CHAPTER FOUR

FINDINGS

4.0 Introduction

Chapter four illustrates the findings of the research into the semantic relations of chemistry texts. The results of the scanning and analysing stages of the study are presented in lexical analyses. Lexical analyses which display the semantic relationship between cohesively related lexical items of the two chemistry chapters studied are shown in Figures 4.1.1 to 4.1.7 (corresponding to subtopics 2.1 to 2.7 of the chapter "Atoms and The Atomic Theory") and Figures 4.2.1 to 4.2.10 (corresponding to subtopics 10.1 to 10.10 of the chapter "Gases").

A summary of the lexical analyses is also given in Tables 4.1.1 to 4.1.7 (corresponding to lexical analyses presented in Figures 4.1.1 to 4.1.7) and Tables 4.2.1 to 4.2.10 (corresponding to lexical analyses presented in Figures 4.2.1 to 4.2.10.) These tables classify the lexical strings whose semantic relations have been established under the sections of complexity, length and phoricity.

The classification of the lexical strings in terms of complexity is based on the theoretical construct outlined in chapter three. As stated in chapter one (section 1.2), chapter two (section 2.6) and chapter three(section 3.4), a lexical string is a set of taxonomically related items whose members are in a semantic relation with preceding and prospecting items. The classification of the lexical strings in terms of length and phoricity are based on general observations of the lexical strings. These classifications serve as convenient reference when one needs to know immediate details about the status of a lexical string in relation to other strings. The classification does not seek to explore the strength of the cohesive power of a string whose measurement is beyond the scope of the present analysis.

The complexity of a string depends on the number of lexical relations involved. A string is denoted simple when it is constructed in only one semantic relation and a string is denoted complex when it is constructed in more than one semantic relation ; a string which is constructed of only repetition relations is considered simple and a string which is constructed of both repetition and hyponymy relations is considered complex.

The strings may also be categorised according to their length across the text. A minor string is a relatively short string across the text which may be constructed in only a few or a number of cohering lexical items. Conversely, a major string runs across almost the entire text and may be constructed of a few or a number of cohering lexical items.

The term phoricity refers to the density of the lexical string. When the distribution of the majority of the cohesively related lexical items are close by each other such that they do not have many mediating sentences between them, the resulting string is said to be dense. On the other hand, when the cohering lexical items are distributed such that there are many mediating sentences, the string is classified as sparse or one which has its lexical items widely separated.

The lexical strings may also be subsumed under different semantic fields. There appears to be some overlap between one semantic field and another due to the narrow focus of each point in the analysis which is a subtopic. The semantic fields identified are entirely text-bound and are therefore context specific which means that each taxonomic analysis of the subtopic has its own set of semantic fields. However, the same semantic field may be realised in different taxonomic analyses. The categorisation of the lexical strings into various semantic fields facilitate the development of system networks in capturing the concepts expounded in a particular subtopic.

Specific references are made to selected extracts of the texts to observe the application of the theoretical construct to establish the semantic relations between lexical items. The extracts help to reconstruct how only the paradigmatically related lexical items which exert a cohesive influence in the text are coded in the formation of the string.

Finally, the results of the conceptualising stage shows how semantically related lexical items may be further exemplified to be related systemically in networks. The networks capture concepts of a particular idea or theory in chemistry. Semantically related lexical items are displayed as features and options. The motivated features and explicit options are made finer in distinction on a scale of delicacy or of more possible groupings of items. The scale of delicacy was explained in the preceding chapter in section 3.4. System networks for the chapter "Atoms and The Atomic Theory" are presented in Figures 4.1.a to 4.1.o and system networks for the chapter "Gases" are presented in Figures 4.2.a to 4.2.l.

4.1 **The Analysis of Chapter Two "Atoms and the Atomic Theory"**

(Petrucci & Harwood 1993)

The following taxonomic analyses and system networks relate to the contents of the subtopics of the chapter. The subtopic is the longest stretch of text examined at any one time of the analysis.

4.1.1 The analysis of subtopic 2.1 on "Early Chemical Discoveries and The Atomic Theory"

The taxonomic analysis of subtopic 2.1 on "Early Chemical Discoveries and The Atomic Theory" presented in Figure 4.1.1 on page 55 shows 14 lexical strings labelled L1 to L14.

Table 4.1.1 below illustrates an overview of the lexical strings from the perspectives of complexity, length and phoricity.

Table 4.1.1

Classification of Lexical Strings		
Complexity	**Length**	**Phoricity**
Simple: rep: L2,L3, L4,L8 L13 & L14	Minor: L1, L2 & L14	Sparse: L8 & L10
Complex: hyp/rep: L5 & L12 rep/syn: L1 mer/comer: L10 & L11 hyp/cohyp/rep: L6 & L9	Major: L1,L3, L4, L5, L6, L7, L8, L9 L10, L11,L12 & L13	Dense: L1, L2, L3, L4, L5, L6, L7, L9, L11, L12, L13 & L14

The taxonomic analysis organises the text around five semantic fields. The semantic field combustion organises strings L1 and L2, semantic field fundamental concepts organises strings L3, L4, L5, L6, and L7, semantic field formulation of laws organises strings L8, L9 and L10, semantic field chemical reaction organises string L11 and semantic field formulation of theory organises strings L12, L13 and L14.

A segment of the discourse of subtopic 2.1 from S1, to S17 will be used to explain how some lexical relations are arrived at.

Law of Conservation of Mass

(S1) The process of combustion - burning - is so familiar it is hard to realize what a difficult riddle this posed for early scientists. (S2) Some of the difficult-to-explain observations are described in Figure 2-1.

(S3) In 1774, Antione Lavoisier (1743-1794) performed an experiment in which he heated a sealed glass vessel containing a sample of tin and some air. (S4) He found that the mass before heating (glass vessel + tin + air) and after heating (glass vessel + tin calx + remaining air) were the same. (S5) Through further experiments he showed that the tin calx (we now call it tin oxide) consisted of the original tin together with a portion of the air. (S6) Experiments such as this proved to Lavoisier that oxygen from air is essential to combustion and also led him to formulate the **law of conservation of mass.** (S7) *The mass of substances formed by a chemical reaction is the same as the mass of substances entering into the reaction.*. (S8) Stated another way, this law says that matter can neither be created nor destroyed in a chemical reaction.

Law of Constant Composition

(S9) In 1799, Joseph Proust (1754-1826) reported that "One hundred pounds of copper, dissolved in sulfuric or nitric acids and precipitated by the carbonates of soda or potash, invariably gives 180 pounds of green carbonate." (S10)" This and similar observations became the basis of the **law of constant composition or the law of definite proportions:** (S11) *All samples of a compound have the same composition - the same proportions by mass of the constituent elements.*
(S12) To see how the law of constant composition works, consider the compound water. (S13) Water is made up of two atoms of hydrogen (H) for every atom of oxygen (O) a fact that can be represented symbolically by a *chemical formula*, the familiar H_2O. (S14) The two samples described below have the same proportions of the two elements, expressed as percentages by mass. (S15) To determine the percent by mass of hydrogen, for example, simply divide the mass of hydrogen by the sample mass and multiply by 100%. (S16) For each sample you will obtain the same result: 11.19% H.

Dalton's Atomic Theory

(S17) From 1803 to 1808, John Dalton, an English schoolteacher, used the two fundamental laws of chemical combination that we have just described as the basis of an atomic theory. (S18) His theory involved three assumptions.

The most complex lexical strings are L6 and L9 which are analysed as hyponymy, cohyponymy and repetition relations. One instance of the realisation of a hyponymy in L9 is between the superordinate term "law" (S8) and the specific term "law of conservation of mass" (S6). "Law" in this instance refers anaphorically to "law of conservation of mass" through an overtly displayed cohesive signal, the demonstrative "this" (S8). Likewise, "fundamental laws"(S17) refers retrospectively to "law of constant composition" (S12) forming a semantic relation of the hyponymy kind through the presence of the reference item "the" (S17). However, this is not a necessary condition for the recovery of a lexical item. An example of the absence of a reference item or demonstrative for the recovery of a lexical item is in L5 where “substance” (S7), a superordinate term is cohesively related to “tin calx” (S5) through a relation of hyponymy. This relation is not linguistically signalled but was arrived at through the use of domain knowledge, in this case knowledge of chemistry, that tin calx is a kind of substance.

One typical example where a lexical item is repeated in the same form but which specifies a different entity is found in L6. In L6, the lexical item “oxygen”(S6) which denotes an element entering a chemical reaction, is semantically tied to “oxygen”(S13), which is one of the elements forming the compound water; the other element is “hydrogen”(S13). Although they refer to different entities, one as a participant in a chemical reaction (oxygen of S6) and the other as part of the building blocks of a compound (oxygen of S13), they are both used as examples to illustrate the meaning of the lexical item element, one of the fundamental terms in chemistry. Therefore, the presence of oxygen (S6) and oxygen (S13) may be recognised as exerting a cohesive influence in the text. An element is different from a compound (another fundamental term) because of its chemical composition. Incidentally, hydrogen (S13) is also cohesively linked to oxygen (S7) along the paradigmatic dimension but oxygen (S13) is the preferred lexical item to be coded onto the lexical string. When a choice had to be between the relationship of repetition and cohyponymy the preference was for coding the relationship of repetition. I made this decision based on the higher frequency of the manifestation of repetition relations in the texts analysed.

One example of the preference of a repetition relation over a synonymy relation is observed in L1. "Heating" (S4) is cohesively tied to "heated" (S3) through a relation of repetition, Both are derivational variants of the same lexeme "heat." Other examples observed are in L4 of the lexical item "sample" and in L13 of the lexical item "assumption." However, an instance when a lexical item or lexical phrase is repeated identically is found in L3 of the item "mass" and in L8 of the item "can neither be created nor destroyed."

Some elementary concepts introduced in subtopic 2.1 may be conceptualised in the following simple networks.

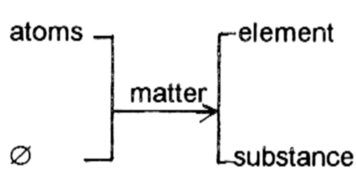


Fig. 4.1.a

The system in Figure 4.1.a has compound entry conditions atoms or ∅ (molecules) to motivate the features element and substance in chemistry. An element is a collection of atoms or molecules of one type. A substance is composed of a pure compound or a mixture of elements or a mixture of compounds.

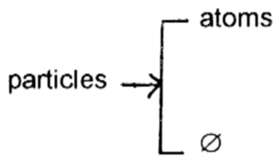


Fig. 4.1.b

The system network in Figure 4.1.b has the entry condition particles to motivate either the feature atoms or ∅. Atoms are fundamental particles of matter.

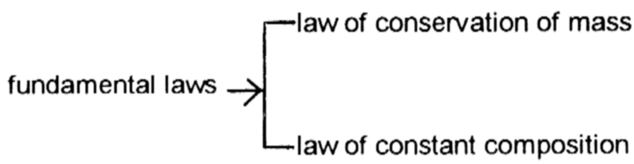


Fig. 4.1.c

The system network in Figure 4.1.c has the entry condition fundamental laws to realise either the feature law of conservation of mass or law of constant composition. The lexical phrase "law of conservation of mass" usually co-occurs with the lexical phrase "law of constant composition" in contexts concerning discussions on Dalton's Atomic Theory.

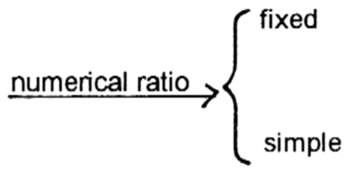


Fig. 4.1.d

The system network in Figure 4.1.d has the entry condition numerical ratio to realise the simultaneously occurring features simple and fixed. The elements in combination in a compound are always expressed in a simple, fixed, numerical ratio.

4.1.2 The analysis of subtopic 2.2 on “Electrons and Other Discoveries in Atomic Physics”

Continuing with the findings, the taxonomic analysis of subtopic 2.2 on “Electrons and Other Discoveries in Atomic Physics” presented in Figure. 4.1.2 on page 62 shows 18 lexical strings labelled L1 to L18.

Table 4.1.2 gives an overview of the lexical strings from the perspectives of complexity, length and phoricity.

