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Expert System for Identification of Acid Radical of Salts

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Title of Thesis

((Expert System for Identification of Acid Radical of Salts))

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ABSTRACT

Expert systems make knowledge accessible to people who query the systems for advice . They can work faster than humans and that means fewer workers are needed. Therefore, it reduces the costs and increases the output.

This thesis is devoted to designing and implementing an expert system to help chemists in teaching the practical part of chemical laboratory to identify the acid radical of salt.

Taking into consideration the essential elements of expert system, I am going to build an Expert System for the proposed requirements.

Dedication

I dedicate this work to my dear wife,

my parents , and my friends whose support and

encouragement was a major factor behind

endeavor towards success.

Acknowledgement

My first and greatest sense of gratitude goes to my supervisor Dr. Abd-Alhaned Abd-Alkafi for his invaluable help throughout the various stages of writing this piece of research .

My greatest sense of gratitude goes to all staff of computer department of faculty of science, al-tahadi university; who helped me during my studies in the postgraduate program .

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CHAPTER ONE

INTRODUCTION

1- Introduction:

Computer has greatly developed to be involved in all our life activities. In the past, the role of computer was just calculating numbers or analyzing data. Nowadays, computers are used for data processing and decision making trying to imitate man in some activities. Artificial intelligence transformed computer from being a machine used only in calculating to a machine able to think like human beings. Then, many fields emerged, for example, understanding natural language by automatic programming or by expert systems that can imitate human in his ability that based on different domains.

For decades, the human dreamt to invent a machine able to imitate him. This dream has come to reality. The man now is able to make automatic machines do this job. Therefore, the gap between this dream and reality has been bridged. Since then, it was possible to make smart programs which can achieve some of these dreams. Lately, in 1960, a group of scientists began to develop a program able to imitate doctors in their diagnosis and describing medications. This group of scientists changed the structure of programs by separating them from expert's data with new independent frames. This method establishes new techniques used as bases to structure any expert system up to date. The scientists adopted the dialogue approach with doctors to extract their knowledge. This knowledge was developed through their university studies and through their practical experiments by means of time. The expert system called MYCIN has worked to imitate doctors in diagnosing their patients, but it can not be put into effect before doctors gradual agreement. MYCIN has been developed through stages, in each stage, doctors advices were inserted into the program code. After continued adjustments, the program reached a stage equal to doctors level. Therefore, it was not possible to add any experience. The program becomes a real copy of doctors at its best. Because of this program, born a new generation of programs called expert.

Expert systems are considered to be the most successful in the domain of artificial intelligence because, for example, chemistry field is rich with thoughts that can be applied using expert systems. DENDRAL was the first and most popular of all artificial intelligence system. After I have interviewed some chemical experts, I found out that the idea of designing an expert system to replace the chemical experts may saves much efforts and much money and protects students from dangers that they may face while dealing which chemical materials.

The expert system may explain all the experiments that were conducted to discover the acidic part of salts. Students can be trained to conduct these experiments and observes the interactions and their result before applying these experiments, in addition, students can apply these experiments with out consulting a human expert.

1.1- Overview Artificial Intelligence (AI):-

Artificial intelligence may be defined as the branch of computer science that is concerned with the automation of intelligent behavior. The two most fundamental concerns of artificial intelligence researchers are knowledge representation and search.

The intelligent activity is achieve through the use of:

1- Symbol patterns to represent significant aspects of problem domain.

2- Operations on these patterns to generate potential solutions to problems.

3- Search to select solution from among these possibilities [1].

The physical symbol system hypothesis outlines the major foci of artificial intelligence research and application development: defining the symbol structures and operations necessary for intelligent problem solving and developing strategies to efficiently and correctly search the potential solutions generated by these structures and operations. These are the interrelated issues of knowledge representation and search; together, they are at the heart of modern research in artificial intelligence. The physical symbol system hypothesis is disputed by critics who argue that intelligence is inherently biological and existential, and cannot be captured symbolically [2].

These arguments provide a well-considered challenge to the dominant direction of artificial intelligence research, and have influenced the direction of research in neural network, genetic algorithms and agent-based approaches. In spite of these challenges, the assumptions of the physical symbol system hypothesis underlie nearly all practical and theoretical work in expert systems, planning, and natural language understands.

The function of any representation scheme is to capture the essential features of a problem domain and make that information accessible to a problem-solving procedure. It is obvious that a representation language must allow the programmer to express the knowledge needed for problem solution.

The representation of only that information needed for given purpose. is an essential tool for managing complexity. It is also important that the resulting programs be computationally efficient. Expressiveness and efficiency are major dimensions for evaluating knowledge representation languages. Many highly expressive representations are too inefficient for use in certain classes of problems. Sometimes, expressiveness must be sacrificed to improve efficiency. This must be done without limiting the representation's ability to capture essential problem-solving knowledge. Optimizing the trade-off between efficiency and expressive-ness is a major task for designers of intelligent systems. Knowledge representation languages are also tools for helping humans solve problems. As such, a representation should provide a natural framework for expressing problem-solving knowledge; it should make that knowledge available to the computer and assist the programmer in its organization. A representational scheme should be adequate to express all of the necessary information, support efficient execution of the resulting code, and provide a natural scheme for expressing the required knowledge.

In general, the problems artificial intelligence attempts to solve do not lend themselves to the representations offered by more traditional formalisms such as arrays. Artificial intelligence is concerned with qualitative rather than quantitative problem solving, with reasoning rather than calculation, with organizing large and varied amounts of knowledge rather than implementing a single, well-defined algorithm. To support these needs, an artificial intelligence programming requires a means of capturing and reasoning about the qualitative aspects of problem.

The ability to infer additional knowledge from world description is essential to any intelligent entity. Rather, we are able to formulate and reason from abstract descriptions of classes of objects and situations. A knowledge representation language must provide this capability.

In addition to demonstrating the use of logical rules, infer additional knowledge from basic facts, the intelligent system must be as general as possible, any useful representation language needs variables. The requirements of qualitative reasoning make the use and implementation of variables subtly different from their treatment in traditional programming languages. Many artificial intelligence problem domains require large amount of highly interrelated knowledge. An intelligent system must not only know things but also must know what it knows. It must be able to solve problems as well as explain how it solved them and why it made certain decisions. It should be able to describe its knowledge in both specific and general terms, recognize its limitations, and learn from its interactions with the world. This knowledge about what you know constitutes a higher level of knowledge called meta-knowledge, and is essential to the design and development of truly intelligent systems [1].

Artificial intelligence applies human reasoning techniques to computers. The software and hardware are designed to simulate the human mind. Expert systems and neural networks are just one application of artificial intelligence. Expert systems are computer programs that reflect the behavioral characteristics of hired experts how are specialists in a given field. The software is designed to emulate how the experts would make decision to solve clearly defined problems. An expert system provides advice using its knowledge and experience base. It is designed to ask for additional information in a reasoning process directed to solving a specific business problem, such as how reduce a given cost while improving productivity and quality. It is also appropriate for unstructured situations and tasks, is interactive, and uses judgment.

There are many branches of artificial intelligence, figure (1.1) shows that, it includes Expert Systems, Neural Network, Robotic, Visual Image Understanding, Pattern Recognition, Speech Processing, and Natural Language Processing. Among all different artificial intelligence applications, expert systems are the most promising and have received the most attention from the commercial world.

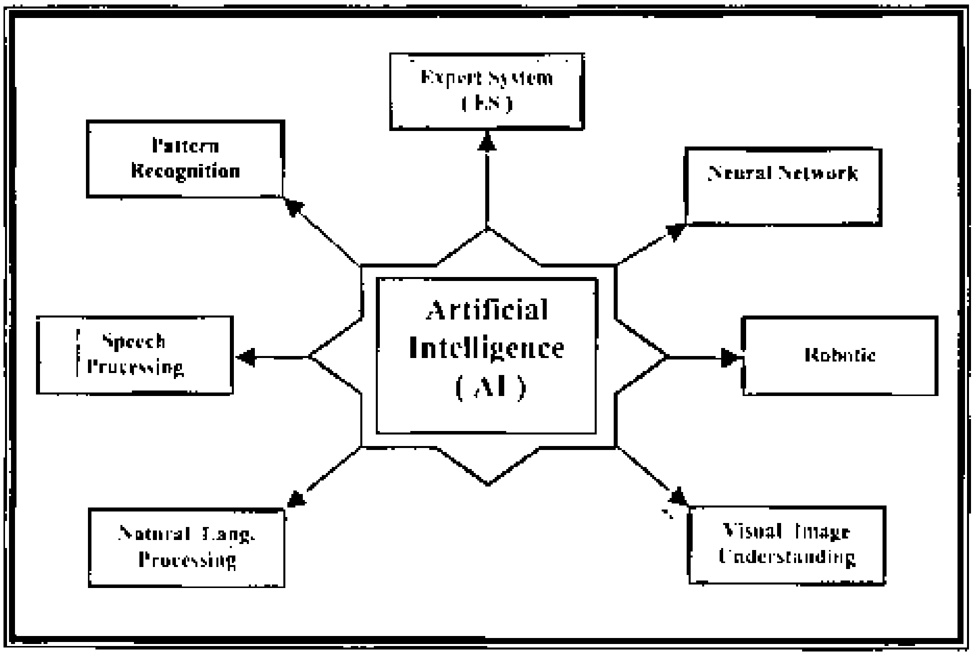


Figure (1.1) Fields of Artificial Intelligence.

While artificial intelligence programs have been written in almost every programming language, the most popular are Prolog, Lisp, C/C++, and Java. Prolog, a high-level language, is very popular for artificial intelligence programming especially where logic plays a significant role. Lisp, another high-level language, offers the advantage of fast prototyping at the expense of slower execution. Universities and laboratories use Lisp extensively for artificial intelligence research. C/C++, a general-purpose language, is used extensively for both artificial intelligence and non-artificial intelligence applications. C/C++, which is very fast, is often used when speed is of paramount importance. For instance, back-propagation in neural networks, which requires fast execution, can be handled simply in C/C++. Java syntax is like that of C/C++. Java should be used when portability among different platforms is of prime importance [3].

The goal of artificial intelligence is to develop computers programs that solve problems in a manner that would be considered intelligent if done by a human. Artificial intelligence scientists discovered that it was too difficult to make an all-purpose intelligent program. Therefore, artificial intelligence scientists began to focus their efforts on developing generalized knowledge presentation and search techniques for specialized programs. Knowledge representations focus on ways to formulate a problem so that it becomes solvable. Search focuses on ways to efficiently navigate throw the solution space to minimize computation time and memory requirement [4].

Artificial intelligence is a field of study that encompasses computational techniques for performing tasks that apparently require intelligence when performed by humans. Such problems include diagnosing problems in automobiles, computers and people, designing new computers, writing stories and symphonies, finding mathematical theories, assembling and inspecting products in factories, and negotiating international treaties. It is a technology of information processing concerned with processes of reasoning, learning, and perception [5].

Artificial intelligence, as we know it today, is relatively new field. Even though some groundwork had been laid earlier, artificial intelligence began earnest with the emergency of the modern computers during the 1940s and 1950s. It was the ability of these new electronic machines to store large amount of information and process it at very high speeds that give researchers the vision of building systems which could emulate some human abilities.

During the past years, we have witnessed the realization of many of these early researchers ' vision. We have seen computer systems shrink in size and cost by several orders of magnitude. We have seen memories increase in storage capacity to the point where they equal a significant fraction of the human brain's storage capacity. We have seen the speed and reliability of systems improve dramatically. And, we have seen the introduction of many impressive software tools.

Like other definitions of complex topics, an understanding of artificial intelligence requires an understanding of related terms such as intelligence, Knowledge, reasoning, thought, cognition, and number of computer-related terms. While we lack precise scientific definitions for many of these terms, we can give general definitions of them. And, of course, one of the objectives of this text is to impart special meaning to all of the terms related to artificial intelligence, including their operational meanings.

