1863) and Lothar Meyer (1864).

9. Sir J.J. Thomson (1856-1940), Physicist and Mathematician, Master of Trinity College, Cambridge from 1918-1940 and Cavendish Professor of experimental physics at Cambridge from, 1884- 1919 was awarded Nobel Prize in 1906 for his work on conduction of electricity through gases and also discovered the electron.

10. Since the electrons emerge from matter, they are presumably parts of atoms. The relation between the negative electrons and the positively charged currents of matters was elucidated by the great experimenter Lord Rutherford and the great theoretician Niels Bohr. Their work, just before the first world war (1914-1918), showed that the positive charge, together with almost of all mass, is concentrated in the central core or nucleus of the atom about which the very light weight electrons revolve. The diameter of an atom is about 10 cm., roughly, one-three hundred millionth part of an inch. The central nucleus has a diameter about 10,000 times smaller still. The nucleus and the electrons hold together because of the electric attraction between them.

11. The *Pilupākavāda* theory of *Nyāya-Vaiśeṣika* enshrined that before the chemical action, the constitutent parts of the element are very loosely connected, but after it, those loosely connections become quite hard. Both the loose and hard connec tions, being mutually opposed, cannot simultaneously remain in the same subbtratum. Hence, it has to be assumed that the old structure is destroyed and a fresh new one is produced

in its place (*Kandalī* p. 109; *Kandalī* was a commentary on *Praśastapāda-bhāṣya* authored by Srīdharācārya).

12. This phenomenon in modern physics is called as endothermic (denoting a chemical reaction that takes heat from its surroundings) and exothermic (denoting a chemical reaction that gives out energy).

13. He was a champion of *Nyāya* School of Indian philosophy. By his logic in *Kusumānjalī,* he proved the existence of God and criticized the Buddhist atheists.

14. The primary germ of nature is indistinct or the primordial element or productive principle from which all the phenomenon of the material world developed. In spiritual concept it is applied for Brahmā as well as for soul too.

15. In the term of physics *paramāṇu* means atom, which is the smallest part of an element that can exist and its mass is always expressed in relative terms called as atomic mass unit, which is equal to 1 /12 of the mass of an atom of the isotope carbon-12, and is equal to 1.66033×10^{-27} kg. This unit superseded both the physical and chemical mass units based on oxygen-16 and sometimes called the unified mass unit.

16. Among the Buddhist, we find both the opposing groups, the atomists and the anti-atomists. The *Hīnayāna* (comprising the two schools of *Sautrāntika* and *Vaibhāṣika)* are atomists while *Mahāyāna* (comprising the two schools of *Mādhyamika* and *Yogacāra)* on the other hand reject the reality of external world, therefore, they were anti-atomists. The school of *Mahāyāna,* particularly criticised the atomic theory in a very strong term.

17. A British scientist John Dalton (1766-1844) propounded his atomic theory for chemical combination by which all elements consist of indivisible particles called an atom which can neither be created nor destroyed. 'Compound elements' (i.e. compound) are formed when atoms of different elements join in simple ratios to form compound atoms (i. e. molecules).

18. Thermodynamics is the study of the laws that govern the conservation of energy from one form to another, the direction in which heat will flow, and the availability of energy to do work. It is based on the concept that in an isolated system anywhere in the universe there is a measurable quantity of energy called the internal energy (u) of the system which is the total kinetic and potential energy of the atoms and molecules of the system of all kinds that can be transferred directly as heat; it, therefore, exclude chemical and nuclear energy. The value of internal energy can only be changed if the system ceases to be isolated.

18a. M. L. Barker (ed.), *Pears Encyclopaedia*, pp.16-17 (Kent, 1968).

19. In covalent compounds it is equal to the number of bonds formed by sharing of electrons; in O_2, both oxygen have a valency of 2, in CO_2 carbon have a valency of four, shared by 2 x 2 valency of oxygen.

20. It is equal to the ionic charges in an ionic compound; for examples, in Na_2S, sodium has a valency of 1 (Na^+) and sulphur a valency of 2(S^{-2}); in NaCI, sodium has a valency of 1 (Na^+) and chlorine has a valency of 1 (Cl^{-1}); in $CaCl_2$, calcium has a valency of 2 (Ca^{++}) and chlorine a valency of 1 (Cl^{-1}).