Table 4.1.2

Classification of Lexical Strings

Complexity	**Length**	**Phoricity**
Simple: rep: L11 hyp: L7 syn: L15 ant: L17 & L18	Minor: L1, L4, L5, L7, L9 , L11, L15, L16, L17, & L18	Sparse: L2, L3, L6, L8, L9, L10, L12 & L14.
Complex: hyp/rep: L1,L4,L6,L12 & L16 cohyp/ant: L5 rep/syn: L9 rep/ant: L10 cohyp/rep/syn: L13 cohyp/rep/mer: L14 hyp/rep/syn/ant: L2 hyp/rep/ant/mer: L3 hyp/cohyp/rep/syn/mer: L8	Major: L2,L3,L6,L8,L10,L12 L13 & L14	Dense: L1,L4,L5,L7,L11 L13,L15,L16,L17 & L18

The vocabulary of the text is organised into 6 semantic fields resulting in the construction of the 18 lexical strings. Semantic field charge organises the lexical items into strings L1, L2 and L3. The semantic field force organises the lexical items into strings L4 and L5. The semantic field force lines organises the lexical items into strings L6 and L7 and the semantic field atomic structure organises the lexical items into strings L14 and L15. Strings L16, L17 and L18 constitute the semantic field photographic film and the biggest semantic field radioactivity organises the lexical items into strings L8, L9, L10, L11, L12 and L13.

The most complex strings are L2, L3 and L8. L8 is constructed of three kinds of superordination relationships which are hyponymy, repetition and synonymy and one composition relationship which is meronymy. A segment of the discourse from S20 to S24 is presented to show how the complex relationships of repetition, synonymy and hyponymy are obtained for L8, how a simple string of repetition relations is obtained for L11 and how an instance of an ellipsis creates cohesion with a preceding item in L7.

(20) The first cathode ray tube was made by Michael Faraday (1791 - 1867) about 150 years ago. (21) In passing electricity through evacuated glass tubes, Faraday discovered cathode rays, a type of radiation emitted by the negative terminal or *cathode* that cross the evacuated tube to the positive terminal or *anode*. (22) Later scientists found that cathode rays travel in straight lines and have properties that are independent of the cathode material (i.e. whether it is iron, platinum, etc.) (23) As suggested by Figure 2-4, cathode rays are invisible and they can only be detected by the light emitted by materials that they strike. (24) (*Flouorescence* is the term used to describe the emission of light by a material when it is struck by energetic radiation.)

"Cathode material" (S22) refers anaphorically to "cathode ray tube" (S20) and is related through a relationship of synonymy. "Materials"(S23) a superordinate term refers retrospectively to the specific term "cathode materials" (S22) through a relationship of hyponymy. "Material" (S24) is a repetition of the inflectional variant "materials" (S23). Thus the complex relationship of synonymy, hyponymy and repetition form part of L8. The same segment may be used to explain the simple string L11. "Cathode rays" (S23) presupposes "cathode rays" (S22) which presupposes "cathode rays" (S21) and a series of repetition relations is formed in the construction of L11.

Lexical item "invisible" (S23) of the same extract is an instance of an ellipsis where it forms a cohesive bond with "straight lines" (S22).The lexical item "lines" is implied and has been left unsaid in S23. "Invisible" (S23) is considered a superordinate term and is related to "straight lines" (S22) through a relationship of hyponymy in L7.

The following segment from S7 to S14 shows how another complex relationship is obtained for L3.

(S7) Objects with like charges (either both positive or both negative) repel one another. as represented in Figure 2-2a.(S8) As shown in Figure 2-2c, objects with unlike charges (one positive and one negative) attract one another.(S9) The force *(F)* of attraction or repulsion is *directly* proportional to the magnitude or quantity of the charges (*Q1 and Q2*) and *inversely* proportional to the square of the distance between them (r^2). In mathematical terms

$$F \alpha \frac{Q1 \, . \, Q2}{r^2}$$

(S10) A positive force is a force of repulsion, and a negative force is bne of attraction. (S11) As we learn in section, all objects of matter are made up of electrically charged particles. (S12) An electrically *neutral* object has equal numbers of positve anfid negative charges. (S13) If the number of positive charges exceeds the number of negative charges, an object has a net *positive* charge. (S14) If negative charges exceed positive charges in number, an object has a net *negative* charge.

"Unlike charges" (S8) is opposite in meaning to "like charges" (S7) and thus an antonymy relationship is obtained. Similarly "net negative charge" (S14) is opposite in meaning to "net positive charge" (S13) giving rise to another relationship of antonymy. "Net positive charge" (S13) which is the whole has as its parts "positive and negative charges" (S12) and these are cohesively related through a meronymy relation. The lexical item "charges" (S9) which is of a higher level of generality refers anaphorically to "unlike charges" (S8) thus the occurrence of a hyponymy relationship.

The discourse may be further explicated to produce another relationship of antonymy between "repulsion" (S10) and "attraction" (S9) and between "attraction" (S10) and "repulsion" (S9). The antonymy relationship obtained constitutes part of L5. Parts of string L1 may be constructed through the specific term "electrically neutral object" (S12) which refers to the more general term "objects" (S11) forming a hyponymy relation. "Objects" (S11) is related to "objects" (S8) which is related to "objects" (S7) forming a string of identical repetitions.

The following system networks shown in Figures 4.1.e, 4.1.f, 4.1.g and 4.1.h capture the non-gradable lexical items in opposition.

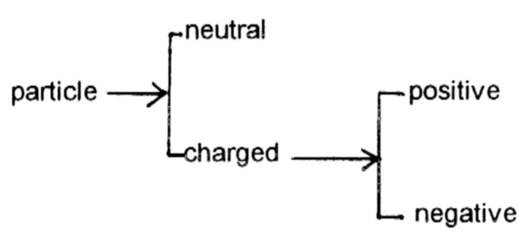


Fig. 4.1.e

The system network in Figure 4.1.e shows the entry condition particle which realises the features neutral and charged. The feature charged realises more delicate options which are positive and negative. Therefore, a particle may be electrically neutral or electrically charged. An electrically charged particle may be charged positively or negatively.

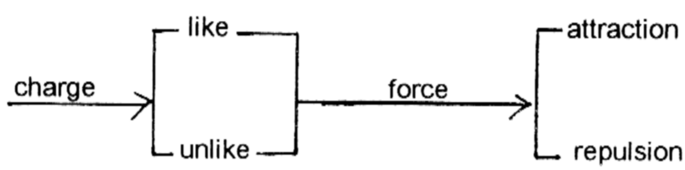


Fig. 4.1.f

The system charge in Figure 4.1.f has a compound entry condition of like or unlike charges. The system is made finer by the motivator "force" that realises the features attraction and repulsion. If either like charges or unlike charges is chosen, then either the feature attraction or repulsion is realised. Particles with unlike charges exert a force of attraction with each other and particles with like charges exert a force of repulsion with each other.

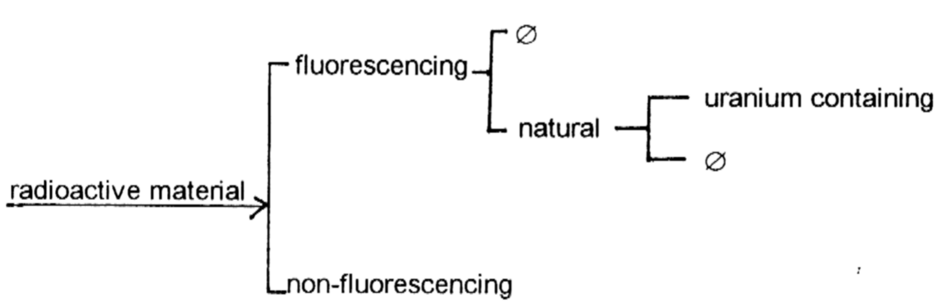


Fig. 4.1.g

Figure 4.1.g on page 67 shows the system radioactive material which captures the features fluorescencing and non-fluorescencing radioactive material in the initial stages of delicacy. The feature fluorescencing further forecloses the choices natural and ∅. The choice natural may be further abstracted to realise the options uranium containing and ∅ in a more delicate system. Radioactive material may be of the fluorescencing type or the non-fluorescencing type. Natural uranium-containing flourescencing type of radioactive material was used by the scientist Becquerel in his experiment on radioactivity.

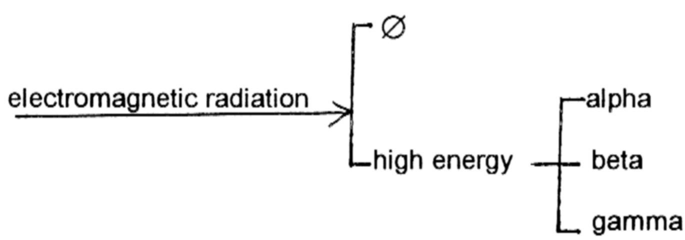


Fig. 4.1.h

In Figure 4.1.h the system electromagnetic radiation motivates the features ∅ and high energy. The feature high energy may be further abstracted to realise the features alpha, beta and gamma. Alpha rays, beta rays and gamma rays are three types of high energy electromagnetic radiation. When the radiation from a radioactive material is made to pass through an electric field, it separates or divides into three beams which are named alpha rays (positively charged particles), beta rays (negatively charged particles) and gamma rays (neutrally charged particles).

The following systems network shown in Figure 4.1.i exemplifies gradable lexical items in opposition.

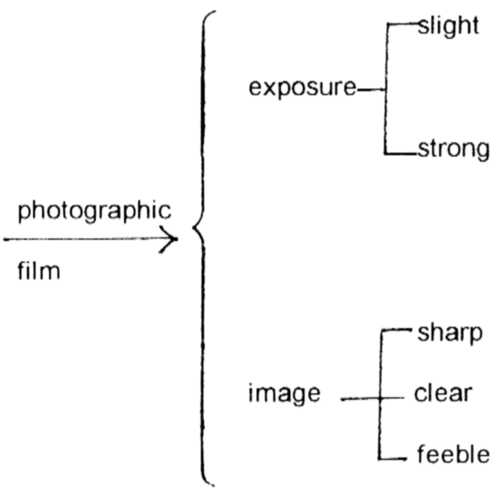


Fig. 4.1.i

The entry condition photographic film expounds the simultaneous entries exposure and image. The entry exposure motivates the features ∅ and strongly and the entry image motivates the features sharp, clear or feeble. A photographic film may experience a slight or strong exposure and the image formed may be denoted sharp, clear or feeble.

4.1.3 The analysis of subtopic 2.3 on “The Nuclear Atom”

To continue with the findings, the lexical organisation of subtopic 2.3 on “The Nuclear Atom” presented in Figure 4.1.3 on page 71 shows 11 lexical strings labelled L1 to L11.

Table 4.1.3 illustrates an overview of the lexical strings from the perspectives of complexity, length and phoricity.

Table 4.1.3

Classification of Lexical Strings		
Complexity	**Length**	**Phoricity**
Simple:	Minor:	Sparse:
rep: L2, L6 & L8 syn: L9 mer: L10	L6, L10 & L11	L2
Complex:	Major:	Dense:
hyp/rep: L3 hyp/ant: L4 syn/mer: L11 hyp/rep/ant: L7 hyp/cohyp/rep/syn: L1	L1,L2, L3, L4, L5, L7, L8 & L9	L1,L3, L4, L5, L6, L7, L8, L9 L10 & L11

The lexical items are organised around 5 semantic fields resulting in the construction of 11 lexical strings. The semantic field fundamental particles organises strings L1, L2, L5 and L7, semantic field deflections organises string L4, semantic field mass organises strings L6, L9, L10 and L11 and semantic field atomic structure organises strings L3 and L8.

The following extract from S2 to S11 is used to show how two instances of ellipses are cohesively related to preceding lexical items in L1 and how interesting gradable oppositions construct L4.

(S2) Based on Thomson's "plum pudding" model (recall Figure 2-8), Rutherford expected that a beam of alpha particles would pass through thin sections of matter largely undeflected. (S3) However, he believed that some alpha particles would be slightly scattered or deflected as they encounter electrons. (S4) By studying these scattering patterns, he hoped to deduce something about the distribution of electrons in atoms.

(S5) The apparatus used for these studies is pictured in Figure 2-10. (S6) Alpha particles were detected by the flashes of light they produced when they struck a zinc sulfide screen mounted on the end of a telescope. (S7) When Geiger and Ernest Marsden, a student, bombarded very thin foils with alpha particles, here is what they observed.

(S8) The majority of α particles penetrated the foil undeflected.
(S9) Some α particles experienced slight deflections.
(S10) A few (about one in every 20,000) suffered rather serious deflections as they penetrated the foil.
(S11) A similar number did not pass through the foil at all but "bounced back" in the direction from which they had come.
(S12) The large-angle scattering greatly puzzled Rutherford.

The most complex string is L1 formed of hyponymy, cohyponymy, repetition and synonymy relations. Lexical item "a few"(S10) which is an occurrence of an ellipsis is semantically related to "α particles"(S9) through repetition and "a similar number"(S11) which is another occurance of an ellipsis is also semantically related to "a few"(S10) through repetition. The lexical items "large-angle scattering"(S12), "bounced back"(S11) , "serious deflections"(S10), "slight deflections"(S9),"undeflected"(S8) , "slightly scattered"(S3) and "largely undeflected"(S2) are all gradable oppositions exerting a semantic continuity in the text. The following system network in Figure 4.1.j on page 74 captures the concept of the behaviours, movements and types of fundamental particles of matter in an electric field.