Artificial intelligence one of the most important developments of the world. The importance of artificial intelligence become apparent to many of the world's leading countries who recognized the potential for artificial intelligence were willing to seek approval for long-term commitments for the resources needed to fund intensive research programs in artificial intelligence [6].

Artificial intelligence is concerned with programming computers to perform tasks that are presently done better by humans, because they involve such higher mental processes such as perceptual learning, memory organization, and judg-mental reasoning. Thus, writing a program to perform complicated statistical calculations would not be seen as an artificial intelligence activity, while writing a program to design experiments to test hypotheses would. Most people are not very good at doing long calculations by hand, whereas computers excel at such tasks. On the other hand, devising good experiments to test hypotheses is a skill that the research scientist derives partly from training and partly from experience. Programming a computer to perform such a task would be entirely non-trivial [7].

From a practical standpoint, the artificial intelligence makes computers more useful for humans. This can be achieved by producing computer programs that assist humans in decision making, intelligent information search, or simply making computers easier to use with natural language interfaces. A second goal of artificial intelligence, but an equally important one, is to better understand human intelligence. Building an intelligent computer system requires us to understand how human capture, organize, and use knowledge during their problem solving [8].

1.1.1- The basic heuristic situations to solve artificial intelligence problem:-

1- A problem may not have an exact solution because of inherent ambiguities in the problem statement or available data. Medical diagnosis is an example of this. A given set of symptoms may have several possible causes; doctors use heuristics to choose the most likely diagnosis and formulate a plan of treatment. Vision is another example of an inherently inexact problem. Visual scenes are often ambiguous, allowing multiple interpretations of the connectedness, extent, and orientation of objects. Optical illusions exemplify these ambiguities. Vision systems typically use heuristics to select the most likely of several possible interpretations of any given scene.

2- A problem may have an exact solution, but the computational cost of finding it may be prohibitive. In many problems (such as chess), state space growth is combinatorially explosive, with the number of possible states increasing exponentially or factorially with the depth of the search. In these cases, exhaustive, brute-force search techniques such as depth-first or breadth-first search may fail to find a solution within any practical length of time. Heuristics attack this complexity by guiding the search along the most promising path through the space. By eliminating unpromising states and their descendants from consideration, a heuristic algorithm can defeat this combinatorial explosion and find an acceptable solution.

Like all rules discovery and invention, heuristic are fallible. A heuristic is only an informed guess of the next step to be taken in solving a problem. It is often based on experience or intuition. Because heuristics use limited information, such as the descriptions of the states currently on the open list, they are seldom able to predict the exact behavior of the state space farther along in the search. A heuristic can lead a search algorithm to a suboptimal solution or fail to find any solution at all. This is an inherent limitation of heuristic search. It cannot be eliminated by better heuristics or more efficient search algorithms [9].

Heuristics and the design of algorithms to implement heuristic search have long been a core concern of artificial intelligence research.

Game playing and theorem proving are two of the oldest applications in artificial intelligence; both of these require heuristics to prune spaces of possible solutions. It is not feasible to examine every inference that can be made in a mathematics domain or every possible move that can be made on a chessboard. Heuristic search is often the only practical answer.

Expert systems research has affirmed the importance of heuristics as an essential component of problem solving. When human expert solves a problem, he or she examines the available information and makes a decision. The rules of thumb that a human expert uses to solve problems efficiently are largely heuristic in nature. These heuristics are extracted and formalized by expert systems designers [1].

1.2- Research Goals:

1- Identify artificial intelligence problem solving technique.

2- Identify development practice of artificial intelligence problem.

3- Applying the artificial intelligence technique to real world problem.

4- User can observe chemistry experiments whenever he wishes.

5- Provide protection to user from risk of exposing to chemistry substances.

6- Provide saving in cost and time.

7- Facilitate information gathering process using expert system.

1.3- Contribution:

1- Apply artificial intelligence technique using the expert systems.

1- Studied the main component and new applications for expert systems.

2- Used the subject of study to solve problem in some Libyan universities.

1.4- Research Problem:-

Inorganic Chemistry embraces the chemistry of elements. Consequent it ranges from the border of what is called organic chemistry to the border of physical chemistry. Inorganic chemistry concerned with substances similar to those encountered in organic chemistry, but additionally with gases, insoluble solids, air sensitive compounds, and with compounds that are soluble in water. as well as those that are soluble in organic solvents.

The majority of chemical reactions and many measurements of properties are carried out in solvent. The properties of the solvent are crucial to the success or failure of the study. For the inorganic chemist, water has been the most important solvent, and it will continue to be, but many other solvents have been tried and found useful. A few of them, and the concepts that influence the choice of a solvent, are discussed here. Closely connected with the properties of solvent is the behavior of acids and bases.

Through the interviews that I had with some laboratory technicians who observing first year students of chemical department at El-Marj Science and Arts faculty, And El-Marj faculty of teacher training, I found out that those technicians have been faced with some difficulties while the students are doing their experiments. The students overuse many expensive chemical elements due to their lack of experience in using these elements. They also ask many questions and inquiries the matter that makes training sessions very boring. Some students, especially females, feel embarrassed and afraid of asking questions because the technicians are usually males. Some of these experiments are very dangerous.

I have been told by the technicians themselves that they face this problem in most chemical laboratories at different universities. Therefore, I decided to design an expert system for training students in order to detect the acidic part of salt.

The concepts of acidity and basicity are so pervasive in chemistry that acids and bases have been defined many times and in various ways. One definition, probably the oldest, is so narrow as to water as solvent. According to this, acids and bases are sources of H^+ and HO^-, respectively. A somewhat broader, but closely allied definition that is applicable to all protonic solvents is that of BrØnsted and Lower (an acid is a substance that supplies protons and base is a proton acceptor) [10].

1.4.1- Identification of Acid Radicals:

Acid radicals (anions) are divided into three groups:

1- Dilute Hydrochloric acid group (dil. HCl):

This group includes carbonate (CO_3^{2-}), bicarbonate (HCO_3^-), sulphide (S^{2-}), sulphite (SO_3^{2-}), thiosulphate ($S_2O_3^{2-}$) and nitrite (NO_2^-), which are affected by dilute hydrochloric acid (HCl).

2- Concentrated Sulphuric acid group (Con. H_2SO_4) :

This group includes chloride(Cl^-), bromide(Br^-), iodide (I^-) and nitrate(NO_3^-)which are affected by Concentrated sulphuric acid H_2SO_4.

3- Precipitation group (p.p.t. group) :

This group includes sulphate(SO_4^{2-}), phosphate (PO_4^{3-}) and borate ($B_4O_7^{2-}$) which are not visibly affected by acid [11].

1.4.2- Scheme For Detection Of Acid Radical :

I) Treat solid substance with dil. HCl and observe the effect.

S.N.	Observation	Inference
1	Effervescence in the cold with evolution of CO_2.	Carbonate (CO_3^{2-}) or Bicarbonate (HCO_3^-)
2	Colorless gas is evolved , odor of rotten eggs , blackens lead acetate paper (H_2S).	Sulphide (S^{2-})
3	Colorless gas is evolved with suffocating odor , turns potassium dichromate paper green (SO_2).	Sulphite (SO_3^{2-})
4	Nitrous fumes evolved in the cold , recognized by reddish-brown color.	Nitrite (NO_2^-)

II) Treat solid substance with Con. H_2SO_4 and heat gently. This acid reacts (more vigorous) with the above, as well as with the following radicals :

S.N.	Observation	Inference
1	Colorless gas evolved (HCl) with pungent odor and which fumes in the air; with fume of (NH_4Cl) in contact with glass rod wet with (NH_4OH) solution.	Chloride (Cl^-)
2	Gas evolved with pungent odor (HBr + Br_2) reddish color , and solution turns brown.	Bromide (Br^-)
3	Violet vapors evolved ($HI+I_2$), accompanied by pungent acid fumes and often (SO_2).	Iodide (I^-)
4	Pungent acid fumes evolved (HNO_3+NO_2) often colored brown by (NO_2) . color deepens on addition of copper turnings.	Nitrate (NO_3^-)

III) If the above reactions fail to detect the acid radical, test for sulphate, phosphate or borate as following [11] :-

	S.N.	Observation	Inference
Silver nitrate solution ($AgNO_3$)	1	No p.p.t. .	Sulphate (SO_4^{2-})
	2	Gives a yellow p.p.t. soluble in dil. HNO_3.	Phosphate (PO_4^{3-})
	3	Gives a white p.p.t. soluble in dil. HNO_3 .	Borate ($B_4O_7^{2-}$)

1.5- Thesis Outline:

In ***chapter two*** I display some related works and literatures. In ***chapter three*** I discuss the generally definition, characteristics, structure, types, development team, building, development lifecycle, benefits of the expert systems and I discuss some expert system applications. In ***chapter four*** I define how I acquiring the knowledge and represented it in the knowledge base, and shows the inference engine and user interface. In ***chapter five*** I will show some conclusions and Recommend for future work.

My study aims to design system which will be applied to determine the acid radical of unknown salt.

CHAPTER TWO
RELATED WORK

2- Related Work :

The following includes several works of designing of expert systems related to chemistry domain .

2.1- DENDRAL :

Dendral is a typical project expert system in chemistry. Dendral was developed at Stanford University to determine the molecular structure Martian soil. Dendral proved to be a useful analytical tool chemists and was marketed commercially in the United States [12].

2.2- Green Chemistry Expert System (GCES) :

The Green Chemistry Expert System is a stand-alone computer program that can be used to select green chemicals and reactions. Green chemistry is the design of chemical products and processes that reduce or eliminate the use or generation of hazardous substances. This new approach to pollution prevention is the central focus of the U.S. Environmental Protection Agency's (EPA's) Green Chemistry Program, an initiative under the EPA Design for the Environment program [13].

2.3- An Expert System for Selection of Measurement Instruments For Industrial Chemical Process (Case study : Flow meters) :

This work an expert system developed that supports the different applications in the industrial chemical processes[14].

2.4- An Expert System for Product Management (Case Study : Pharmaceutical Companies) :

This work devoted to designing and implementing an expert system for pharmaceutical product management in the Egyptian market that can advice, analyze, diagnose, explain and justify. The system is supported with a database for the Egyptian Pharmaceutical companies and the Pharmaceutical products in the Egyptian market. The pharmaceutical product management expert system is suitable for real time practical applications and for training purposes [15].

2.5- An Expert System for Diagnosis of Heart Diseases:

The proposed system deals with Heart Diseases with a view to determining whether the disease is Anging Pectoris or Myocardial Information.

In order to accomplish its tasks, the system collects data about the patient's background; habits, style of life, etc., family history, etc., complaint; the pain type and site, and finally results of different investigations methods such as ECG and enzymes test. All of these data lead to the identification of the Ischemic Heart Disease.

The system is implemented in Prolog2 and uses production rules as a means of knowledge representation [16].

2.7- The development of an expert system in cabin crew pattern :

Cabin crew pattern generation according to flight schedules requires the intensive use of human experts in a limited time. The patterns generated aim to incur minimum cost of crew expenditure to the company. The automation of such a planning activity can reduce the pressure on a planner due to the frequently changing flight schedules. This paper describes the role of knowledge in the cabin crew pattern generation process from the viewpoint of acquisition, representation and utilization. A hybrid knowledge representation strategy has been adopted in modeling the system. The expert system embraces the important area of domain knowledge in Duty Travel. The application of the Duty Travel technique can help to reduce the living and accommodation expenses of cabin crew staying away from base by shortening the whole pattern duration significantly. An iterative verification and validation process has been conducted to ensure the system correctness [17].

2.6- DIAGNOSIS AND EXPLANATION BY A NUCLEAR CARDIOLOGY EXPERT SYSTEM :

Examines a project directed toward the design and development of a knowledge-based expert system (NUCES). Interpretation of radionuclide imaging in the heart using NUCES [18].

CHAPTER THREE
EXPERT SYSTEMS

3- EXPERT SYSTEMS :

3.1- History :

Expert systems are a recent product of artificial intelligence. They began to emerge as university research systems during the early 1970s. They have now become one of the more important innovations of artificial intelligence since they have been shown to be successful commercial products as well as interesting research tools.