21. Molecule is one of the fundamental units forming a compound; the smallest part of a chemical comound that can take part in a chemical reaction. In most, covalent compounds (by sharing of electrons), molecule consists of groups of atoms held together by covalent or coordinate bonds. Covalent substance that form macromolecular (in a sense, the whole crystal is a molecule). Similarly ionic compounds do not have single molecules being collection of oppositely charged ions.

22. *Dvyad* in *Nyā̃ya-Vaiśeṣika* is a type of molecule, which is formed by the combination of two atoms by covalent bond and not by electrovalent bonding.

23. *'Adṛṣṭa'* is a energy level, which is a definite fixed energy that a molecule, atom, electron or nucleus can have. In an atom, for example, the atom has a fixed energy corresponding to the orbital in which its electrons moved around the nucleus. The atom can accept a quantum of energy to become an excited atom, if that extra energy could raise an electron to a permitted orbit. Between the ground state, which is the lowest possible energy level for a particular system, and the first excited state there are no permissible energy levels. According to the quantum theory, only certain energy levels are possible. An atom passes from one energy level to the next without passing through fractions of that energy transition. These levels are usually described by the energies associated with the individual electrons in the atoms, which are always lower than an arbitrary level for a free electron. The energy level of molecules also involved quantized vibrational and rotational motion.

24. *Pudgala* means matter, which included solid liquid and gas. Solid is a state of matter in which there is a three dimensional regularity of structure, resulting from the proximity of the component atoms, ions or molecules and the strength of the force between them by crystal lattice energy. Liquid is a phase of matter between solid and gas in which the large-scale three-dimensional atomic or ionic or molecular regulatory of the solid is absent but, on the other hand, show the total disorganisation of the gas. The average distance between particles in air is about 10 times that in ordinary solids, and air particles have an average speed of 5×10^4 cm/sec.

25. *Paramāṇu* is the utlimate and fundamental particle of *pudgala* or, *dravya* which posses all the properties of the *pudgala.*

26. In Jain text *pradeśa* was used both for point and particles and it is a space (volume) which is occupied by *paramāṇu.*

27. As per Jains view, the *pudgala* are of four types of elements — namely earth, water, fire and air—also are atomic. They have 100 kinds of properties, natural *(svabhova)* and derived *(upadaya).* The natural properties of the four are respectively: solidity

(*khara*), viscidity *(sneha),* heat *(uṣma)* and motion *(irana).* Because of the presence of such specific properties in them each is capable of a special function also. Thus, because of solidity, earth holds or acts as a support of other things *(dhriti)* e.g. the jar holds water. Because of viscidity, water causes cohesion *(saṃ graha),* e.g. grains of flour form a lump when water is poured into them. Because of heat, fire gives rise to chemical transformation *(pakti)* e.g. black unbaked jar turns red when put into fire. Because of motion, air causes displacement and growth *(vyacana- prasārpaṇa* and *vṛddhi)* e.g. a blade of grass is carried away by the wind or they separate gradually, grow into a plant due to influence of water and air.

28. Hiuen Tsiang, *Si-yu-ki*, i. 60; In Purānic measures 8 *paramāṇu* =1 *para-sukṣam* (Wilson, *Vishnu Purana*, 1.93n), H. J. J. Winter, *Eastern Science* (London, 1952) pp. 47-52

29. S.S. Barlingay, *A Modern Introduction to Indian Logic,* (New Delhi, 1976), p.67.

30. Y. J. Padmarajiang, *Jaina Theories of Reality and Knowledge,* (Bombay 1963), pp. 22-24.

31. N. Tatia, *Studies in Jaina Philosophy*, (Banaras, 1951), pp.29-41; A.B. Keith, *Indian Logic and Atomism*, (Oxford, 1921), p.67.

32. *Vasubandhu* was a *Hīnayāna* Buddhist philosopher who wrote *'Abhidharma-kośa'* or *Treasury of the Abhidharma*, a work which represents the culmination of *Hīnayāna* in the 5th Century AD.

33. *Ajīva,* means non-living substance or matter *(pudgala)* also possesses a sense quality. Earth, water, fire and air are gross forms of matter, the individual ultimate unit is the atom or *aṇu*. The next two types of non-living substance are *dharma* and *adharma,* the principles of motion and rest. These two terms are used in Jain *ajīvaka* in this special sense, which should be distinguished from their usual meaning — imperceptible and all - pervasive. Therefore, *Ajīvakas* were the champion of atomism in Jaina philosophy.