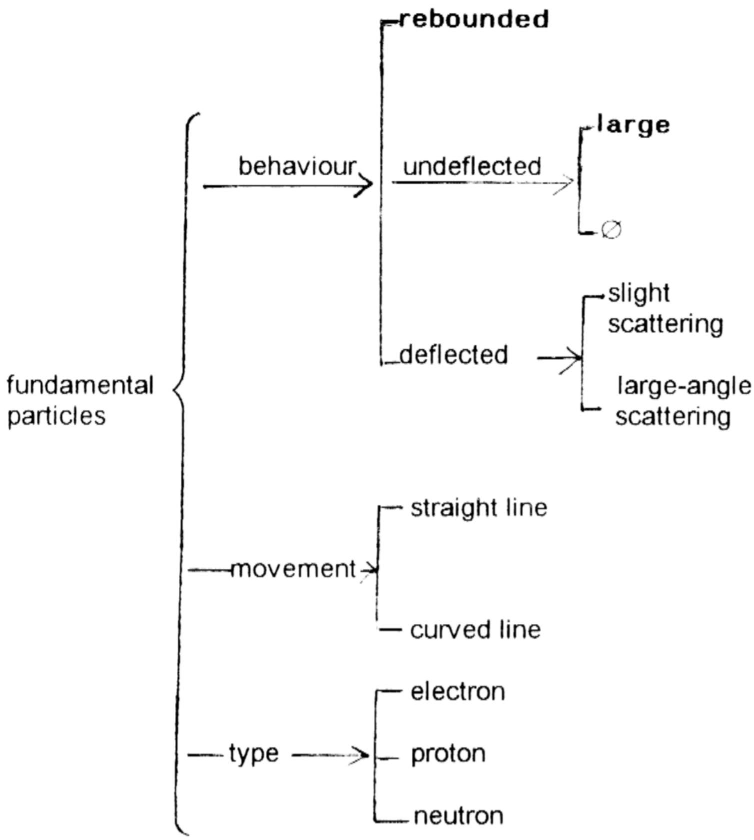


Fig. 4.1.j

The system fundamental particles has simultaneous entry conditions behaviour, movement and types. The entry behaviour motivates the features rebounded , undeflected and deflected. The feature undeflected can be made more delicate by abstracting the options largely and ∅. The feature deflected can also be made more delicate by abstracting the options slight scattering and large-angle scattering. The entry movement motivates the features straight line and curved line and does not abstract any more delicate options. The entry type motivates the features electron, proton and neutron and also does not abstract any more delicate options. Electrons, protons and neutrons are the subatomic particles of an atom. In an electric field, fundamental particles exhibit three kinds of behaviours. They may be deflected, undeflected or they may bounce back. The deflected ones may be slightly scattered or may experience large-angle scattering. There may also be a large number of particles which are undeflected. The particles either move in a straight line or they move in a curved line in an electric field.

4.1.4 The analysis of subtopic 2.4 on "Chemical Elements"

Continuing with the findings, the taxonomic analysis of subtopic 2.4 on "Chemical Elements" presented in Fig. 4.1.4 on page 76 shows 16 lexical strings labelled L1 to L16.

Table 4.1.4 below gives an overview of the lexical strings from the perspectives of complexity, length and phoricity.

Table 4.1.4

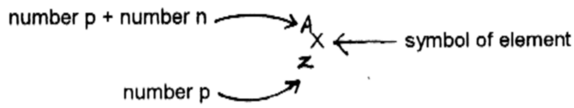
Classification of Lexical Strings

Complexity	**Length**	**Phoricity**
Simple: hyp: L14 & L15 rep: L3,L4,L5,L6,L8,L9, L16 & L17	Minor: L14,L15,L16 & L17	Sparse: L3,L4,L5,L6, L8,L9 & L11
Complex: hyp/rep: L2 & L7	Major: L1,L2,L3,L4,L5,L6,L7, L8,L9,L10,L11,L12 & L13	Dense: L1,L2,L7,L10, L12,L13,L14 L15,L16 & L17
cohyp/mer: L8 rep/syn: L11 hyp/cohyp/rep: L12 & L13 hyp/cohyp/rep/mer: L1		

The text organises its lexical items into 7 semantic fields of which L1 is a member of the semantic field chemical elements, L2, L12, L13 and L17 are members of the semantic field isotopes, L7 and L8 of the semantic field symbols and names, L6, L9, L10 and L16 of mass number, L3, L4, L5 and L11 of atomic structure, L14 of charge and L15 of energy.

The most complex string is L1 which is associated with hyponymy, cohyponymy, repetition and meronymy relations. The following segment of the discourse from S15 to S22 is used to explain how some of the relationships are obtained.

(S15) By this scheme element 106 is named "unnilhexium" and has the symbol Unh. (S16) Some nuclear scientists do not care for this system and simply use atomic numbers in place of names for atoms with atomic number greater than 100.
Isotopes
(S17) To represent the composition of any particular atom we need to specify the number of protons (p), neutrons (n), and electrons (e) in the atom. (S18) We can do this with a symbolism



(2.1)

(S19) This symbolism indicates that the atom is of the element X. (S20)It has an atomic number Z and a mass number A. For example, an atom of aluminium represented as $^{27}_{13}$Al has 13 protons and 14 neutrons in its nucleus and 13 electrons outside its nucleus. (S22) Contrary to what Dalton thought, we now know that atoms of an element do not necessarily all have the same mass.

"Element" (S22) is the superordinate term for "aluminium" (S21), "element X" (S19) and "element 106" (S15). "Symbolism" (S19) refers anaphorically to "symbolism" (S18) forming a a relationship of repetition in L7. "Atoms" (S22), "atom" (S21), "atom" (S19) and "atom"(S17) also form a string of repetition relations to construct L2.

Two instances of ellipses are found in the segment from S36 to S39.

(S36) The number of protons never changes when an atom becomes an ion. (S37) Ne and Ne are ions. (S38) The first one has ten protons, ten neutrons, and nine electrons. (S39) The seond one has ten protons, 12 neutrons, and eight electrons.

"The first one"(S38) presupposes "ions"(S37) for its interpretation. Likewise "the second one"(S39) presupposes "ions"(S37) for its interpretation. These constitute L13 and are assigned the relationship of repetition.

The following system network captures lexical items which are in opposition but of the non-gradable kind.

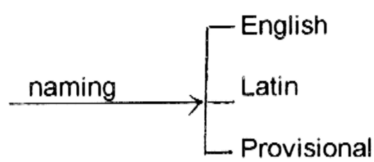


Fig. 4.1.k

In Figure 4.1.k the entry condition naming realises the features English, Latin and Provisional. Chemical elements may be ascribed English, Latin or Provisional names. Some elements have symbols based on their English names such as O for oxygen and S for sulfur whereas some elements have symbols based on their Latin names such as Fe for iron and Pb for lead. The Latin name for iron is ferrum and the Latin name for lead is plumbum. The use of provisional names was suggested by the International Union of Pure and Applied Chemistry for newly discovered elements. For example, the element 106 was given the provisional name "unnilhexium."

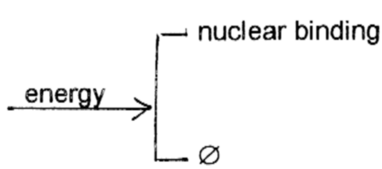


Fig. 4.1.l

In Figure 4.1.l on page 79, the entry condition energy realises the features nuclear binding and ∅. Nuclear binding energy is the energy that holds individual atoms together in an atomic nucleus.

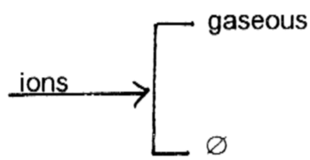


Fig. 4.1.m

In Figure 4.1.m the entry condition ions realises the features gaseous and ∅. An ion may be in a gaseous state or some other state of matter (liquid or solid). A gaseous ion is a gas atom which has either lost or gained electrons.

4.1.5 The analysis of subtopic 2.5 on “Atomic Masses”

To continue with the findings, the taxonomic analysis of subtopic 2.5 on “Atomic Masses” presented in Fig. 4.1.5 on page 81 shows 6 lexical strings labelled L1 to L6.

FIG. 4.1.5 THE TAXONOMIC ANALYSIS OF SUBTOPIC 2.5 ON "ATOMIC MASSES"

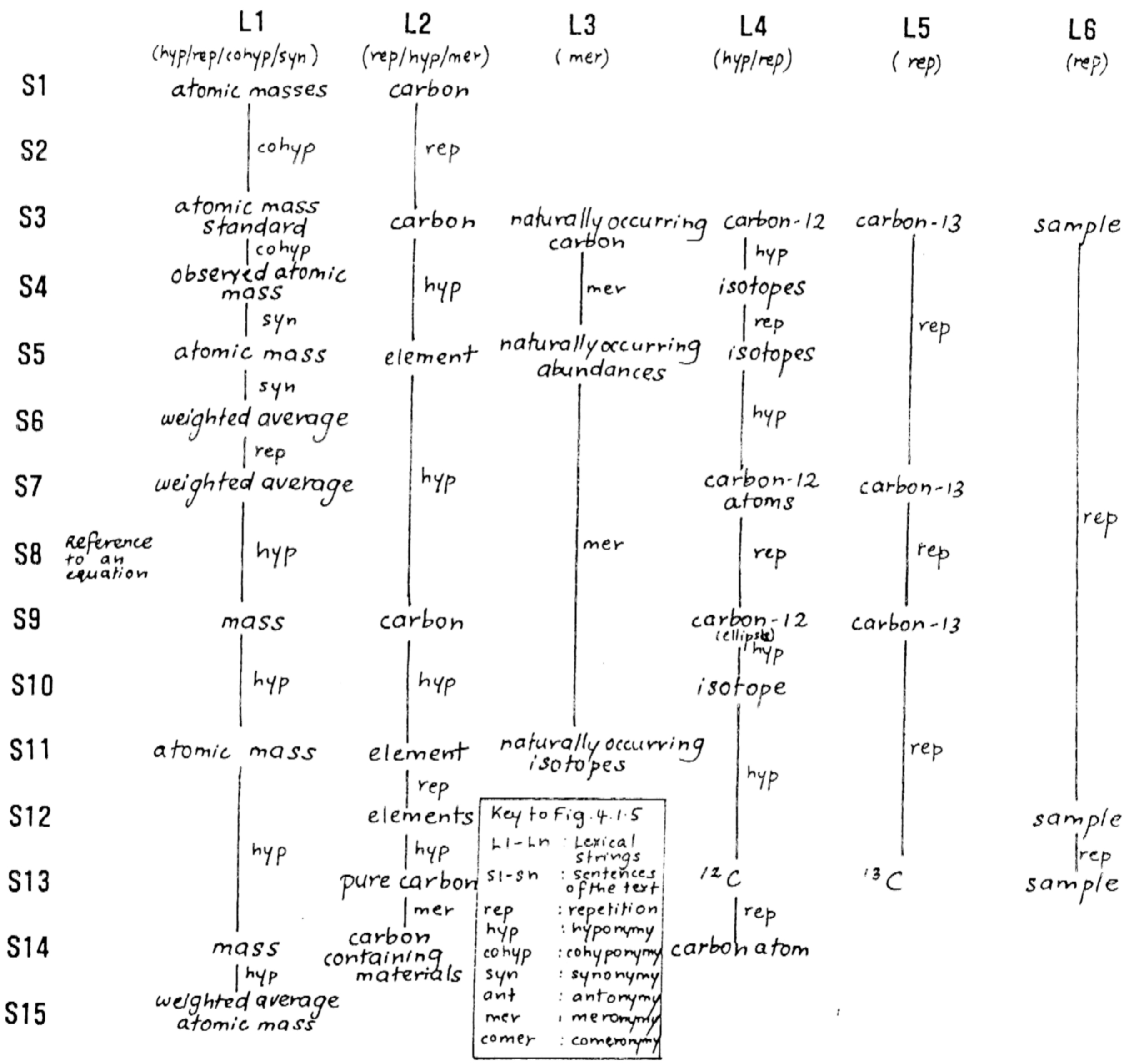


Table 4.1.5 below illustrates an overview of the lexical strings from the perspectives of complexity, length and phoricity.