The first expert system to be completed was DENDDRAL, developed at Stanford University. This system was capable of determining the structure of chemical compounds given a specification of the compound's constituent elements and mass spectrometry data obtained from samples of compound. DENDDRAL used heuristic knowledge obtained from experienced chemists to help constrain the problem and thereby reduce the search space. During test, DENDDRAL discovered a number of structures previously unknown to expert chemists[6].

In 1980, General Electric company build an expert system by modeling the way a human troubleshooter works. The system builders spent several months interviewing the expert and transferring his knowledge to a computer. The computer programming was prototyped over a three-year period, slowly increasing the information and the number of decision rules stored in the computer. The final product, called DELTA, was able to reason much the same way an experienced locomotive engineer reasons. The new diagnostic technology enables a novice engineer or a technician to uncover a fault by spending only a few minutes at the computer terminal [19].

Expert systems have proven to be effective in a number of problem domains which normally require the kind of intelligence possessed by a human expert. The areas of application are almost endless. Wherever human expertise is needed to solve problems, expert systems are likely candidates for application. Application domains include law, chemistry, biology, engineering, manufacturing, aerospace, military operations, finance, banking, meteorology, geology, geophysics, and more [6].

3.2- Definitions :-

There are many definitions of expert system, I will display it in this section :

* **Expert system** is a computer program designed to model the problem-solving ability of a human expert [8].

* **An expert system** is a system that employs human knowledge captured in a computer to solve problems that ordinarily require human expertise[19].

* **An expert system** is a computer program that emulates the behavior of a human expert within a specific domain of knowledge [20].

* **An expert system** is a knowledge-based program that provides "expert quality" solution to problems in a specific domain [21].

* **Expert systems** are programs for reconstructing the expertise and reasoning capabilities of qualified specialists within limited domains [22].

* **knowledge-based system** is a computer system that attempts to replicate specific human expert intelligent activities [23].

* **An expert system** is a set of programs that manipulate encoded knowledge to solve problems in a specialized domain that normally requires human expertise. An expert system's knowledge is obtained from expert sources and coded in a form suitable for the system to use in its inference or reasoning process. The expert knowledge must be obtained from specialists or other sources of expertise, such as texts, journal articles. and data bases. This type of knowledge usually requires much training and experience in some specialized field such as medicine, geology, system configuration, or engineering design. Once a sufficient body of expert knowledge has been acquired. it must be encoded in some form, loaded into a knowledge base, then tested, and refined continually throughout the life of the system [6].

3.3- Characteristics :-

Expert system elements as show in figure (3.1) include: a user interface. a knowledge base. an inference engine and control mechanism, and computer hardware [23].

* **User Interface**: the user interacts with the system through a ***user interface*** that simplifies communication and hides much of the complexity, such as the internal structure of rule base. Expert system interfaces employ a variety of user styles. such as question-and-answer, menu-driven. or graphics interface. The final decision on the interface type is a compromise among user needs, the requirements of the knowledge base and inferencing system.

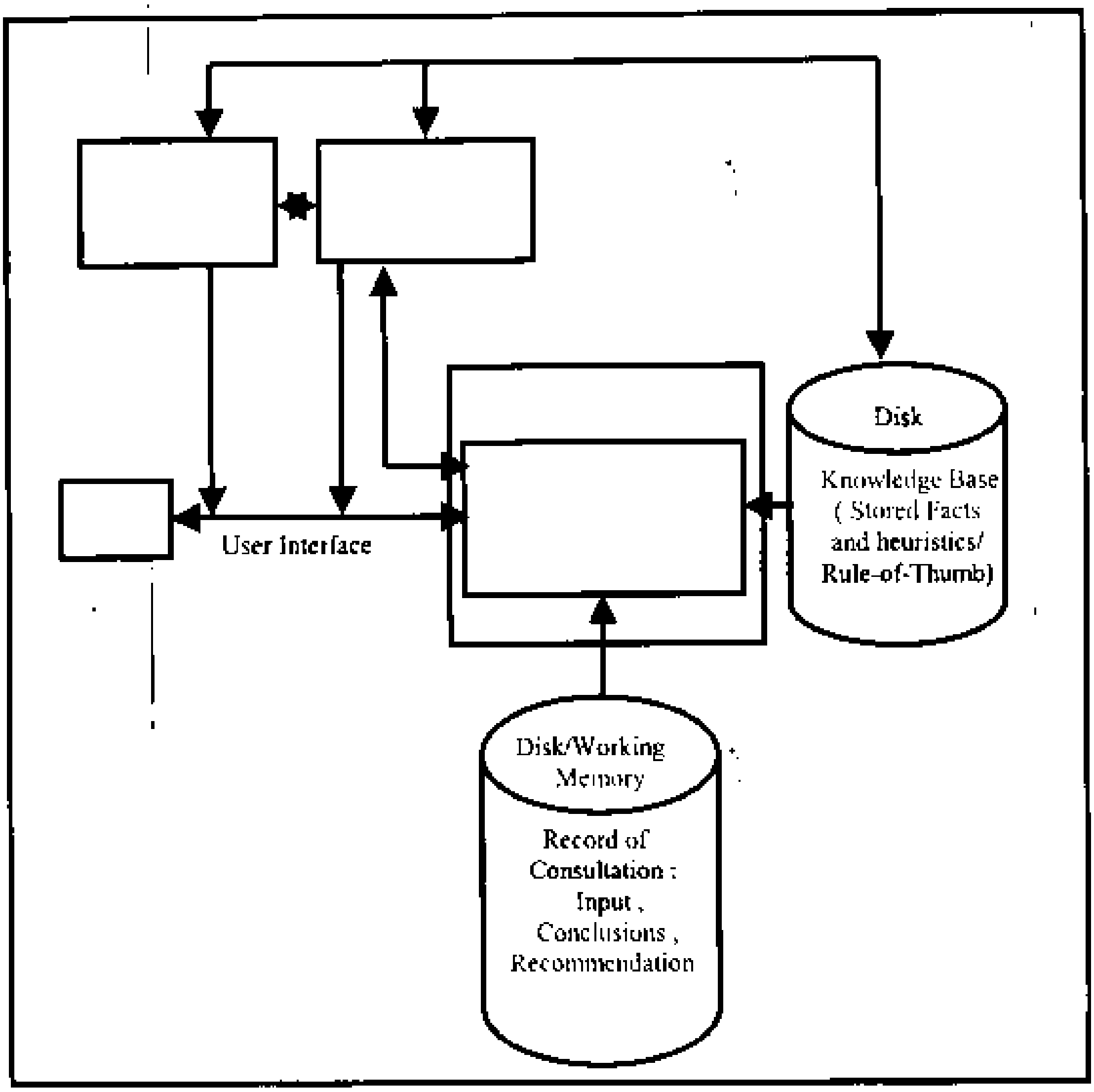


Figure (3.1) Essential components of expert system.

* **Knowledge Base:** the heart of the expert system is the ***knowledge base***, which contains the knowledge of a particular application domain. In the rule-based expert system, this knowledge is represented in the form of (*if ...then...)* rules. The knowledge base contains both *general knowledge* as well as *case-specific* information.

* **Inference Engine:** the ***inference engine*** applies the knowledge to the solution of actual problems [1].

The major characteristics that distinguish expert systems from conventional computer systems are that they :-

1- Expert systems use knowledge rather than data to control the solution process. Much of the knowledge used is heuristic in nature rather than algorithmic.

2- The knowledge is encoded and maintained as entity separate from the control program. As such, it is not compiled together with the control program itself. This permits the incremental addition and modification (refinement) of the knowledge base without recompilation of the control programs. Furthermore, it is possible in some cases to use different knowledge bases with the same control programs to produce different types of expert systems. Such systems are known as expert system shells since they may be loaded with different knowledge bases.

3- Expert systems are capable of explaining how a particular conclusion was reached, and why requested information is needed during a consultation. This is important as it gives the user a chance to assess and understand the system's reasoning ability, thereby improving the user's confidence in the system.

4- Expert systems use symbolic representations for knowledge (rules, networks, or frames)and perform their inference through symbolic computations that closely resemble manipulations of natural language.

5- Expert systems often reason with meta-knowledge; that is, they reason with knowledge about themselves, and their own knowledge limits and capabilities [6].

Other distinguishing characteristics of expert systems are that they :-

6- Have a facility to explain their advice or reasoning process, so that a user can see why and how a conclusion was reached.

7- Contain symbolic programming and reasoning capabilities.

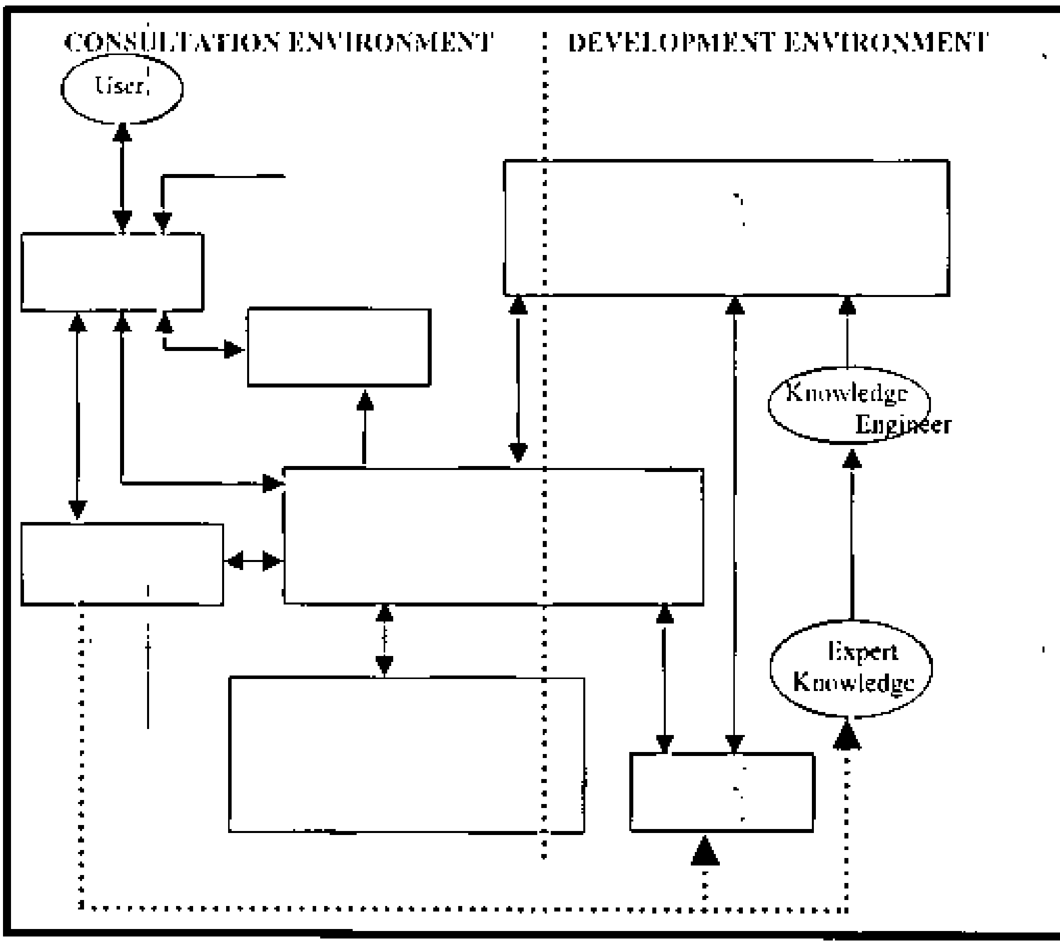
8- Use IF–THEN rules extensively, but not necessarily exclusively, and so are more readily understandable to non-technical users.

9- Can handle uncertain, unknown, and conflicting data.

10- Very often require a high level of involvement of a human expert in their development [23].

3.4- Structure :

Expert systems are composed of two major parts : the **development environment** and the **consultation** (runtime) **environment** figure (3.2) show that. The development environment is used by the expert system builder to build the components and introduce knowledge into the knowledge base. The consultation environment is used by a nonexpert to obtain expert knowledge and advice.



Figure(3.2) Structure of an expert system.

The following components may exist in an expert system :

3.4.1- Knowledge acquisition subsystem :-

Knowledge acquisition is the accumulation, transfer, and transformation of problem-solving expertise from some knowledge source to a computer program for constructing or expanding the knowledge base. Potential sources of knowledge include human expert, textbooks, database, special research reports, and pictures.

3.4.2- Knowledge base :-

The knowledge base contains knowledge necessary for understanding, formulating, and solving problems. It includes two basic elements: (1) **Facts**, such as the problem situation and theory of the problem area and (2) **Special heuristics**, or Rules that direct the use of knowledge to solve specific problems in a particular domain. The heuristics express the informal judgmental knowledge in an application area. Global strategies, which can be both heuristics and a part of the theory of the problem area, are usually included in the knowledge base. Knowledge, not mere facts, is the primary material of expert system. The information in the knowledge base is incorporated into a computer program by a process called **knowledge representation**. There are many methods to represent the knowledge of expert system are discussed as bellows :

*** Rule-based Representation :**

Rule-based systems are comprised of rule, working memory, and a rule interpreter. The domain knowledge in a rule-based system is represented as a set of rules. In their simplest form, rules are condition-action pairs specifying that *if* some *condition* is true, *then* some *action* is performed.

*** Frame Representation:**

Frames are a straightforward way to represent descriptive information. Each frame contains information about one particular object, concept, or event and typically has *slots* which contain values. Often, a frame will describe a *stereotyped* class of objects, concepts, or events which has a set of expected slots.

*** Hybrid Representation:**

Often, a single form of knowledge representation is not adequate for the solution of an expert system task, so many recent systems have exploited the advantages of different representations by combining them in one system.

*** Semantic network Representation:**

A semantic network is a graph consisting of nodes and links. Each node represents one or more data items such as objects, concepts, events, or hypotheses, while each link between two nodes represents a binary relationship between those nodes [20].

3.4.3- Inference engine :-

The brain of expert system is the inference engine, also knows as the control structure or the rule interpreter. This component is essentially a computer program that provides a methodology for reasoning about information in the knowledge base and in the blackboard, and for formulating conclusions. This component provides directions about how to use the system's knowledge by developing the agenda that organizes and controls the steps taken to solve problems whenever consultation is performed.

The inference engine has three major elements :

* An interpreter, which executes the chosen agenda items applying the corresponding knowledge base rules.

* A scheduler, which maintains control over the agenda. It estimates the effects of applying inference rules in light of item priorities or other criteria on the agenda.

* A consistency enforcer, which attempts to maintain a consistent representation of the emerging solution.

3.4.4- Blackboard (workplace) :-

The blackboard is an area of working memory set aside for the description of a current problem, as specified by the input data; it is also used for recording intermediate results. The blackboard records intermediate hypotheses and decisions. Three types of decisions can be recorded on the blackboard: (1)Plan – how to attack the problem, (2)Agenda – potential actions awaiting execution, and (3)Solution – candidate hypotheses and alternative courses of that the system has generated thus far.

3.4.5- User interface :-

Expert systems contain a language processor for friendly, problem-oriented communication between the user and the computer. This communication could best be carried out in a natural language, and in some cases it is supplemented by menus and graphics.

3.4.6- Explanation subsystem (justifier) :-

The ability to trace responsibility for conclusions to their sources is crucial both in the transfer of expertise and in problem solving. The explanation subsystem can trace such responsibility and explain the expert system behavior by interactively answering questions such as the following :

* Why was a certain question asked by the expert system ?
* How was a certain conclusion reached ?
* Why was a certain alternative rejected ?
* What is the plan to reach the solution ?

3.4.7- Knowledge refining system :-

Human experts have a knowledge refining system; that is, they can analyze their own performance, learn from it, and improve it for future consultations. Similarly, such evaluation is necessary in computerized learning so that the program will be able to analyze the reasons for its success or failure. This could lead to improvements that result in a better knowledge base and more effective reasoning .

3.5- Types :-

Expert systems appear in many varieties. The following classifications of expert systems are not exclusive, that is, one expert system can appear in several categories.

3.5.1- Rule-based expert systems :-

In such systems the knowledge is represented as a series of production rules.

3.5.2- Frame-based expert systems :-

In these systems, the knowledge is represented as frames, a representation of the object-oriented programming.

3.5.3- Hybrid systems :-

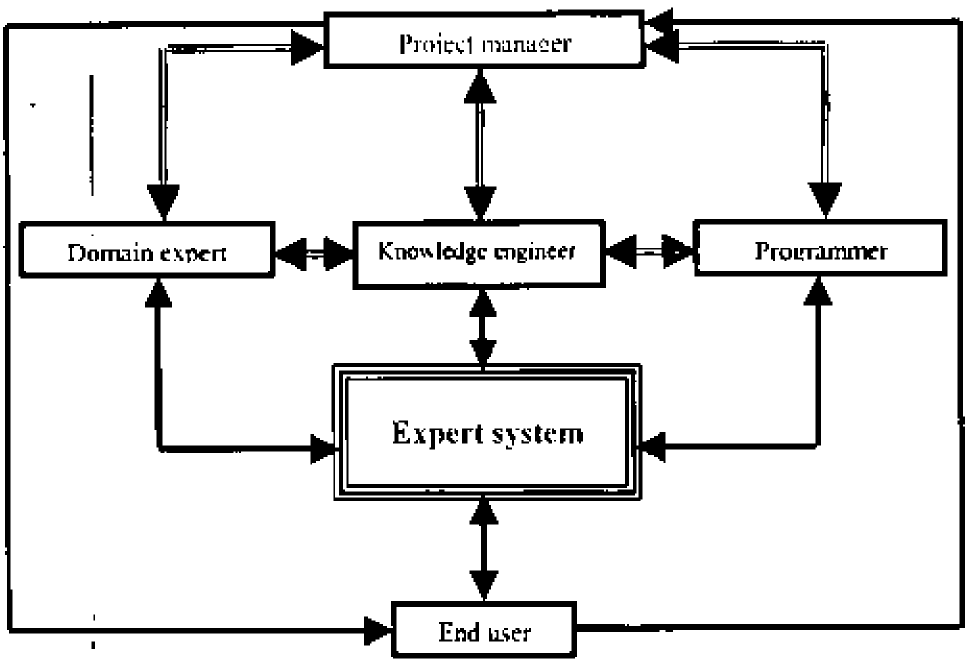
These systems include several knowledge representation approaches, at minimum frames and rules, but usually much more.

3.5.4- Model-based systems :-

Model-based systems are structured around a model that simulates the structure and function of the system under study. The model is used to compute values which are compared to observed ones [19].

3.6- Expert System development team :-

In general, there are five members of the expert system development team: the domain expert, the knowledge engineer, the programmer, the project manager, and the end user. The success of expert system entirely depends on how well the members work together. The basic relations in the development team are summarized in figure(3.3).



Figure(3.3) The expert system development team.

The domain expert is a knowledgeable and skilled person capable of solving problems in a specific area or domain. This person has the greatest expertise in a given domain. This expertise is to be captured in the expert system. Therefore, the expert must be able to communicate his knowledge, be willing to participate in the expert system development and commit a substantial amount of time to the project. The knowledge engineer is someone who is capable of designing, building, and testing an expert system. This person is responsible for selecting an appropriate task for the expert system. He interviews the domain expert to find out how a particular problem is solved. Through interaction with the expert, the knowledge engineer establishes what reasoning methods the expert uses to handle facts and rules and decides how to represent them in the expert system. The knowledge engineer then chooses some development software or an expert system shell, or look at programming languages for encoding the knowledge. And finally, the knowledge engineer is responsible for testing, revising, and integrating the expert system in to the workplace. The programmer is the person responsible for the actual programming, describing the domain knowledge in terms that a computer can understand. The programmer needs to have skills in symbolic programming in such artificial intelligence languages as Prolog, LISP, and OPS5 and also some experience in the application of different types of expert system shell. The project manager is the leader of the expert system development team, responsible for keeping the project on track. The end user is a person who uses the expert system when it is developed[12].

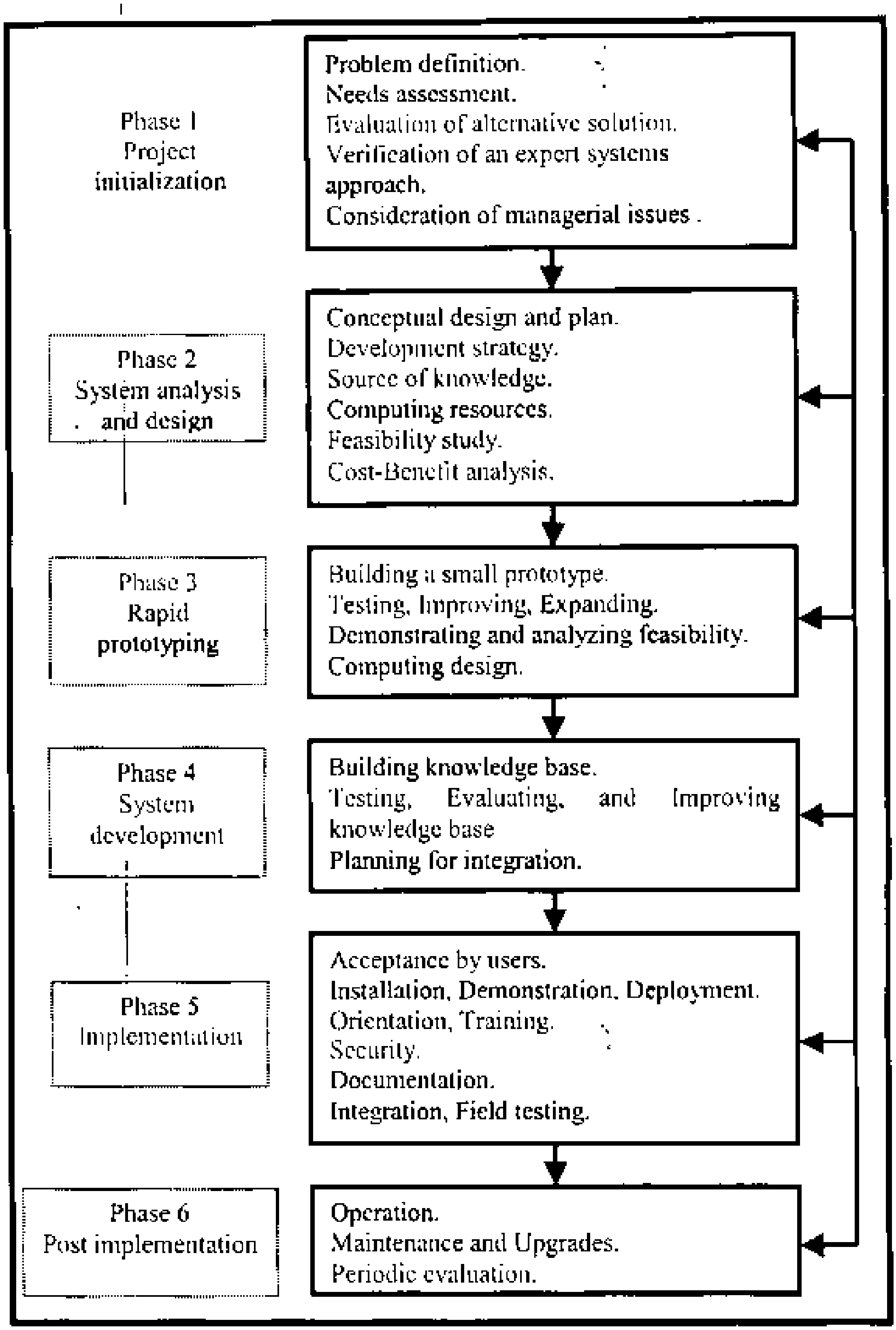
3.7- Building Expert Systems :-

3.7.1-Expert Systems Development lifecycle :-

An expert system is basically computer software and as such its development follows a software development process. The goal of such a process is to maximize the probability of developing viable, sustainable software within cost limitations and according to schedule. The main functions of model of this process are to determine the order of the steps involved in the software development and to establish the criteria for progressing from one stage to another. Many such models have been proposed; notable is waterfall model for a system development life cycle.