Table 4.1.5

Classification of Lexical Strings		
Complexity	**Length**	**Phoricity**
Simple:	Minor:	Sparse:
rep: L5, L6 mer: L3	none	L3 & L6
Complex:	Major:	Dense:
hyp/rep: L4 hyp/rep/mer: L2 hyp/cohyp/rep/syn: L1	L1,L2,L3, L4,L5 & L6	L1, L2, L4 & L5

The text organises its lexical items into 4 semantic fields. Strings L1 is identified with semantic field mass, strings L3, L4 and L5 with semantic field isotopes, string L2 with semantic field element and string L6 with semantic field sample.

The following extract from S1 to S6 of subtopic 2-5 shows how some significant relationships are identified to form L1.

(S1) In a table of atomic masses the value listed for carbon is 12.011 yet the atomic mass standard is *exactly* 12. (S2) Why the difference? (S3) The atomic mass standard is based on a sample of carbon containing *only* atoms of carbon - 12, whereas *naturally occurring* carbon contains some carbon-13 atoms, as well. (S4) The existence of these two isotopes causes the *observed* atomic mass to be greater than 12. (S5) The atomic mass (weight) of an element is the average of the isotopic masses *weighted* according to the naturally occurring abundances of the isotopes of the element. (S6) In a "weighted" average we must assign greater importance- -give greater weight--- to the quantity that occurs more frequently.

In the absence of overtly explicit cohesive signals to relate one lexical item to another, domain knowledge is the guiding principle in establishing lexical relations. "Weighted average"(S6) presupposes "atomic mass"(S5) in order to make sense. "Atomic mass"(S5) presupposes "observed atomic mass"(S4) in order to make sense. The lexical items "weighted average", "atomic mass" and "observed atomic mass" are synonyms realising the same concept that the weight of the sample is an average of the weight of the isotopes contained in it. "Observed atomic mass"(S4) and "atomic mass standard"(S3) may be considered non-gradable oppositions. They are also cohyponymys of a superordinate term "mass" as both are ways of expressing the mass of atoms. The non-gradable opposition constructing part of L1 is captured in the following system network.

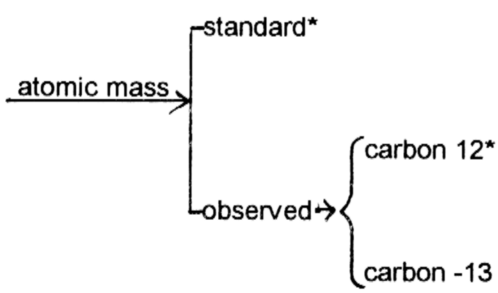


Fig. 4.1.n

The entry condition atomic mass realises the features standard and observed. The feature observed enters a second system to realise the simultaneous features carbon-12 and carbon-13 of simultaneous entries. The symbol * means that if the feature standard is chosen then only carbon-12 is realised. If the feature observed is chosen then both carbon-12 and carbon-13 are realised. The standard atomic mass of carbon takes account of only the mass of carbon-12 isotopes whereas the observed atomic mass of carbon takes the mass of both carbon-12 and carbon-13 isotopes into consideration.

There are two ways in which the mass or weight of a sample is described in chemistry which are the standard atomic mass or the observed atomic mass. A sample of carbon atoms contain two kinds of isotopes, carbon-12 and carbon-13. The standard atomic mass value for carbon is exactly 12 whereas the observed atomic mass value for carbon is 12.011u(u=atomic mass unit). The atomic mass standard is a denotation of the weight of the sample of carbon atoms assuming that the sample contains only carbon-12 atoms. On the other hand, the observed atomic mass of the sample is the average weight of both carbon-12 and carbon-13 atoms which is a much more precise value. The observed atomic mass is also known as the weighted average atomic mass.

4.1.6 The analysis of subtopic 2.6 on “The Avogadro Constant and the Concept of The Mole”

Continuing with the findings, the lexical items of subtopic 2.6 ”The Avogadro Constant and the Concept of The Mole” is organised around 6 lexical strings labelled L1 to L6 as shown in Fig. 4.1.6 on page 86.

FIG. 4.1.6 THE TAXONOMIC ANALYSIS OF SUBTOPIC 2.6 ON "THE AVOGADRO CONSTANT AND THE CONCEPT OF THE MOLE"

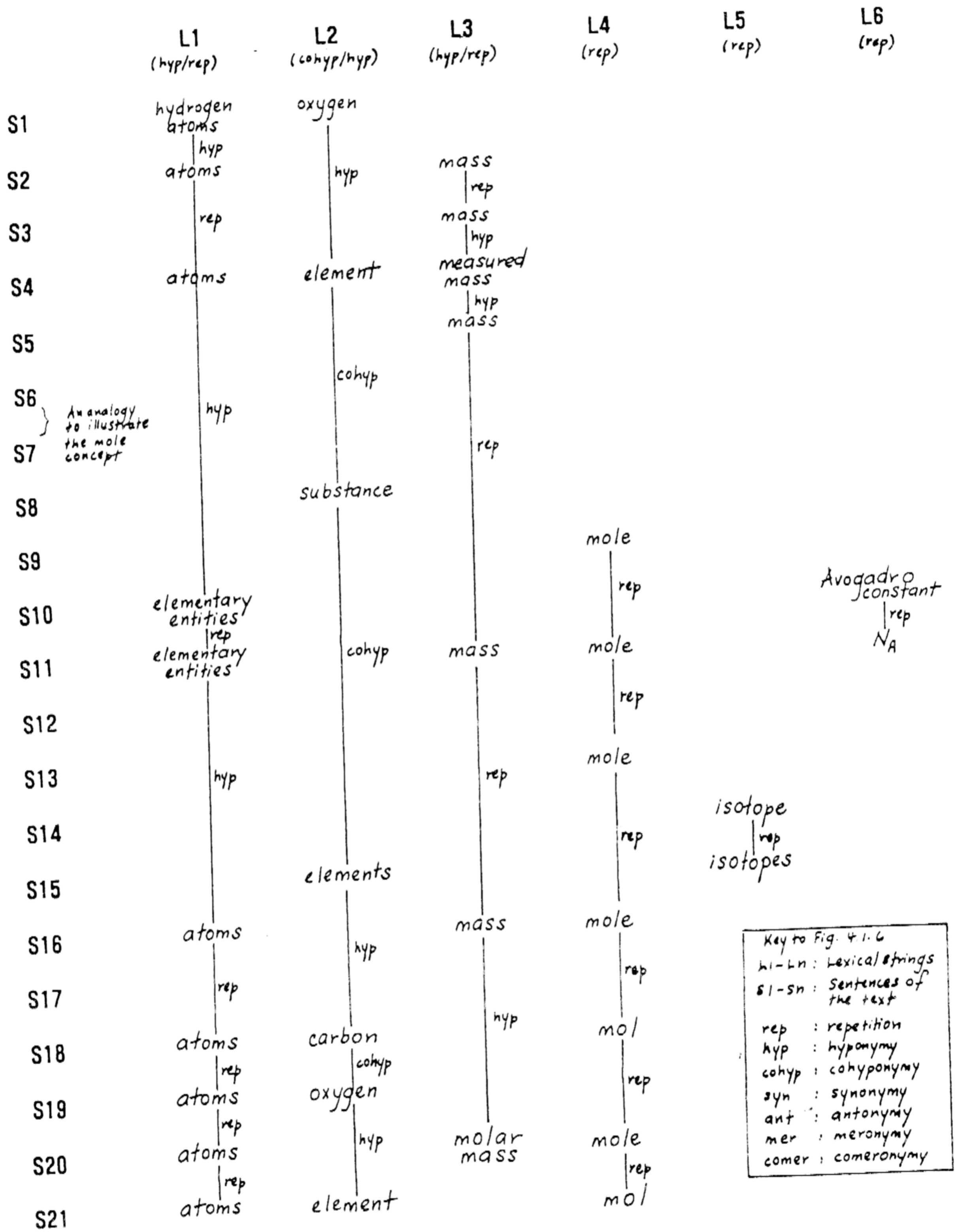


Table 4.1.6 below illustrates an overview of the lexical strings from the perspectives of complexity, length and phoricity.

Table 4.1.6

Classification of Lexical Strings		
Complexity	**Length**	**Phoricity**
Simple:	Minor:	Sparse:
rep: L4, L5 & L6	L5 & L6	none
Complex: hyp/rep: L1 & L3 hyp/cohyp: L2	Major: L1, L2, L3 & L4	Dense: L1, L2, L3, L4, L5 & L6

The text organises its lexical items into 3 semantic fields. Lexical strings L3 and L4 are members of the semantic field mole concept, L1, L2 and L5 of semantic field elementary entities and L6 of the semantic field Avogadro constant.

The following system network captures mass as entry condition to realise the three contrastive features standard, measured and molar. The mass of an atom may be expressed as standard mass, measured mass or molar mass. The <u>standard mass</u> is the mass of an element usually used in calculations. It assumes that a sample contains only atoms of a single isotope. The mass of atoms measured using a mass spectrometry accurately establishes the isotopic masses of the atoms. The <u>measured mass</u> is also known as the observed mass or weighted average mass. The mass of one mole of atoms is called the <u>molar mass</u>. For example, the molar mass of carbon is the mass of one mole of carbon atoms which contain 6.022124 x 10 atoms of carbon.

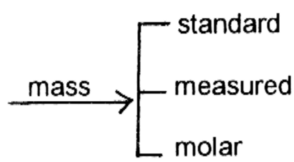


Fig. 4.1.o

4.1.7 The analysis of subtopic 2.7 on "Using the Mole Concept in Calculations"

To continue with the findings, the taxonomic analysis of subtopic 2.7 on "Using the Mole Concept in Calculations" is organised around 8 lexical strings labelled L1 to L8 as shown in Figure 4.1.7 on page 89.

Table 4.1.7 gives an overview of the lexical strings from the perspectives of complexity, length and phoricity.

Table 4.1.7

Classification of Lexical Strings

Complexity	**Length**	**Phoricity**
Simple:	Minor:	Sparse:
hyp: L8 cohyp: L3 & L7 rep: L4, L5 & L6	L3, L5, L6 & L7	L4, L5, L6 & L8
Complex: hyp/rep: L2 rep/mer: L1	Major: L1, L2, L4 & L8	Dense: L1, L2, L3 & L7

The text organises its vocabulary into one semantic field which is the mole concept resulting in the construction of 8 lexical strings.

A segment of the discourse from S1 to S7 below is used to show how a part-whole relationship is obtainable in L1.

(S1) Throughout the text, the mole concept will provide us with conversion factors for problem solving situations. (S2) As we encounter each new situation we will explore how the mole concept applies. (S3) For now we will deal with the relationship between the number of atoms and the mole. (S4) Consider the statement: 1 mol Mg = 6.022×10^{23} Mg atom = 24.31 g Mg. (S5) This allows us to write the conversion factors

$$\frac{1 \text{ mol Mg}}{6.022 \times 10 \text{ Mg atoms}} \quad \text{and} \quad \frac{24.31 \text{ g Mg}}{1 \text{ mol Mg}}$$

(S6) We use these factors in Example 2-7. (S7) Example 2-6 is perhaps the simplest possible application of the mole concept: relating the number of atoms in a sample to the number of moles of atoms.

The lexical items "mole concept" (S2 and S7) form a relationship of meronymy with the lexical item "mole" (S3) in the

(S6) We use these factors in Example 2-7. (S7) Example 2-6 is perhaps the simplest possible application of the mole concept: relating the number of atoms in a sample to the number of moles of atoms.

The lexical items "mole concept" (S2 and S7) form a relationship of meronymy with the lexical item "mole" (S3) in the construction of L1. Most chemical calculations are based on the mole concept which covers the unit of measurement for counting atoms which is the mole, the Avogadro number and the ratios of atomic masses involved, among other things.

4.2 The Analysis of Chapter Ten "Gases"

(Brown & Le May, 1988)

The following taxonomic analyses and system networks relate to the contents of the subtopics of the chapter.

4.2.1 The analysis of subtopic 10.1 on "Characteristics of Gases"

The taxonomic analysis of subtopic 10.1 on "Characteristics of Gases" presented in Fig. 4.2.1 on page 92 shows 13 lexical strings labelled L1 to L13.

Table 4.2.1 below gives an overview of the lexical strings from the perspectives of complexity, length and phoricity.

Table 4.2.1

Classification of Lexical Strings		
Complexity	**Length**	**Phoricity**
Simple: hyp: L9 & L12 rep: L2, L3, L7, L8 & L10 ant: L5 & L11	Minor: L2, L5, L8,L9, L11, L12 & L13	Sparse L1,L3 & L10
Complex: hyp/rep: L4,L6 & L13 hyp/rep/mer: L1	Major: L1, L3, L4, L6, L7 & L10	Dense: L2, L4, L5 L6, L7, L8. L9, L11, L12 & L13

The vocabulary of the text is organised into 3 semantic fields resulting in the construction of the 13 lexical strings. Semantic field states of matter organises strings L2, L4, L6, L7, L8 & L9, semantic field substance organises string L1 and semantic field properties organises strings L3, L5, L10, L11, L12 & L13.