When expert systems are constructed, some or all of the software development tasks are being performed. The nature of the specific application determines which tasks are going to be performed, in which order, and to what depth.

The various tasks that are encountered in building expert systems are organized in six phases, as show in figure (3.4) [19].



Figure(3.4) Expert system development lifecycle.

3.7.2- Questions to begin building an expert system :

Why are we developing this expert system?

Will the effort in building the system be justified?

What will the return on investment be?

How are we going to building it?

What tools are available?

Can the system be built in the way that we envisage?

What can go wrong?

When do we stop development?

How do we maintain the system after it has been built?

The first question, as any software development effort, is Why are we doing this? with the associated questions Will the effort in building the system be justified? and What will the return on investment be?

The issue of *why* is quickly followed by *how*. If we think that the expert system can be justified and will produce a return on investment, how are we going to building it? In general, one will also ask who is going to help us? The development of most expert systems is a joint, rather than an individual effort. Joint efforts have one advantage in that there are more people who are knowledgeable about the system and who can potentially support it after its built.

The development of knowledge acquisition tools, makes it feasible for experts to make on some, if not all, of the knowledge engineering task. In general, the need for a knowledge engineer is often inversely proportional to the quality of the knowledge acquisition tools that are available.

Apart from domain experts and knowledge engineers, a third type of person who should be consulted is the user. In some cases, experts will use expert system themselves. In other cases there will be a different class of user. The user should be involved early in the process so that the input-output characteristics of the system, and its interface, can be molded to personal needs.

The way in which expert systems should be built; i.e., the how of building expert systems, is strongly affected by what tools are available.

At one extreme the choice of tools to be used in building the expert system is predetermined by organizational policy. At the other extreme, one has total freedom in the choice of the hardware and software to be used for expert system development. However, most situations lie somewhere between these two extremes and compromises need to be made.

Other important tools include knowledge acquisition tools and programs for testing and validating the knowledge base. An interface building toolkit will also be useful in testing early prototypes. Such a toolkit would allow a variety of screen design utilities, windowing and menu options, etc. This toolkit may be built into the expert system shell or added by linking external routines.

Another major question is Can it be done? One way to get a better perspective on this question is to think through the possible failure modes and construct a "fault-tree" as it were.

3.7.3- Reasons of failure in expert system :

* The knowledge required and the difficulty in acquiring it is underestimated, or the expert finds it difficult to express how the knowledge is structured.

* During the project key members of the development team depart without leaving behind sufficient documentation of their activity. The system never fully recovers from the resulting internal chaos.

* The project has insufficient financial backing, or because of internal policy or management changes, the level of resources originally promised is not fulfilled.

* The inference engine is too slow when the system is fielded, producing unacceptably poor real-time performance.

* Users cannot use the system because they do not understand how to operate it due to either poor interface design or to the lack of appropriate instructions.

* No one is available to update and maintain the system as the knowledge in the domain changes. Consequently, the system falls out of step with the knowledge domain.

* A serious attempt should be made at the beginning of the development process to think through the stages of building the expert system and anticipate any flaws or pitfalls that may be encountered. A sufficiently serious flaw may lead one to suspend the project, while in other cases it may produce a modified strategy.

* Like any software development effort, building an expert system requires some discipline in the methods and processes that are used. Enforcing discipline can be difficult as a result of social issues that

interfere with building expert systems. These social issues are often different from the issues involved in conventional software development.

* A final feature of expert system development can be overlooked: Knowing when to stop. An expert system can always be refined, rewritten in a new shell, and so on. Deciding when development stops and the system becomes operational can be a difficult decision. Stopping early can lead to an immature system that is rejected by users. Stopping too late is wasteful at the least; and after a certain point the ratio of return to effort becomes unfavorable [24].

3.8- Benefits Of Expert Systems :-

Expert systems can provide major benefits to users, I will discussed some of it :-

1- Increased output and productivity :

Expert systems can work faster than humans.

2- Increased quality :

Expert systems can increase quality by providing consistent advice and reducing error rate.

3- Reduced downtime :

Many operational expert systems are used for diagnosing malfunctions and prescribing repairs. By using expert system it is possible to reduce downtime significantly.

4- Capture of scarce expertise :

The scarcity of expertise becomes evident in situations where there are not enough experts for a task, the expert is about to retire or leave a job, or expertise is required over a broad geographic location.

5- Flexibility :

Expert systems can offer flexibility in providing services and in manufacturing.

6- Easier equipment operation :

Expert systems make complex equipment easier to operate.

7- Elimination of the need for expensive equipment :

In many cases a human must rely on expensive instruments for monitoring and control. Expert systems can perform the same tasks with lower-cost instruments because of their ability to investigate more thoroughly and quickly the information provided by instruments.

8- Operation in hazardous environments :

Many tasks require humans to operate in hazardous environments. The expert systems may enable humane to avoid such environments. This characteristic is extremely important to enable workers to avoid hot, humid; or toxic environments, such as a nuclear power plant that has malfunctioned.

9-Accessibility to knowledge :

Expert systems make knowledge and information accessible. People can query systems and receive advice.

10- Reliability :

Expert systems are reliable. They do not become tired or bored. Expert systems also consistently pay attention to all details and so do overlook relevant information and potential solutions.

11- Increased capabilities of other computerized systems :

Integration of expert systems with other systems makes the other systems more effective.

12- Integration of several experts opinions :

In certain cases, expert systems force us to integrate the opinions of several experts and thus may increase the quality of the advice.

13- Ability to work with incomplete or uncertain information :

In contrast to conventional computer systems, expert system can, like human experts, work with incomplete information. The user can respond with a "don't know" or "not sure" answer to one or more of the system's questions during a consultation, and the expert system will still be able to produce an answer, although it may not be a certain one. Expert systems do not have to be complete in the same way in which a set of FORTRAN IF-statements do. They can also deal with probabilities, as long as the inference engine can cope with them.

14- Provision of training :

Expert systems can provide training. Novices who work with expert system become more and more experienced. The explanation facility can also serve as a teaching device, and so can notes that may be inserted in the knowledge base.

15- Enhancement of problem solving :

Expert systems enhance problem solving by allowing the integration of top experts' judgment into analysis. They also increase users' understanding through explanation. Expert systems can be used to support the solution of difficult problems.

16- Ability to solve complex problems :

Expert systems may solve problems whose complexity exceeds human ability. Already some expert systems are able to solve problems where the required scope of knowledge exceeds that of any one individual. However, these problems must be in a narrow domain.

17- Knowledge transfer to remote locations :

One of the greatest potential benefits of expert systems is its ease of transfer across international boundaries. This can be extremely important to developing countries that cannot pay for knowledge delivered by human experts [19].

3.9-Expert Systems Applications :-

The range and depth of applications has broadened dramatically. Applications can now be found in almost all areas of business and government. They include such area as:

Different types of medical diagnoses (internal medicine, pulmonary diseases, infectious blood diseases, and so on). Diagnosis of complex electronic and electromechanical systems. Diagnosis of diesel electric locomotion systems.

Diagnoses of software development projects. Forecasting crop damage. Identification of chemical compound structures and chemical compounds. Location of faults in computer and communications system. Scheduling of customer orders, job shop production operations, computer resources for operating systems, and various manufacturing tasks. Evaluation of loan applications for lending institutions. Assessment of geologic structures from dip meter logs. Analysis of structural systems for design or as a result of earthquake damage. The optimal configuration of components to meet given specification for a complex system (like computer or manufacturing facilities). Estate planning for minimal taxation and other specified goals. Stock and bond portfolio selection and management. The design of very large scale integration (VLSI) systems. Numerous military applications ranging from battlefield assessment to ocean surveillance. Numerous applications related to space planning and exploration. Planning curricula for students. Planning experiments in biology, chemistry, and molecular genetics. Teaching students specialized tasks (like trouble shooting equipment faults) [6].

The previous applications can be organized by their generic tasks as illustrated in table(4.1).

Table (4.1) classification of expert systems applications.

N	Domain	Description
1	Control	Governing system behavior specification.
2	Design	Configuring objects under constraint.
3	Diagnosis	Inferring system malfunction from observable.
4	Simulation	Modeling the interaction between system components.
5	Interpretation	Inferring situation description from data.
6	Monitoring	Comparing observations to expectations.
7	Planning	Designing actions.
8	Prediction	Inferring likely consequences of given situations.
9	Prescription	Recommending solution to system malfunction.
10	Selection	Identifying best choice from a list of possibilities.
11	Instruction	Diagnosing, debugging, and repairing student behavior.

1- Control :

Control systems adaptively govern the behavior of a given system. For example, controlling a manufacturing process or the treatment of a patient in the hospital. An expert control system obtains data on the system's operation, interprets the data to form an understanding of the state of the system or a prediction its future state, and determines and executes needed adjustments. Control systems must also perform monitoring and interpretation tasks to track system behavior over time. Some systems include prediction and planning tasks that allow them to formulate plans to avoid anticipated problems.

2- Design :

Design systems configure objects under a set of problem constraints. For example, designing a computer system under user-defined constraints of needed memory, speed, etc. These systems usually perform their tasks following a series of steps, each with its own specific constraints. Complicating matters, these steps are usually dependent upon each other, which makes it difficult to assess the impact a change in one step will have on the other steps. Because of this complication, these types of systems are often built using a non-monotonic reasoning technique.

3- Diagnosis :

Diagnosis systems infer system malfunctions or faults from observable information. Most diagnosis system have knowledge of possible fault conditions with means to infer whether the fault exists from information on the system observable behavior. For example, diagnosis a given disease from the patient's symptoms, or locating malfunctions in an electronic circuit from test results. A more recent trend in the field relies on a model-based reasoning approach, which models the system's normal behavior, and detects and diagnosis faults from deviations in expectations. Most diagnosis systems include a prescription task that offers a remedy to the detected fault [8]. DIAGNOSIS AND EXPLANATION BY A NUCLEAR CARDIOLOGY EXPERT SYSTEM: Examines a project directed toward the design and development of a knowledge-based expert system (NUCES). Interpretation of radionuclide imaging in the heart using NUCES [25].

4- Simulation :

Simulation systems model a process or system to permit operational studies under various conditions. They model the various components of the system and their interactions. Users are usually permitted to make adjustments to the model to account for either existing or hypothetical conditions. Using the model along with the user-supplied information, these systems can be used to predict operating conditions for the real system.

5- Interpretation :

Interpretation systems produce an understanding of a situation from available information. Typically this information consists of data from such source as sensors, instruments, test results, etc. For example, machine monitoring sensors, imaging systems, or speech analysis results. These systems translate the raw data into symbolic form that describes the situation. These systems often need to work with noisy, incomplete, or unreliable data that requires inexact or statistical reasoning.

6- Monitoring :

Monitoring systems compare observable information on the behavior of a system with system states that are considered crucial to its operation. Monitoring systems will usually interpret signals from sensors and compare the information with know crucial states. When a crucial state is detected, an established sequence of tasks is performed. An Intelligent System For Credit Management Follow-up, this thesis is a hybrid intelligent system that combines the neural network and expert system technologies. It deals with the credit decision in the two phases of long granting and follow-up. The first subsystem analyzes the financial performance of every client based on quantitative and qualitative information so as to take the decision of whether to grant or reject the loan. Then, the second subsystem starts following up the granted loan. If the customer refrains from paying, it calculates his credit rating. If the customer credit rating is bad, it analyzes the problem causes and reasons and accordingly takes the suitable remedial action [26].

7- Planning :

Planning systems form actions to achieve a given goal under problem constraints. For example, planning the different tasks performed by a robot to accomplish a given work function. Some planning systems must have the flexibility to change the series of planned tasks when they obtain new problem information. To accomplish this, they need the ability to backtrack and reject a current line of reasoning in favor of exploring a better one. As in the case of systems built for design applications, planning systems usually require non-monotonic reasoning.

8- Prediction :

Prediction systems infer likely consequences from a given situation. These systems attempt to predict future events using available information and a model of the problem. Prediction systems often must be able to reason about time or ordered events. Models must be available to infer how some given action influences future events. For example. predicting the expected damage to a crop from an invading insect. Intelligent simulation models are often used in these types of systems.

9- Prescription :

Prescription systems recommend solutions to a given system malfunction. These types of systems usually first incorporate a diagnosis task to determine the nature of the malfunction. Most rely on a "canned" prescription for each known fault. More advanced systems incorporate planning and prediction techniques for creating tailored remedies.

10- Selection :

Selection systems identify the best choice from a list of possibilities. They work from problem specifications defined by the user and attempt to find a solution that most closely matches these specifications. These systems usually employ an inexact reasoning technique or a matching evaluation function when forming their selections.

11- Instruction :

Instruction system guide the education of a student in a given topic. They treat the student as a system that must be diagnosed and repaired. Typically they begin by interacting with the student to form a model of the student's understanding of the topic. They than compare this student model with an "ideal" model to uncover weaknesses in the student's understanding. This task is then followed by remedial instruction to correct any misunderstandings [8].

CHAPTER FOUR

THE CASE STUDY

4- THE CASE STUDY :

In the following section, a description of problem is defined according to the chemical expert.

4.1- Methodology to solve the problem :

I performed some phases to complete my work as following :

1- Identification :

Identify the problem and its characteristics .

2- Conceptualization :

Find concepts to represent knowledge.

3- Formalization :

Design structure to organize knowledge.

4- implementation :

Formulate rules to embody knowledge.

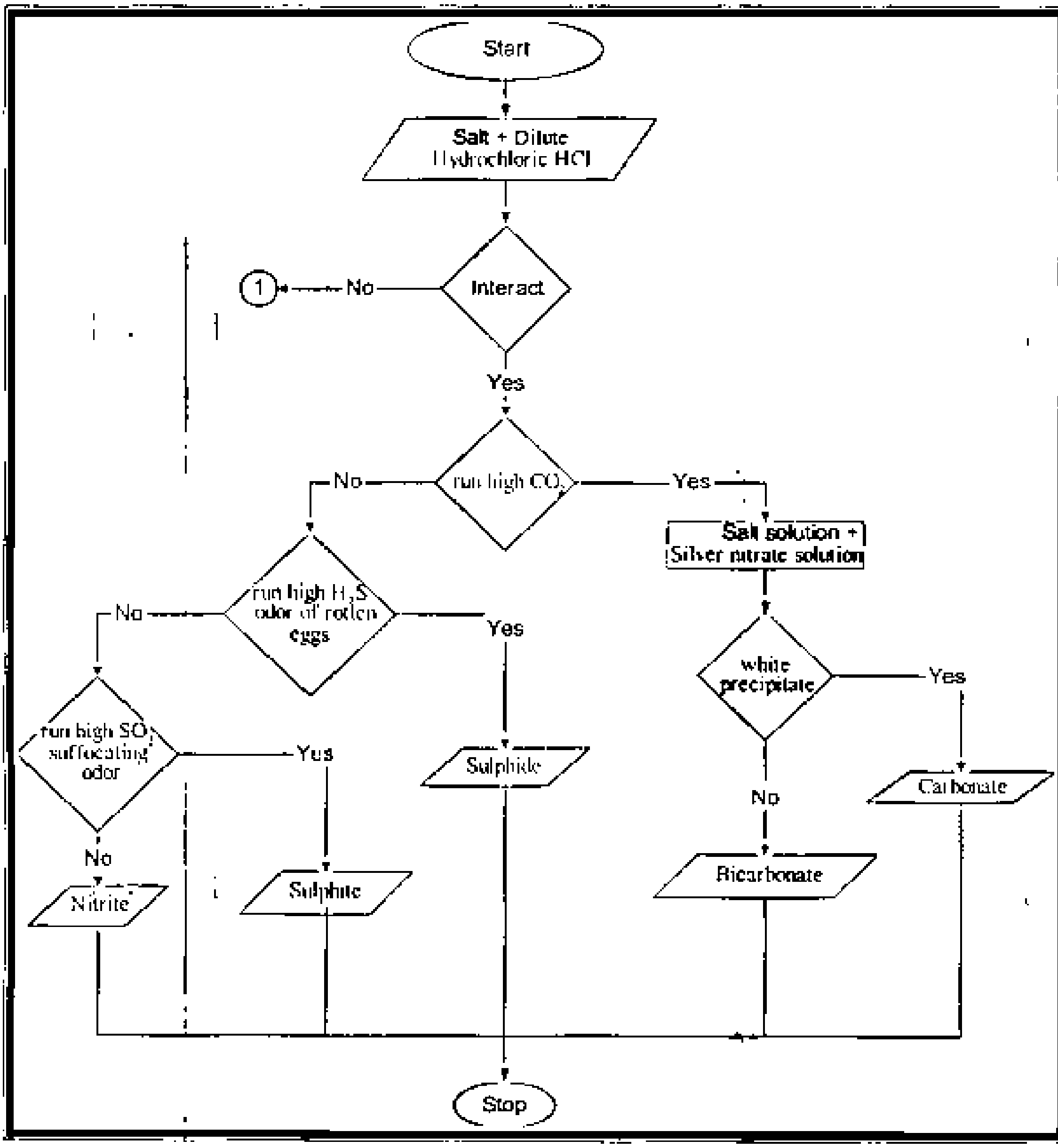
5- Testing :

Validate rules that organize knowledge.

4.1.1- Identification :

1- Dilute Hydrochloric acid group :

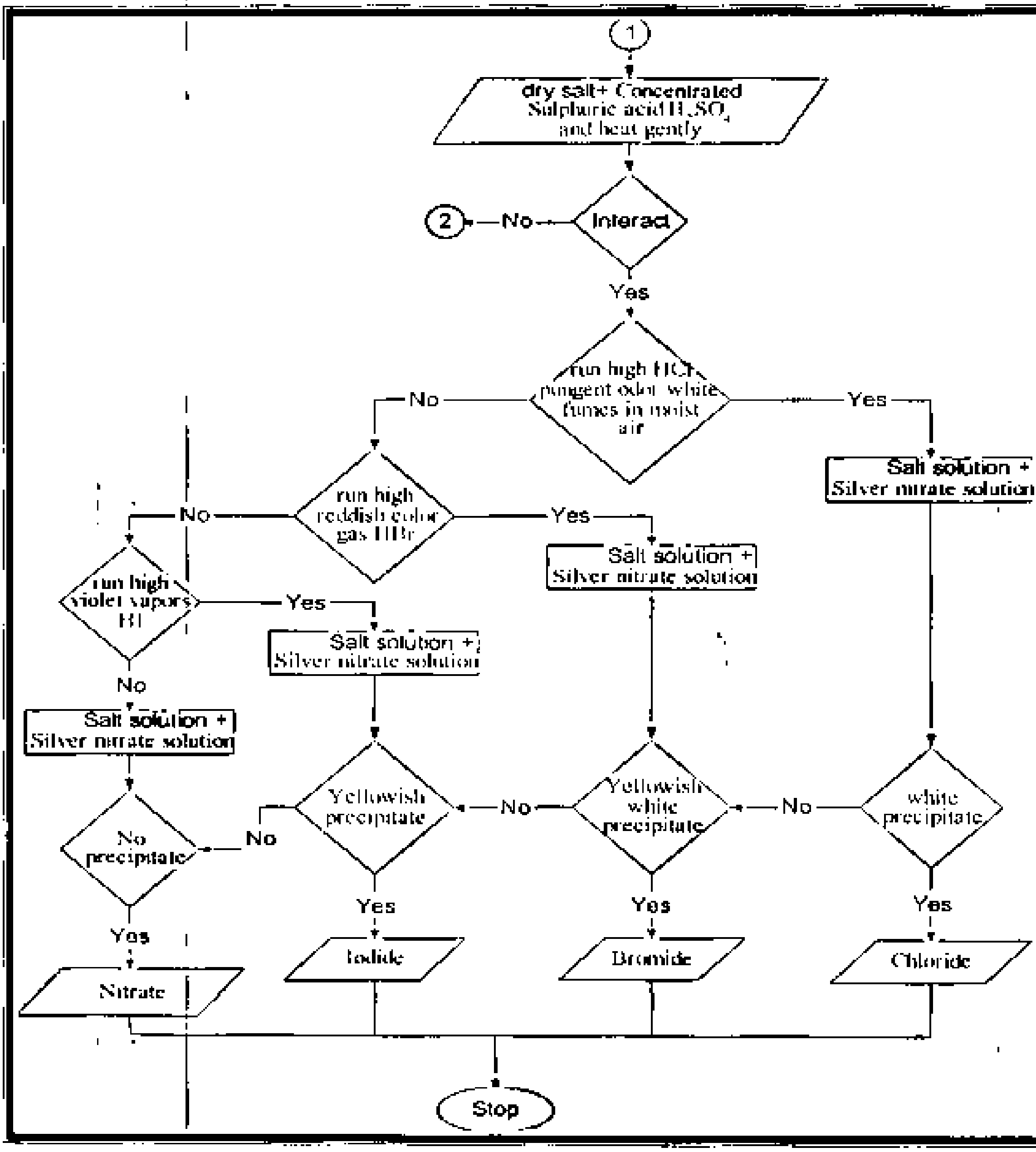
I discuss the steps performing when detection of salt that include in the dilute Hydrochloric acid group, I am represent the steps in flowchart as show in figure(4.1).



Figure(4.1) show the steps in dilute Hydrochloric acid group.

2- Concentrated Sulphuric acid group :

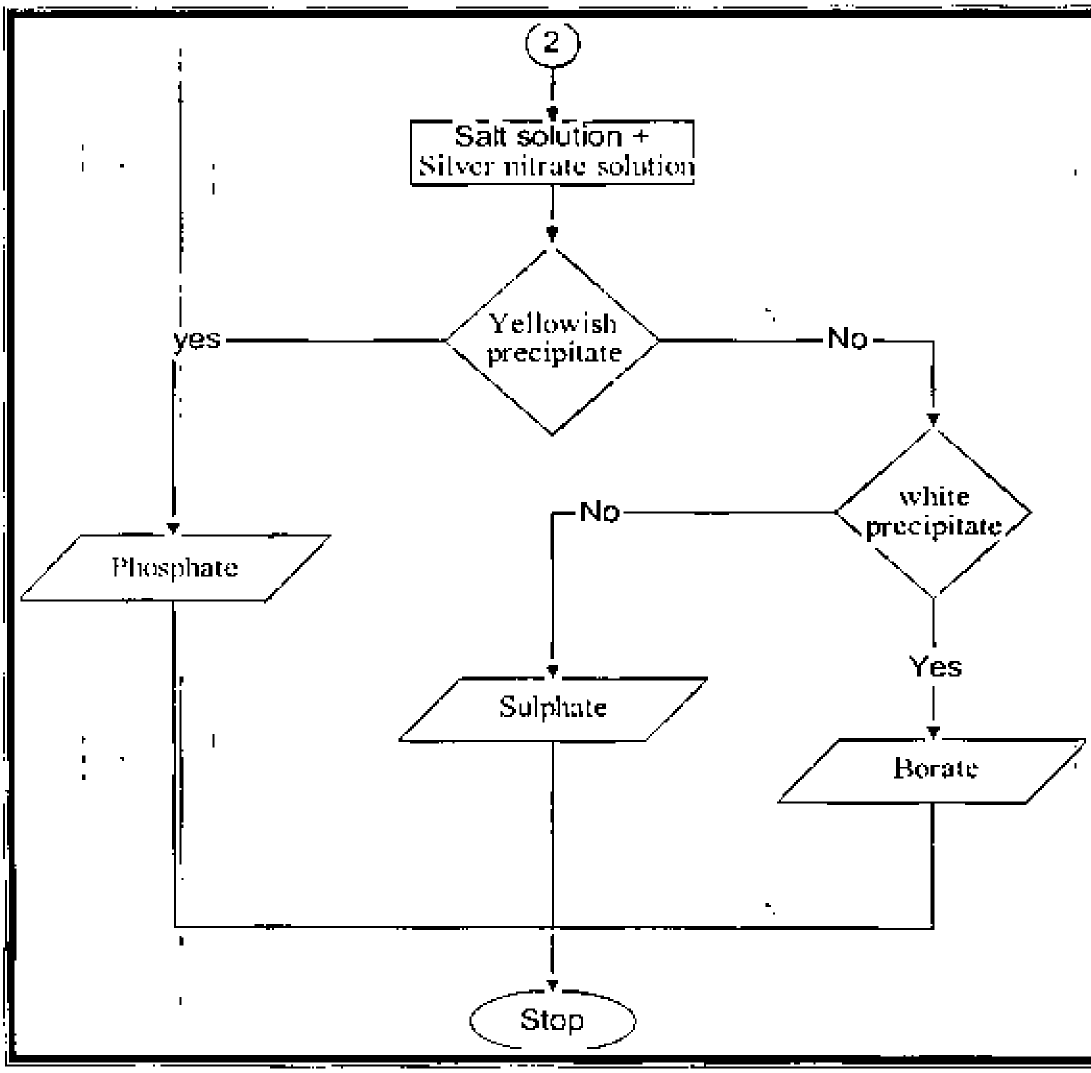
I discuss the steps doing when detection of salt that include in the concentrated Sulphuric acid group, I am represent the steps in flowchart as show in figure(4.2).