The following extract from sentence 10 to sentence 15 of subtopic 10.1 "Characteristics of Gases" is used to show how the text is analysed to obtain antonymy relationships for lexical strings L5 and L11.

(S10) A gas expands to fill its container. (S11) Consequently, the volume of a gas is given simply by specifying the volume of the container in which it is held. (12) Volumes of solids and liquids, on the other hand, are not determined by the container. (13) The corollary of this is that gases are highly compressible. (14) When pressure is applied to a gas, its volume readily contracts. (15) Liquids and solids, on the other hand, are not very compressible at all.

The lexical item "contracts"(S14) is in an opposition relationship with "expands"(S10) and is assigned the relationship of antonymy. The lexical phrase "not very compressible"(15) is cohesively related to "highly compressible"(13) to form another instance of an antonymy relationship.

The system network shown in Figure 4.2.a captures these relationships.

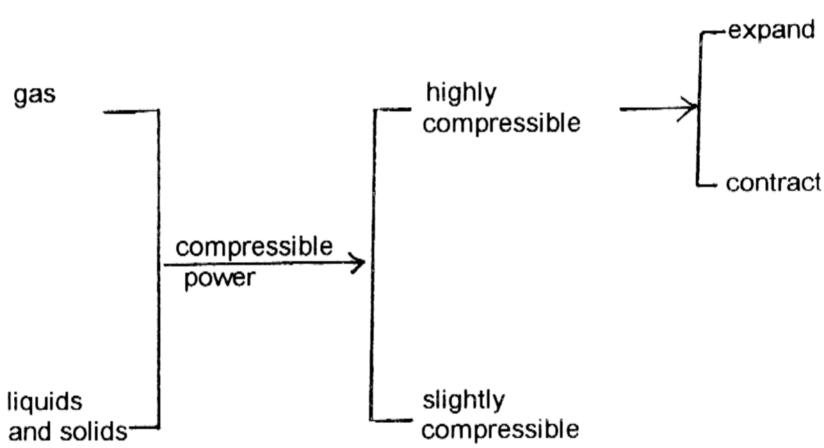


Fig. 4.2.a

The system compressible power with compound entry conditions gas and liquids and solids realise the features highly compressible and slightly compressible. If gas or liquids and solids is chosen, then either the feature highly compressible or slightly compressible is realised. A further point in delicacy is noted when once the feature highly compressible is chosen, either the option expand or contract is realised. A gas is highly compressible and therefore may readily expand or contract. On the other hand, both liquids and solids are not very compressible and the feature slightly compressible is not extended on a further point of delicacy.

4.2.2 The analysis of subtopic 10.2 on "Pressure"

To continue with the findings, the taxonomic analysis of subtopic 10.2 on "Pressure" presented in Fig. 4.2.2 on page 96 shows 18 lexical strings labelled L1 to L18.

Table 4.2.2 below gives an overview of the lexical strings from the perspectives of complexity, length and phoricity.

Table 4.2.2

Classification of Lexical Strings

Complexity	**Length**	**Phoricity**
Simple: rep: L1, L2, L3, L4, L10, L11, L12, L13, L14, L15, L16, L17 & L18 syn: L6 & L9	Minor: L1, L3, L4, L6, L9, L10, L12, L13, L14, L15, L16, L17 & L18	Sparse: L2, L6 & L9
Complex: hyp/rep: L5, L7 & L8	Major: L2, L5, L7, L8 & L11	Dense: L1, L3, L4, L5, L7, L8, L10, L12, L13, L14, L15, L16, L17 & L18

The text is organised around 3 semantic fields. Semantic field measurement organises strings L12, L13, L14, L15, L16, L17 and L18, semantic field pressure organises strings L5, L6, L7, L8, L9 and L10 and semantic field properties organises strings L1, L2, L3 and L4.

The most complex strings L5, L7 & and L8 are associated with only two kinds of taxonomic relations that of hyponymy and repetition. L1, L3, L4, L6, L9, L13, L14, L16, L17 and L18 form lexical ties rather than strings as there are only a pair of lexical items that exert a cohesive effect with each other.

The following network captures the concept of measurement using a manometer.

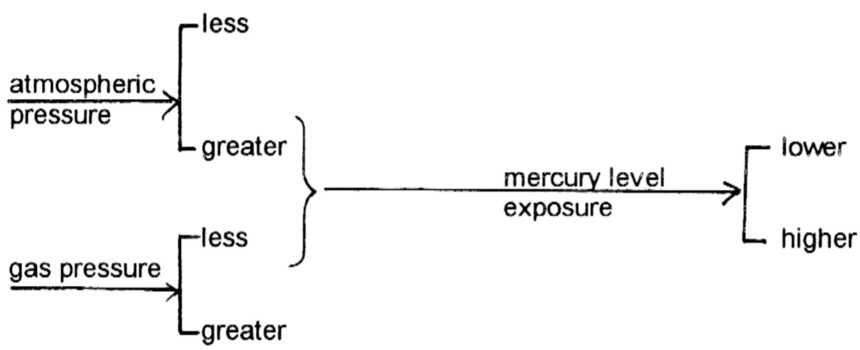


Fig. 4.2.b

Figure 4.2.b shows the system of mercury level exposure with compound entry conditions atmospheric pressure and gas pressure to realise the features lower and higher. In an open-ended manometer, when the atmospheric pressure is greater than the gas pressure, the exposed mercury level will be lower. When the atmospheric pressure is less than the gas pressure, the exposed mercury level will be higher.

4.2.3 The analysis of subtopic 10.3 on "The Gas Laws"

This section continues with the findings. The taxonomic analysis of subtopic 10.3 on "The Gas Laws" reveals 16 lexical strings labelled L1 to L16 as shown in Figure 4.2.3 on page 99.

An overview of the lexical strings from the perspectives of complexity, length and phoricity is shown in Table 4.2.3.

Table 4.2.3

Classification of Lexical Strings		
Complexity	**Length**	**Phoricity**
Simple: rep: L1, L2, L4, L10, L12, L13, L15 & L16 syn: L11	Minor: L2, L4, L12 & L13	Sparse: L8, L10, L15 & L16
Complex: hyp/rep: L3 & L6 syn/mer: L8 rep/ant: L14 hyp/cohyp/rep: L5 hyp/rep/syn: L7 hyp/cohyp/syn: L9	Major: L1, L3, L5, L6, L7, L8, L9, L10, L11, L14, L15 & L16	Dense: L1, L2, L3, L4, L5, L6, L7, L9, L11, L12, L13 & L14

The lexical items are organised around 4 semantic fields resulting in the construction of the 16 lexical strings. Semantic field gases organises strings L1 and L8, semantic field variables organises strings L2, L3, L4, L5, L6, L7 and L11, semantic field gas law organises strings L9, L10, L14 and L16 and semantic field experiment organises strings L12, L13 and L15.

The following extract of subtopic 10.3 from S11 to S16 shows how the cohyponymy relationship between two lexical items are arrived at for the complex string L5.

(S11) A graph of Boyle's pressure versus volume data is shown in Figure 10.6 (a).

(S12) Boyle's relationship can be rearranged to yield *V = c/P*. (S13) This is the equation for a staright line with slope *c* and zero intercept (Appendix A.4) Figure 10.6 (b) shows a graph of *V* versus *1/P* for Boyle's data. (S14) Notice that a linear relationship is obtained.

(S15) The relationship between gas volume and temperature was discovered in 1787 by Jacques Charles (1746-1823), a French scientist. (S16) Charles found that the volume of a fixed quantity of gas at constant pressure increases in a linear fashion with temperature.

The lexical item "constant pressure" (S16) forms a semantic tie with "Boyle's pressure" (S11) through the relationship of cohyponymy. Both lexical items are specific terms of the superordinate term "pressure." There is no explicit cohesive signal to make this connection. This being the case, I looked at the underlying semantic continuity of the idea expressed. This section seeks to define the changing behaviours of a gas when the three variables of pressure, temperature and volume vary in relation to each other. Boyle's pressure is obtained when pressure is varied in relation to volume changes whereas constant pressure is obtained when the pressure is fixed in relation to volume and temperature changes. Therefore, Boyle's pressure and constant pressure are considered cohyponymys, that is, they may be seen as kinds of pressure.

The following system network captures the concept of volume proportionality to temperature which is a concept used to define the state of a gaseous substance. An antonymy relationship between lexical items "inversely proportional"(S3) and "directly proportional"(S21) is constructed to form L10.

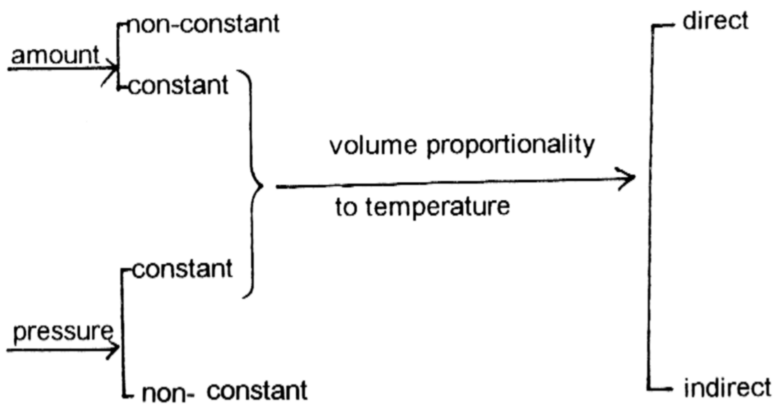


Fig. 4.2.c

The system has simultaneous entries amount and pressure. The entry amount realises the features non-constant and constant. The entry pressure realises the features constant and non-constant. The entry conditions constant amount and constant pressure enter the system volume proportionality to temperature to motivate the features direct or indirect. If a fixed amount of gas is held at constant pressure, the volume of the gas is directly proportional to temperature. Conversely, if the amount of the gas is not fixed but changes and the pressure of the gas is not constant but changes then the volume is inversely proportional to temperature.

4.2.4 The analysis of subtopic 10.4 on "The Ideal-Gas Equation"

Continuing with the findings, the taxonomic analysis of subtopic 10.4 on " The Ideal -Gas Equation" presented in Figure 4.2.4 on page 103 shows 20 lexical strings labelled L1 to L20.

Table 4.2.4 below gives an overview of the lexical strings from the perspectives of complexity, length and phoricity.

Table 4.2.4

Classification of Lexical Strings		
Complexity	**Length**	**Phoricity**
Simple: rep: L3, L7, L8 & L11 hyp: L9, L15 & L19 syn: L16 & L20 comer: L18	Minor: L6, L11, L16, L17, L19 & L20	Sparse: L5, L7 & L14 L15 & L18
Complex: rep/syn: L4 hyp/rep: L5, L6, L10, L12 & L14 hyp/ rep/ syn: L2 hyp/cohyp/rep: L13 hyp/rep/mer/comer: L1	Major: L1, L2, L3, L4, L5 L7, L8, L9, L10, L12, L13, L14, L15, & L18	Dense: L1, L2, L3, L4, L6, L8, L9, L10, L11, L12, L13, L16, L17, L19 & L20

The vocabulary of the text is organised into 6 semantic fields resulting in the construction of the 20 lexical strings. The semantic field gas laws organises strings L1, L2, L3, L4, L18 and L19, semantic field variable organises strings L7, L8, L9, L11, L12 and L13, semantic field value organises strings L5 and L6, semantic field conditions organises strings L14 and L20, semantic field properties organises strings L15, L16 and L17 and semantic field state of matter organises string L10.

The following extract from sentence 33 to 38 of subtopic 10.4 "The Ideal Gas Equation" is used to show how the analysis was done to obtain a hyponymy/synonymy relationship in L8 and L12.

(S33) We would find that the pressure increases linearly with absolute temprature, perhaps as shown by the sample data labeled A in Figure 10.10. (S34) If the experiment were repeated with a different-sized sample of the same gas, we might obtain the results labelled B in the figure. (S35) Note that in both cases the extrapolated pressure at O K is zero.

(S36) If both n and V in Equation 10.1 are fixed, the pressure varies with temperature as expressed in the equation

$$P = \left(\frac{nR}{V}\right)T = \text{constant X } T \qquad [10.4]$$

(S37) Thus the ideal-gas equation predicts a linear relationship between pressure and absolute temperature, extrapolating to zero pressure at O K. (S38) Again, we must remind ourselves that real gases lose their gaseous properties before absolute zero is reached.