Figure(4.2) show the steps in concentrated Sulphuric acid group.

3- Precipitation group :

I discuss the steps doing when detection of salt that include in the Precipitation group, I am represent the steps in flowchart as show in figure(4.3).



Figure(4.3) show the steps in precipitation group.

4.1.2- Knowledge Acquisition :-

Like all expert system projects, I need first to obtain a source of knowledge. Usually this source is an expert on the problem. For this problem, I contact with some technicians professional(Domain experts) in chemistry in chemical department at Sciences College at Garyounis university , El-Marj faculty of teacher training and El-Marj Science and Arts faculty, they have years of experience in chemical laboratories .

Through the interviews that I had with some laboratory technicians who observing first year students of chemical department at El-Marj Science and Arts faculty, And El-Marj faculty of teacher training, I found out that those technicians have been faced with some difficulties while the students are doing their experiments. The students overuse many expensive chemical elements due to their lack of experience in using these elements. They also ask many questions and inquiries that makes training sessions very boring. Some students feed embarrassed and afraid of asking questions because the technicians are usually males. Some of these experiments are very dangerous.

I have been told by the technicians themselves that they face this problem in most chemical laboratories at different universities. Therefore, I decided to design an expert system for training students on some of experiments .

4.1.3- Knowledge Representation :-

The representation method used to encode knowledge of the problem is the rule representation method. The following rule are constructed based on the knowledge acquisition problem.

4.1.3.1- IF-THEN Rules :

IF- THEN rules are the most common way to represent knowledge in currently expert system. Such rules contain premises or conditions in the IF clauses, and conclusions in the THEN clauses. IF-THEN rules differ from similar ones in conventional computer systems, they can be modified much more easily to meet changing needs, and it was easier to update. Rule-based expert systems have the capability to ask users questions about information needed to deal with specific problems during consultations [25].

4.1.3.2- System Rules :

Rule A.1:

IF Solid salt + CHl effervescence.

AND Evolved CO_2 gas.

THEN Salt is Carbonate or Bicarbonate.

Rule A.2:

IF Solid salt + CHl effervescence.

AND Evolved NO_2 gas.

And Brown fumes.

AND Solution turns faint blue.

THEN Salt is Nitrites.

Rule A.3:

IF Solid salt + CHl effervescence.

AND Evolved gas its odor of rotten eggs.

THEN Salt is Sulphide.

Rule A.4:

IF Solid salt + CHl effervescence.

AND Evolved SO_2 gas its odor suffocating.

THEN Salt is Sulphite.

Rule A.5:

IF Solid salt + CHl effervescence

AND Yellow ppt.

THEN Salt is Thiosulphate.

Rule A.1.1:

IF Salt is Carbonate or Bicarbonate.

AND Salt solution + $MgSO_4$ make white precipitate.

AND Salt solution + $HgCl_2$ make white precipitate.

AND Salt solution + BaCl2 make white precipitate.

THEN Salt is Carbonate.

Rule A.1.2:

IF Salt is Carbonate or Bicarbonate.

AND Salt solution+$MgSO_4$ after heating make white precipitate.

AND Salt solution+ BaCl2 after heating make white precipitate.

AND Salt solution+$HgCl_2$ after heating make white precipitate.

THEN Salt is Bicarbonate.

Rule A.2.1:

IF Salt is Nitrites.

AND Salt solution + KI change solution to blue.

AND Salt solution + $AgNO_3$ make white precipitate.

THEN Salt is Nitrites.

Rule A.3.1:

IF Salt is Sulphide.

AND Salt solution + $(CH_3COO)_2Pb$ make black ppt.

AND Salt solution + $AgNO_3$ make white precipitate.

AND Salt solution + Na2[Fe(CN)5NO] change solution to purple.

THEN Salt is Sulphide.

Rule A.4.1:

IF Salt is Sulphite.

AND Salt solution + I2 make white precipitate.

AND Salt solution + $AgNO_3$ make white precipitate.

AND Salt solution + $BaCl_2$ make white precipitate.

THEN Salt is Sulphite.

Rule A.5.1:

IF Salt is Thiosulphate.

AND Salt solution + $(CH_3COO)_2Pb$ make white precipitate.

AND Salt solution + $AgNO_3$ make white precipitate.

AND Salt solution + $FeCl_3$ make violet color precipitate.

THEN Salt is Thiosulphate.

Rule B.1:

IF Solid salt + conc. H_2SO_4 effervescence.

AND Evolved HCl gas which forming white fumes its pungent odor.

THEN Salt is Chloride.

Rule B.2:

IF Solid salt + conc. H_2SO_4 effervescence.

AND Evolved Br_2 gases which forming reddish brown fumes.

And solution turns reddish brown.

THEN Salt is Bromide.

Rule B.3:

IF Solid salt + conc. H_2SO_4 effervescence.

AND Evolved $HI+I_2$ gases.

THEN Salt is Iodide.

Rule B.4:

IF Solid salt + conc. H_2SO_4 effervescence.

AND Run high brown fumes of NO_2 gas.

AND solution turns faint blue.

THEN Salt is Nitrates.

Rule B.1.1:

IF Salt is Chloride.

AND Salt solution + $(CH_3COO)_2Pb$ make white precipitate.

AND Salt solution + $AgNO_3$ make white precipitate.

AND Salt solution + MnO_2 make white precipitate.

THEN Salt is Chloride.

Rule B.2.1:

IF Salt is Bromide.

AND Salt solution+ $(CH_3COO)_2Pb$ make white crystalline precipitate.

AND Salt solution + $AgNO_3$ make pale yellow precipitate.

AND Salt solution+Cl_2+$CHCl_3$ make yellow color in the organic layer.

THEN Salt is Bromide.

Rule B.3.1:

IF Salt is Iodide.

AND Salt solution + $(CH_3COO)_2Pb$ make yellow precipitate.

AND Salt solution + $AgNO_3$ make yellow precipitate.

AND Salt solution+ Cl_2+$CHCl_3$ change solution to brown.

THEN Salt is Iodide.

Rule B.4.1:

IF Salt is Nitrates.

AND Salt solution + $FeSO_4$ a brown ring will form.

THEN Salt is Nitrates.

Rule C.1:

IF Solid salt + CHI not effervescence.

AND Solid salt + conc. H_2SO_4 not effervescence.

AND Salt solution + $BaCl_2$ make white precipitate.

THEN Salt is Sulphate , Borate or Phosphate.

Rule C.2:

IF Salt is Sulphate , Borate or Phosphate.

AND Salt solution + $AgNO_3$ make white precipitate.

AND Salt solution + $(CH_3COO)_2Pb$ make white precipitate.

THEN Salt is Sulphate.

Rule C.3:

IF Salt is Sulphate , Borate or Phosphate.

AND Salt solution + $AgNO_3$ make yellow precipitate.

AND Salt solution + $FeCl_3$ make yellowish whit precipitate.

THEN Salt is Phosphate.

Rule C.4:

IF Salt is Sulphate , Borate or Phosphate.

AND Salt solution + $AgNO_3$ make yellow precipitate.

AND Salt solution + Ph.Ph make pink color.

THEN Salt is Borate.

4.1.4- Implementation :

Expert systems model the reasoning of humans using a technique called **inference** . An expert system performs inference using a module called the **inference engine** . Inference engine combines facts contained in working memory with knowledge contained in the knowledge base . From this action it is able to infer new information that it then adds to the working memory . Figure (4.4) illustrates this process [8].

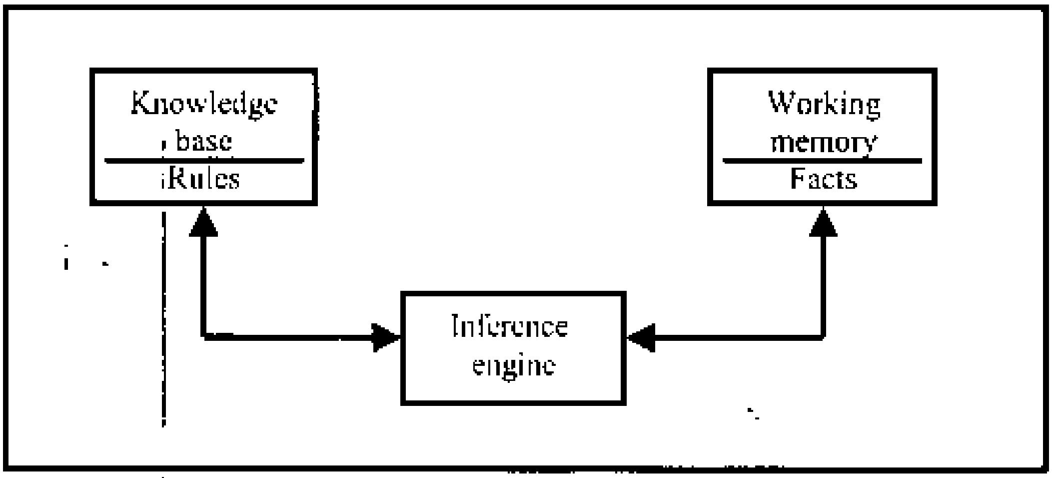


Figure (4.4) Inference process in expert system .

In this system I use the **forward chaining** . Forward chaining is a technique for gathering information and then inferring from it whatever can be inferred . However. in forward chaining , many rules may be executed that have nothing to do with the established goal [12].

A program writing in visual basic version 6.0. implements the following is a session of the implementation phase.

4.1.5- Testing :-

Expert system contain a language processor for friendly, problem-oriented communication between the user and computer . This communication could best be carried out in a natural language, and in some cases it is supplemented by menus or graphics . In this system I use a graphic to design user interface .

When beginning the program, the opening screen appears as show in figure(4.5). This screen contains the expert system caption and shows some useful notices for the user before carrying on the system. It also contains two options: the first (Exit) for closing the system; the second (Start) to starting the system and to move to the next screen.