The meaning of "O K" (S35) is recovered with reference to the preceding lexical item "absolute temperature" (S33). "Absolute temperature" (S37) again refers retrospectively to "O K" (S35) to form a relationship of synonymy. "Absolute zero" (S38) refers to both "pressure" (S37) and "absolute temperature" (S37). "Extrapolated pressure" (S35) is a kind of pressure related to the general term "pressure" (S33).

Another extract from sentence 19 to 22 of the same subtopic is examined to see how synonymy/antonymy relations for L16 and L17 are established.

(S19) The fact that Equation 10.1 is called the *ideal*-gas equation correctly suggests that there may be conditions where gases don't exactly obey this equation. (S20) For example, we might calculate the quantity of a gas, n, for given conditions of P, V, and T and find it to differ somewhat from the measured quantity under these conditions. (S21) Ordinarily, however, the difference between ideal and real behavior is so small that we may ignore it. (S22) We will examine deviations from ideal behavior later, in Section 10.9.

The meaning of "deviations"(S22) is recovered in relation to the lexical phrase "don't exactly obey" (S19) forming the synonymy relationship in L16. "Ideal behaviour" (S22) is semantically related to "real behaviour"(S22) through a relationship of antonymy forming part of L17.

The system shown in Figure 4.2.d shows the entry condition gas behaviour which motivates the features real and ideal. In terms of obeying the ideal gas equation, a gas may be termed real or ideal.

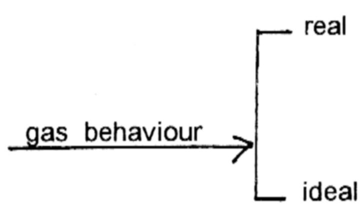


Fig. 4.2.d

A gas that obeys the ideal gas equation is said to exhibit ideal gas behaviour. However, no gas exactly follows the ideal gas law. Real gases under certain conditions approach the ideal gas behaviour which is a hypothetical concept. As we shall see in Figure 4.2.k in section 4.2.10, the magnitude of deviations may also be captured in a system network.

4.2.5 The analysis of subtopic 10.5 on "Dalton's Law of Partial Pressures"

To continue with the findings, the taxonomic analysis of subtopic 10.5 on "Dalton's Law of Partial Pressures" presented in Figure 4.2.5 on page 108 shows 10 lexical strings labelled L1 to L10.

Table 4.2.5 below gives an overview of the lexical items in terms of complexity, length and phoricity.

Table 4.2.5

Classification of Lexical Strings

Complexity	**Length**	**Phoricity**
Simple: hyp: L5 rep: L2, L3, L6, L8 & L10 ant: L7	Minor L9 & L10	Sparse: L5, L6 & L8
Complex: hyp/rep: L4 rep/syn: L9 hyp/rep/mer: L1	Major: L1, L2, L3, L4, L5, L6, L7 & L8	Dense: L1, L2, L3, L4, L7, L9 & L10

The lexical items are organised into 3 semantic fields resulting in the construction of 10 strings. Semantic field gas mixture organises strings L7, L8, L9 and L10, semantic field variables organises strings L1, L3, L4, L5 and L6 and semantic field state of matter organises string L2.

The following extract from sentence 1 to sentence 5 of subtopic 10.5 "Dalton's Law of Partial Pressures" is used to show how strings L1, L7 and L9 are constructed.

(S1) The pressure of a gas under conditions of constant volume and temperaturei is directly proportional to the number of moles of gas:

$$P = \left(\frac{RT}{V}\right)n = \text{constant} \times n \qquad [10.6]$$

(S2) Suppose that the gas with which we are concerned is not made up of a single kind of gas particle but is rather a mixture of two or more different substances. (S3) We expect that the total pressure exerted by the gas mixture is the sum of pressures due to the individual components. (S4) Each of the individual components, if present alone under the same temperature and volume conditions as the mixture, would exert a pressure that we term the **partial pressure**. (S5) John Dalton was the first to observe that the *total pressure of a mixture of gases is just the sum of the pressures that each gas would exert if it were present alone:*

$$P_t = P_1 + P_2 + P_3 + \ldots \qquad [10.7]$$

"Total pressure" (S3) is related to "pressure"(S1) through a relationship of hyponymy. "Partial pressure" (S4) is a meronymy of "total pressure." (S3) "Gas mixture"(S3) is related to "mixture"(S2 & S4) through a relationship of hyponymy. "Individual components"(S3) refers retrospectively to "gas particle"(S2) through a relationship of synonymy.

The following network in Figure 4.2.e captures the concept of partial and total pressures.

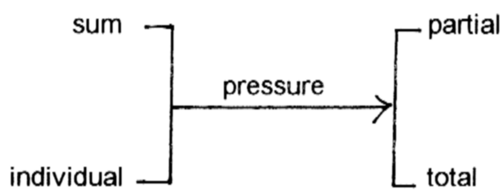


Fig. 4.2.e

The compound entries sum and individual enter the system pressure to motivate the features partial and total. The pressure exerted by individual gas components is the partial pressure of the gas whereas the pressure exerted by the sum of the gas components is the total pressure of the gas.

4.2.6 The analysis of subtopic 10.6 on "Molecular Weights and Gas Densities"

Continuing with the findings, the taxonomic analysis of subtopic 10.6 on "Molecular Weights and Gas Densities" presented in Figure 4.2.6 on page 112 shows 4 lexical strings labelled L1 to L4.

Table 4.2.6 below gives an overview of the lexical strings in terms of complexity, length and phoricty.

Table 4.2.6

Classification of Lexical Strings

Complexity	Length	Phoricity
Simple: rep: L2 & L3	Minor none	Sparse: none
Complex: hyp/syn: L1 mer/comer: L4	Major: L1, L2, L3 & L4	Dense: L1, L2, L3 & L4

The vocabulary of the text is organised into 2 semantic fields. semantic field equation organises string L1 and semantic field density organises strings L2, L3 and L4.

The following extract from sentence sentence 2 to sentence 6 of 10.6 "Molecular Weights and Gas Densities" shows how a meronymy relationship is established.

(S2) Density has the units of mass per unit volume. (S3) We can arrange the gas equation to obtain

$$\frac{n}{V} = \frac{P}{RT}$$

(S4) Now n/V has the units of moles per liter. (S5) Suppose that we multiply both sides of this equation by molecular weight (M), which is the number of grams in 1 mol of a substance:

$$\frac{nM}{V} = \frac{PM}{RT} \qquad [10.9]$$

(S6) But the product of the quantities N/V and M equals density, because the units multiply as follows:

$$\frac{\text{Moles}}{\text{Liter}} \times \frac{\text{grams}}{\text{mole}} = \frac{\text{grams}}{\text{liter}}$$

The lexical phrase "moles per liter" (S4) is in a meronymy relation with "mass per unit volume" (S2). Both "moles per liter" (S4) and "gram in 1 mole" (S5) are comeronyms of "mass per unit volume" (S2).

4.2.7 The analysis of subtopic 10.7 on "Quantities of gases involved in Chemical Reactions"

Continuing with the findings, the taxonomic analysis of subtopic 10.7 on "Quantities of Gases involved in Chemical Reactions" presented in Figure 4.2.7 on page 115 shows 8 lexical strings labelled L1 to L8.

Table 4.2.7 below gives an overview of the lexical strings from the perspectives of complexity, length and phoricity.

Table 4.2.7

Classification of Lexical Strings		
Complexity	**Length**	**Phoricity**
Simple: rep: L2, L3, L4 & L6 cohyp: L5 ant: L7	Minor: L2, L3, L4 & L8	Sparse: L6 & L7
Complex: hyp/rep: L1 hyp/mer: L8	Major: L1, L5, L6 & L7	Dense: L1, L2, L3, L4, L5 & L8

The lexical items are organised around 3 semantic fields to construct the 8 lexical strings. Semantic field chemical reaction organises lexical strings L3, L4, L5 and L7, semantic field states of matter organises lexical strings L1, L2 and L6 and semantic field variable organises lexical strings L6 and L8.

The following extract from sentence 8 to sentence 11 is examined to show how a hyponymy/meronymy relationship is obtained for lexical string L8.

(8) The oxygen gas is collected in a bottle that is filled with water and inverted in a pan.
(9) The volume of gas collected is measured by raising or lowering the bottle as necessary until the water levels inside and outside the bottle are the same. (10) When this condition is met, the pressure inside the bottle is equal to the atmospheric pressure outside. (11) The total pressure inside is the sum of the pressure of gas collected and the pressure of water vapor in equilibrium with liquid water:

$$P_{total} = P_{gas} + P_{H_2O} \qquad [10.12]$$

"Total pressure"(S11) which is a subclass of pressure is related to "pressure"(S10) through a relationship of hyponymy. One of the compositions of total pressure is the pressure exerted by the atmosphere. Therefore, "Atmospheric pressure"(S10) is in a meronymy relation with "total pressure" (S11).

4.2.8 The analysis of subtopic 10.8 on "Kinetic-Molecular Theory"

To continue with the findings, the taxonomic analysis of subtopic 10.8 on "Kinetic - Molecular Theory" presented in Figure 4.2.8 on page 118 shows 20 lexical strings labelled L1 to L20.

Table 4.2.8 gives an overview of the lexical strings from the perspectives of complexity, length and phoricity.

Table 4.2.8

Classification of Lexical Strings		
Complexity	**Length**	**Phoricity**
Simple: hyp: L4 rep: L2, L5, L8, L11, L13, L18, L19 & L20 ant: L12	Minor: L12 & L20	Sparse: L4, L5 & L18
Complex: hyp/rep: L6,L10,L14 & L15 cohyp/ant: L7 cohyp/rep: L9 hyp/rep/mer: L1 hyp/rep/syn:L3 rep/ant/syn: L17 rep/cohyp/ant/syn: L16	Major: L1, L2, L3, L4, L5, L6, L7, L8, L9, L10, L11, L13, L14, L15, L16, L17, L18 & L19	Dense: L1, L2, L3, L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, L16, L17, L19 & L20

The lexical items are organised around 6 semantic fields to construct the 20 lexical strings. Semantic field ideal gas equation organises string L1, semantic field variables organises strings L6, L7, L8 and L11, semantic field states of matter organises strings L2 and L3, semantic field properties organises strings L4 and L5, semantic field kinetic molecular theory organises strings L10, L12, L13, L17, L18 and L19 and semantic field molecular collisions organises strings L15, L16 and L20.

The following extract from sentence 18 to sentence 22 shows how a hyponymy is obtained for L14.

(S18) Figure 10.12 also shows the value of the **root-mean-square** (rms) **speed**, *u*, of the molecules at each temperature. (19) This quantity is the square root of the average squared speeds of the molecules. (S20) The rms speed is not the same as the average speed. (21) The difference between the two, however, is so small that for most purposes they can be considered equal. (22) The rms speed is important because the average kinetic energy of the gas molecules, ε, is related directly to u^2:

$$\varepsilon = 1/2\, mu^2 \qquad [10.13]$$

where *m* is the mass of the molecule.

Both "average speed" (S20) and "rms speed" (S20) are cohyponymys of the superordinate term molecular speed. In the construction of L14, I have chosen to code only "root mean square speed" to be cohesively linked to a preceding and prospecting item and have appended "average speed" to it. The term "average speed" is considered lacking in cohesive function in the text as only one reference has been made to it unlike "root mean square speed" which has a higher frequency of distribution throughout the text.

The concept of "Kinetic Molecular Theory" is captured in the following hierarchically ordered system network shown in Figure 4.2.f on page 121. The compound entries temperature and volume enter the system motional energies to motivate the simultaneous features average kinetic energy and root mean square speed. The feature average kinetic energy realises the options change and non-change and the feature root mean square speed also realises the options change and non-vhange. These features in turn act as entries into the

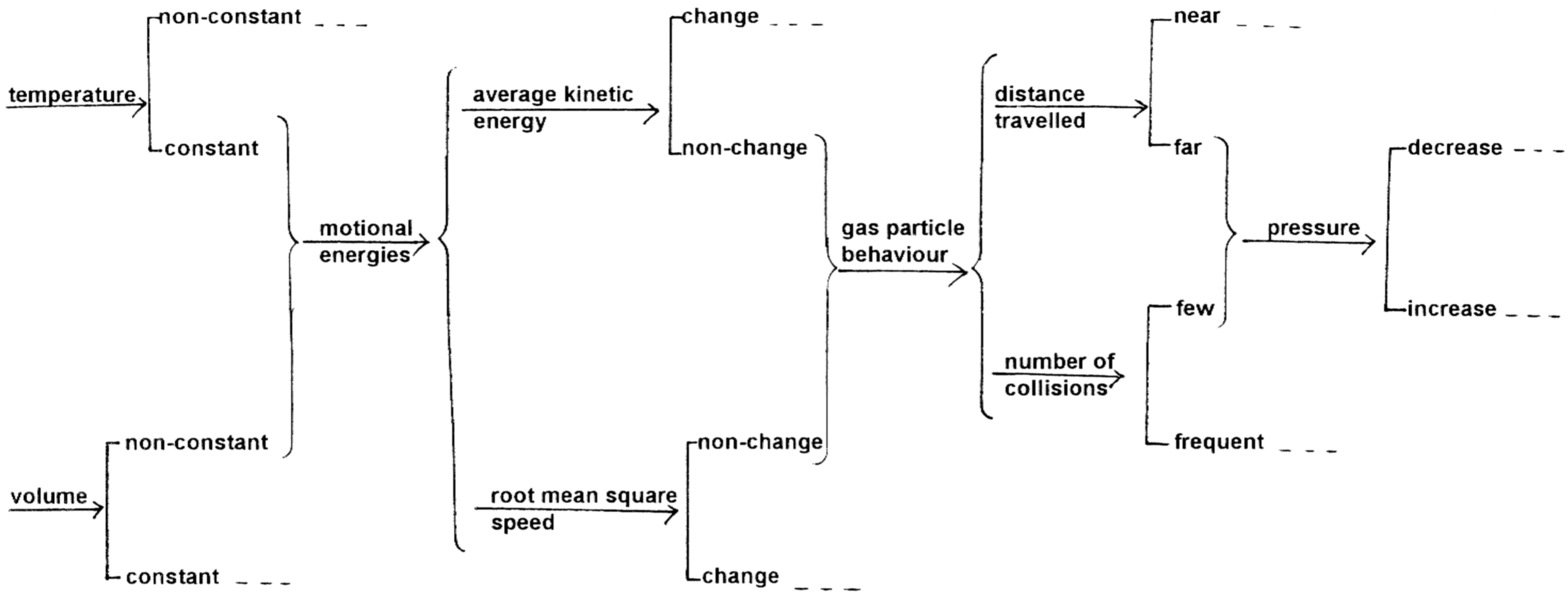

temperature
non-constant
constant
volume
non-constant
constant
motional energies
average kinetic energy
root mean square speed
change
non-change
non-change
change
gas particle behaviour
distance travelled
number of collisions
near
far
few
frequent
pressure
decrease
increase

Fig. 4.2.f

system gas particle behaviour to motivate the features distanced travelled and number of collisions. The feature distance travelled realises the options near and far whereas the feature number of collisions realises the options few and frequent. These options now act as entry conditions for the system pressure. The system pressure may be extended to realise gradable oppositions decrease and increase. When the temperature of a gas is held constant and its volume is allowed to increase the average kinetic energy and the root mean square speed of the gas remains unchanged. The kinetic molecular theory assumes that the gas molecules experience a fewer number of collisions and travel a longer distance resulting in a pressure decrease.

The following system network shown in Figure 4.2 g exemplifies the concepts of molecular collisions and molecular speeds.

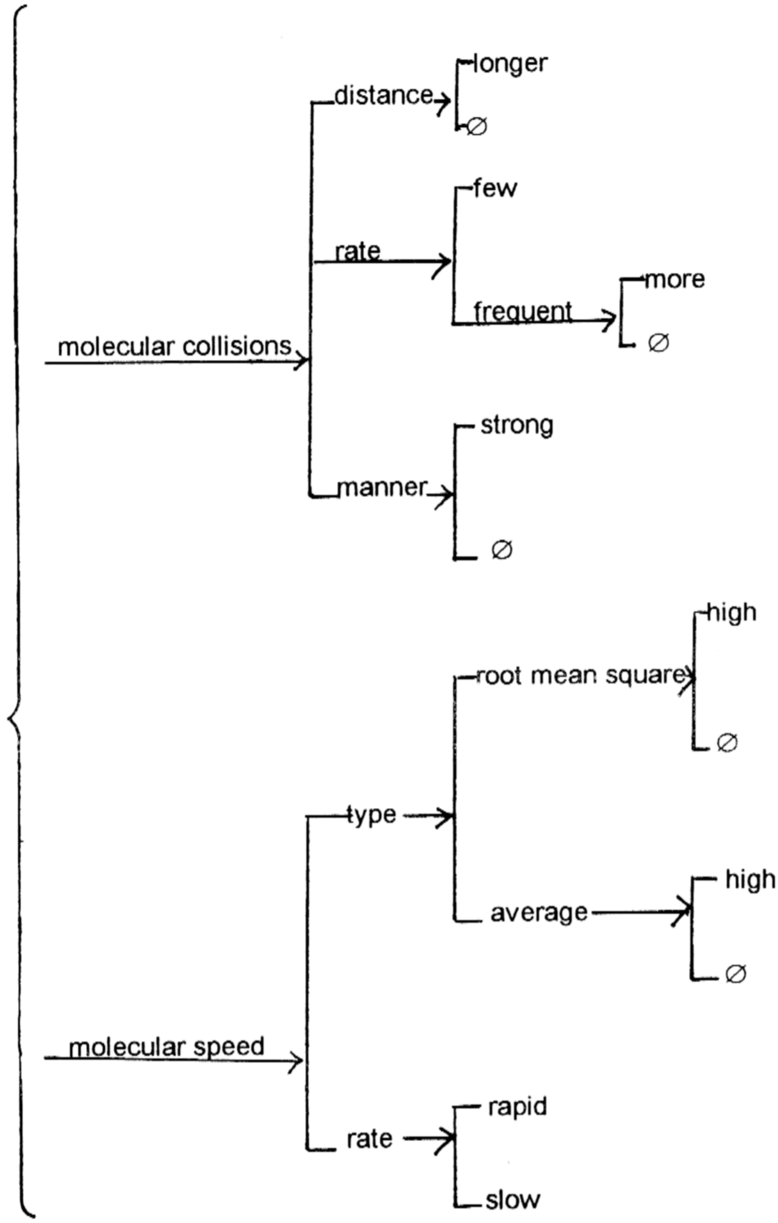


Fig 4.2.g

The system has molecular collisions and molecular speed as simultaneous entries. The entry condition molecular collisions expounds the simultaneous features distance, rate and manner. The feature distance forecloses the choices longer and ∅. The entry condition rate expounds the features few and frequent. The choice frequent may be further abstracted to realise the choices more and ∅. The entry condition manner expounds the features strong and ∅.

The entry condition molecular speed expounds the features type and rate. The feature type forecloses the choices root mean square and average. The choice root mean square may be further abstracted to realise the choices high and ∅. The choice average may also be abstracted to realise the choices high and ∅. Finally the feature rate forecloses the choices rapid and slow.

4.2.9 The analysis of subtopic 10.9 on "Molecular Effusion and Diffusion; Graham's Law"

Continuing with the findings, the taxonomic analysis of subtopic 10.9 on "Molecular Effusion and Diffusion; Graham's Law" presented in Figure 4.2.9 on page 125 shows 23 lexical strings labelled L1 to L23.

Table 4.2.9 gives an overview of the lexical strings from the perspectives of complexity, length and phoricity.

Table 4.2.9

Classification of Lexical Strings		
Complexity	Length	Phoricity
Simple: rep: L10, L14, L15, L17, L18 & L22 hyp: L21 syn: L11 ant: L19 & L23 cohyp: L9, L13 & L16	Minor: L17, L18, L19, L21 & L23	Sparse: L5, L9, L10, & L16
Complex: hyp/rep: L2, L6 & L20 cohyp/rep: L3 rep/ant: L5 hyp/rep/syn: L7 rep/ant/syn: L8 hyp/rep/syn/mer: L1 hyp/cohyp/rep/syn: L12	Major: L1, L2, L3, L4, L5 L6, L7, L8, L9, L10, L11, L12, L13, L14, L15, L16, L20 & L22	Dense: L1, L2, L3, L4, L6, L7, L8, L12, L13, L14, L15, L17, L18, L19, L20, L21, L22 & L23

The lexical strings are organised around 5 semantic fields. semantic field average kinetic energy organises strings L4, L5, L9, L10, L11, and L20, semantic field effusion and diffusion organises strings L12, L13, L14, L15 and L17, semantic field variables organises strings L6 and L16, semantic field states of matter organises strings

L1, L2, L3, L7 and L8 and semantic field mean free path and thermal conductivity organises strings L18, L19, L21, L22 and L23.

The lexical items which are represented as chemical symbols exert a cohesive effect in the text as can be seen in the construction of strings L1 and L3. The L3 string is constructed purely out of hyponymy and repetition relations and there are instances in which symbols have been used to represent the gases.

The following extract from sentence 28 to sentence 31 may help to explain why chemical symbols have been chosen to be included in the development of L1.

(S28)The effort during World War II to develop the atomic bomb necessitated separating the relatively low-abundance uranium isoptope ^{235}U (0.7 percent) from the much more abundant ^{238}U (99.3percent). (29) This was done by converting the uranium into a volatile compound, UF_6 ,which boils at 56°C. (30)The gaseous UF was allowed to diffuse from one chamber into a second through a porous barrier. (31)Because of the slight difference in molecular weights, the relativer rates of passage through the barrier for $^{235}UF_6$ and $^{238}UF_6$ are not exactly the same.

The relationship between " ^{235}U" and " UF_6 " is one of a part-whole kind. Therefore, the relationship of meronymy is assigned between them. "Gaseous U F_6 "(S30) is considered to be linked through a relationship of synonymy with "volatile compound UF_6" (29). " $^{235}UF_6$ "(S31) is assigned a relationship of meronymy as it is a part of "gaseous UF_6" which is composed of both $^{235}UF_6$ and $^{238}UF_6$.

The following system network in Figure 4.2.h captures some of the properties and behaviours of the gas molecules.

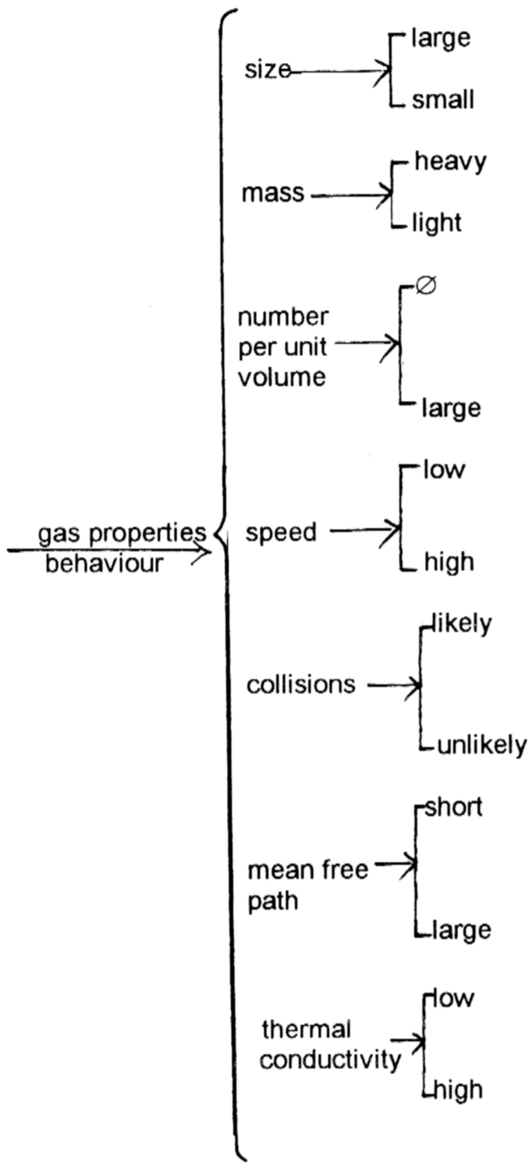


Fig. 4.2.h

The simultaneous entries of the system gas properties are size, mass, number per unit volume, speed, collisions, mean free path and thermal conductivity. Gases are denoted the terms large or small when reference is made to size and they are denoted the terms heavy or light when reference is made to mass. When reference is made the number of gas molecules occupying a unit of volume the term "large" may be used. The speed of a gas may be low or high. A gas is likely or unlikely to undergo molecular collisions under certain favourable conditions. The terms short and large may be used when gases are compared for their mean free path and the terms low and high may be used when gases are compared for their thermal conductivity.

The following system network in Figure 4.2.i shown on page 130 captures the rate of gas effusion. Compound entries initial pressure and temperature enter the hierarchically ordered system molecular mass to motivate the features low and high. The feature low enters a second system motional energies to motivate the simultaneous features rms speed and average kinetic energy. rms speed further forecloses the choices low and high and average kinetic energy also further forecloses the choices large and small. The choices of high and large act as compound entries into the system effusion rate to expound the choices maximum and minimum.

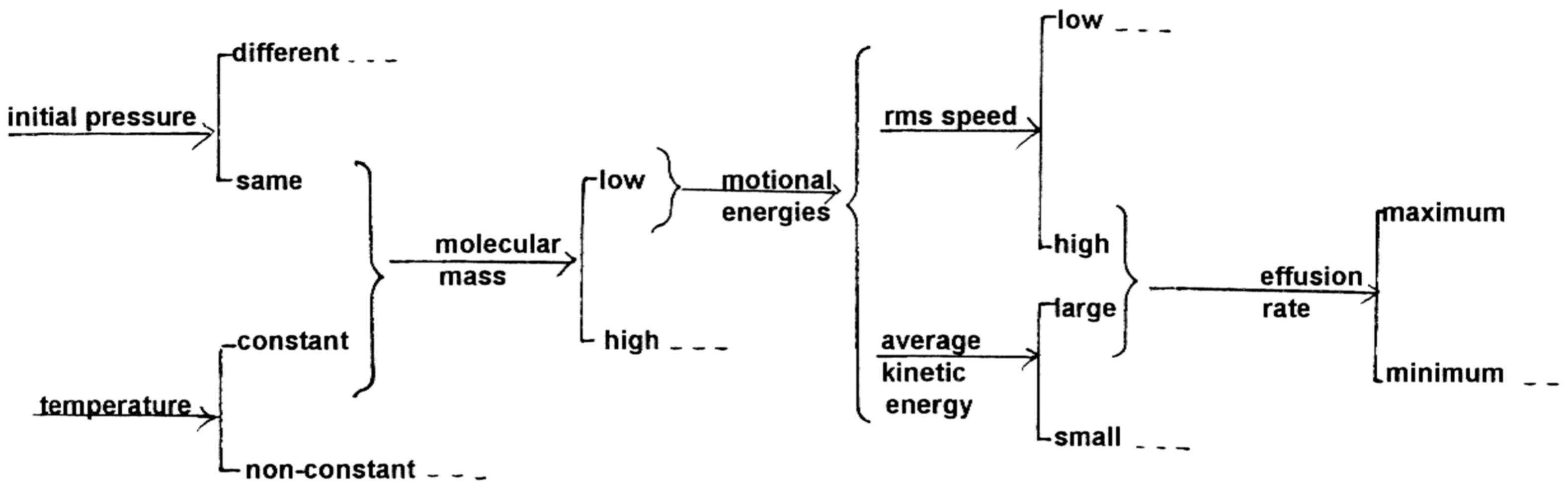

initial pressure
different . . .
same
temperature
constant
non-constant . . .
molecular mass
low
high . . .
motional energies
rms speed
low . . .
high
average kinetic energy
large
small . . .
effusion rate
maximum
minimum . . .

Fig. 4.2.i

In this system (Fig.4.2.i) two gases of different molecular weights or mass, one lower, the other higher are compared for their rate of effusion. Under identical experimental conditions of having the same initial pressure and having a constant temperature, the gas of lower molecular mass experiences a higher rms speed and a higher average kinetic energy and therefore effuses more rapidly.

The following system network in Figure 4.2.j on page 132 captures the concept of gas diffusion. The hierarchically ordered system has the simultaneous entries average speed and movement which enter the system number of collisions to motivate the features few and frequent. The feature few enters the system gas particle property to motivate the simultaneous features mean free path and thermal conductivity. The feature mean free path forecloses the choices small and large and thermal conductivity forecloses the choices high and low. These choices enter a second system diffusion which realises the options maximum and minimum.

When the rates of diffusion of several gases are compared, the gas whose average speed is highest and whose movement is fastest experiences a fewer number of collisions. Therefore their mean free path is largest and their thermal conductivity is highest and this causes it to have the greatest diffusion.

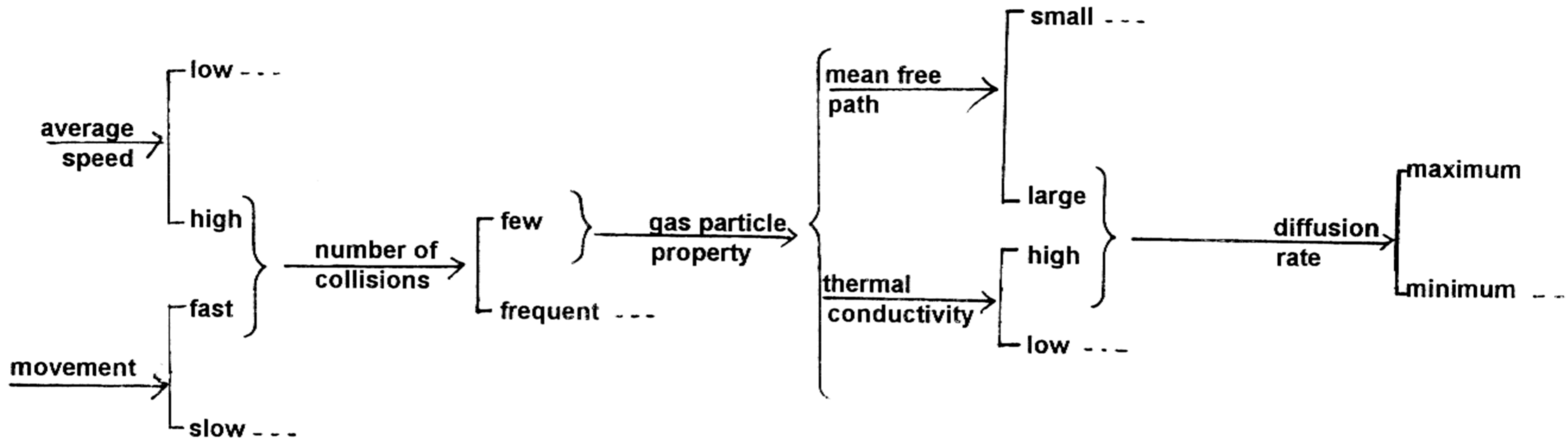

average speed
low - - -
high
movement
fast
slow - - -
number of collisions
few
frequent - - -
gas particle property
mean free path
small - - -
large
thermal conductivity
high
low - - -
diffusion rate
maximum
minimum - - -

Fig. 4.2.j

4.2.10 The analysis of subtopic 10.10 on "Non-Ideal Gases: Departures from the Ideal-Gas Equation"

To conclude the findings, the taxonomic analysis of subtopic 10.10 on "Non-Ideal Gases: Departures from the Ideal-Gas Equation" presented in Figure 4.2.10 on page 134 shows 18 lexical strings labelled L1 to L18.

Table 4.2.10 below gives an overview of the lexical items in terms from the perspectives of complexity, length and phoricity.

Table 4.2.10

Classification of Lexical Strings		
Complexity	**Length**	**Phoricity**
Simple: rep: L9 & L13 hyp: L18 cohyp:L16	Minor: L2, L5, L16 & L18	Sparse: L7, L8, L10 & L14
Complex: hyp/rep: L6 rep/syn: L7 ant/cohyp: L8 & L17 syn/ant: L12 hyp/rep/syn: L1 & L15 cohyp/rep/ant: L5 & L10 syn/mer/comer: L2 rep/ant/syn: L14 rep/syn/mer/comer: L11 hyp/cohyp/rep/syn: L4 hyp/cohyp/rep/syn/mer/comer: L3	Major: L1, L3, L6, L7, L8, L9, L10, L11, L12 L13, L14, L15 & L17	Dense: L1, L2, L3, L4, L5, L6, L9, L11, L12, L13, L15, L16, L17 & L18

The lexical strings are organised around 4 semantic fields. Semantic field gas equation organises strings L1, L2, L11 and L12, semantic field gas behaviour and states of matter organises strings L3, L6, L7 and L8, semantic field variables organises strings L4, L5, L9, L10, L13 and L14, semantic field force and energy organises strings L14, L15, L16, L17 and L18.

The most complex string is L3 which is formed of six different taxonomic relations. The following extract from sentence 40 to 44 shows how some of the taxonomic relations of lexical strings L2, L3 and L4 are arrived at.

(S40) This equation differs from the ideal-gas equation by the presence of two correction terms; one corrects the volume, the other modifies the pressure. (S41) The term *nb* in the expression *(V - nb)* is a correction for the finite volume of the gas molecules; the van der Waals constant *b*, different for each gas has units liters/mole. (S42) It is a measure of the actual volume occupied by the gas molecules. (S43) Values of *b* for several gases are listed in Table 10.4. (S44) Note that *b* increases with an increase in mass of the molecule or in the complexity of its structure.

In string L2 "term nb"(S41) shares a part-whole relationship with "correction term"(S40) and is therefore assigned a relationship of meronymy with it. In the same lexical string "b"(S44), "values of b"(S43) and "van der Waals constant,b"(S42) share a relationship of synonymy with each other. Since gases are composed of gas molecules, "gases"(S43) is cohesively related to "gas molecules"(S42) through a relationship of meronymy in L3. In L4, the meaning of "actual volume"(S42) is interpreted through the recovery of "finite volume"(S41) and they are cohesively linked through a relationship of synonymy.

The following system network in Figure 4.2.k captures the entry condition volume to motivate the features free, container and finite.

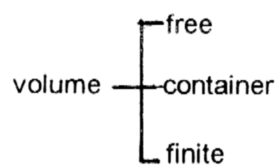


Figure 4.2.k

The lexical items free volume, container volume and finite volume express the meaning of the volume of a gas from different perspectives. The volume in which the gas molecules can move freely is the free volume, the volume of the container which holds the gas molecules is the container volume and the actual volume of the gas molecules taking intermolecular forces into consideration is the finite volume. In calculations using the ideal-gas-equation, the volume of the gas usually refers to the container volume.

The following system network shown in Figure 4.2.I captures the gradable oppositions of the magnitude of deviations from ideal behaviour of a gas.

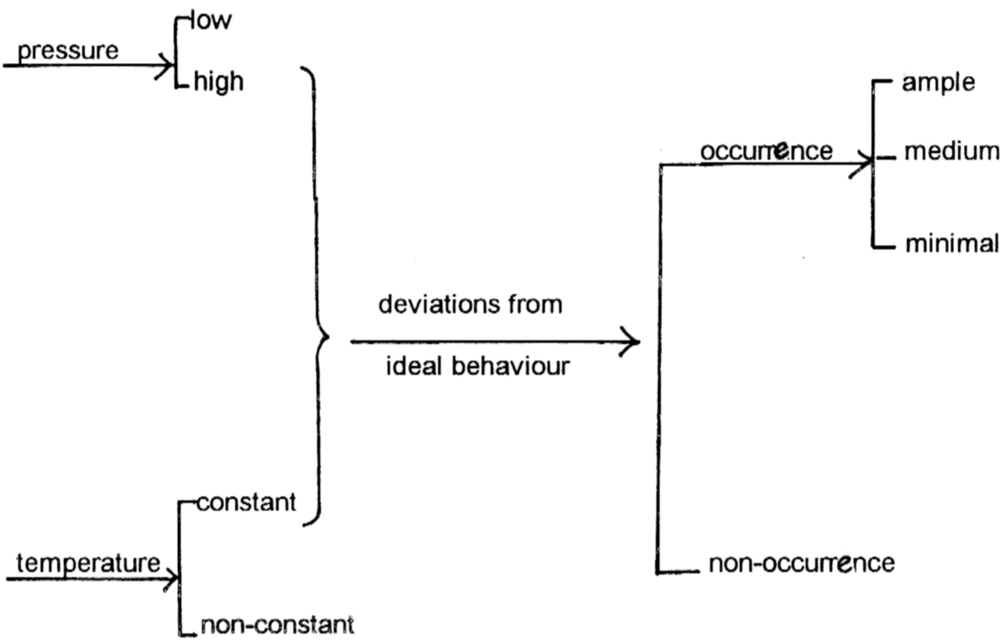


Fig. 4.2.I

The system deviations from ideal gas behaviour in Figure 4.2.I shows the compound entries high pressure and constant temperature which motivate the features occurrence and non-occurrence. The feature occurrence forecloses the choices ample, medium and minimal. A gas may display deviations from ideal gas behaviour under certain conditions. These deviations may be described in terms of whether they are ample, medium or minimal. When the temperature of a gas is held constant and a high pressure is exerted, the gas displays various magnitudes of departures from ideal gas behaviour. Therefore, the ideal gas equation may not be used to predict the pressure-volume properties of the gas under these conditions.

4.3 Conclusion

Lexical analyses and system networks have been illustrated in this chapter to explicate the concept of lexical cohesion in chemistry texts. The following chapter attempts to crystalise the findings in more general terms.