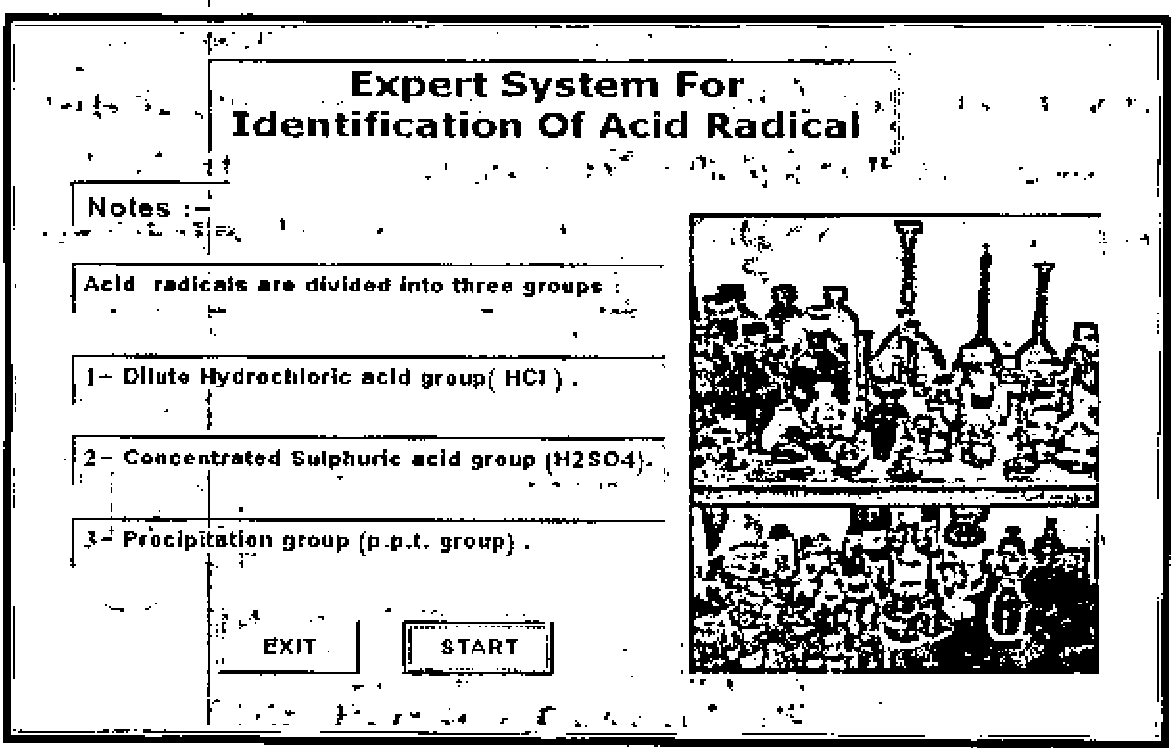


Figure (4.5) show the system opening screen.

When clicking on (Start) in the previous screen, a new screen appears as show in figure(4.6). It asks the user to put one gram of an unknown salt in a test tube and add one ml. of Hydrochloric acid (HCL) and observe what would happen. The screen contains the question (If you see effervescence or not ?). The user may click on (Yes) or (No). Then click on (Next) to move to the next step. The user may move back to the previous screen by clicking on (Previous).

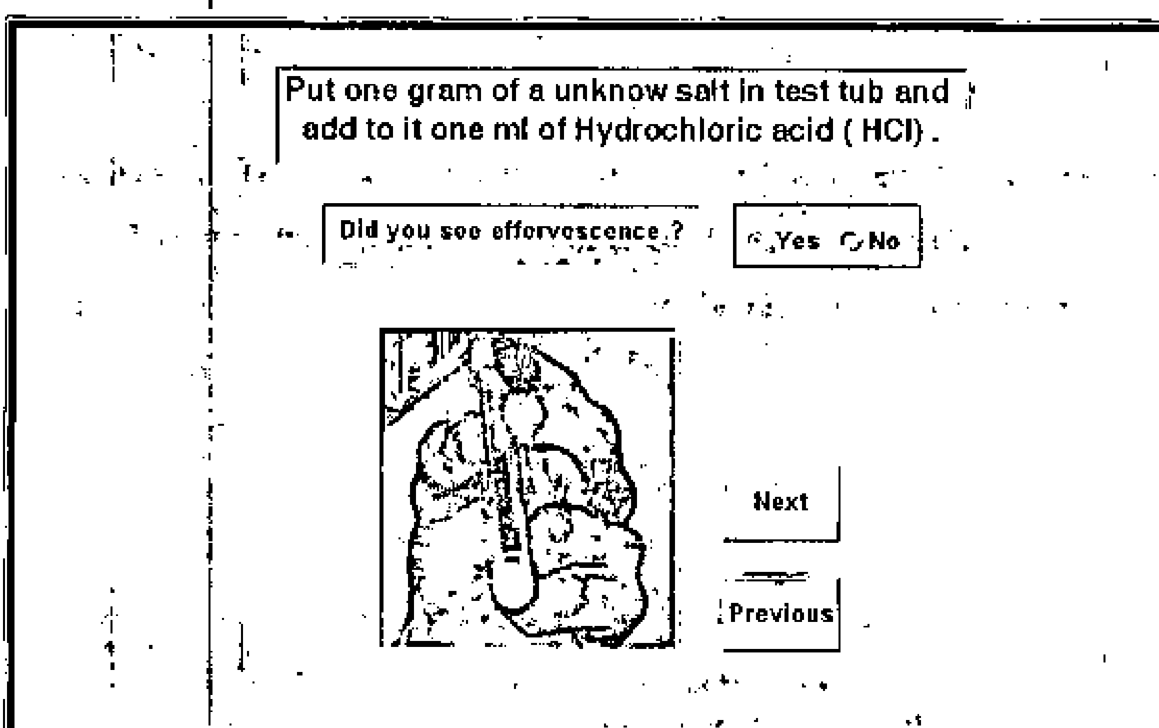


Figure (4.6) show the effervescence when add Hydrochloric acid to unknown salt.

When choose (yes) and then click (Next) in the previous screen, a new screen appears as show in figure (4.7). The screen shows to the user that this salt is hydrochloric acid group. It also asks the user if he see CO_2 evolved or not. The user may choose (Yes) or (No) then click on (Next).

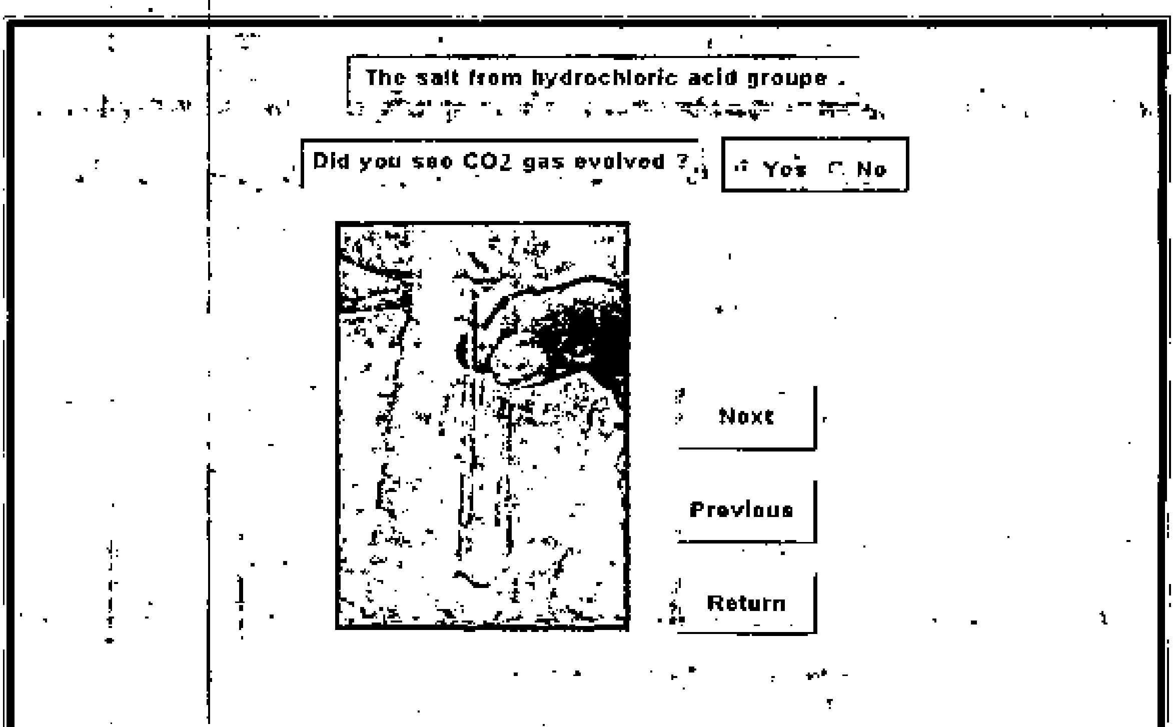


Figure (4.7) show run high CO_2 gas.

When choose (Yes) and click (Next) from the previous screen, a new screen appears as show in figure(4.8) in which a message shows that this salt may be Carbonate or Bicarbonate. It also contains an option to apply one of three confirmatory tests (1, 2, or 3). One of these tests will be applied to confirm the salt type when choosing one of them.

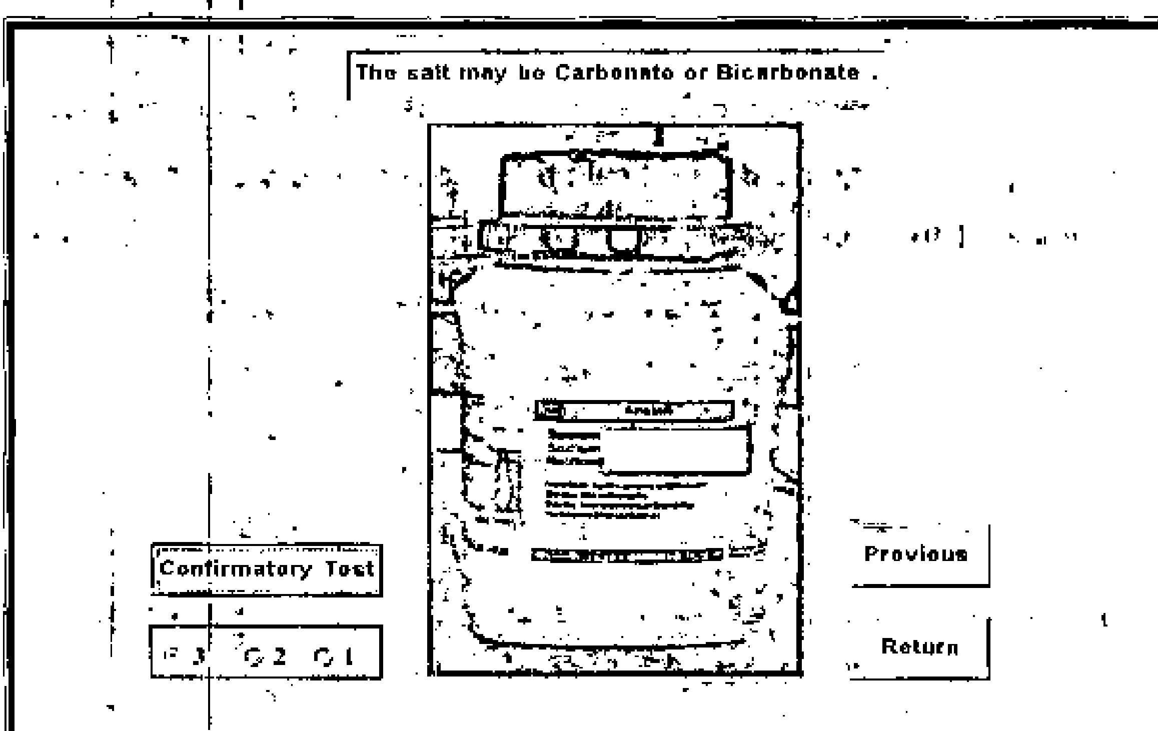


Figure (4.8) show the salt may be Carbonate or Bicarbonate.

When choosing the confirmatory test number one in figure(4.8), a new screen appears in which a message asks the user to add (MgSO4) to the salt solution as indicated in figure(4.9). The screen also asks user if he see white precipitate or not.

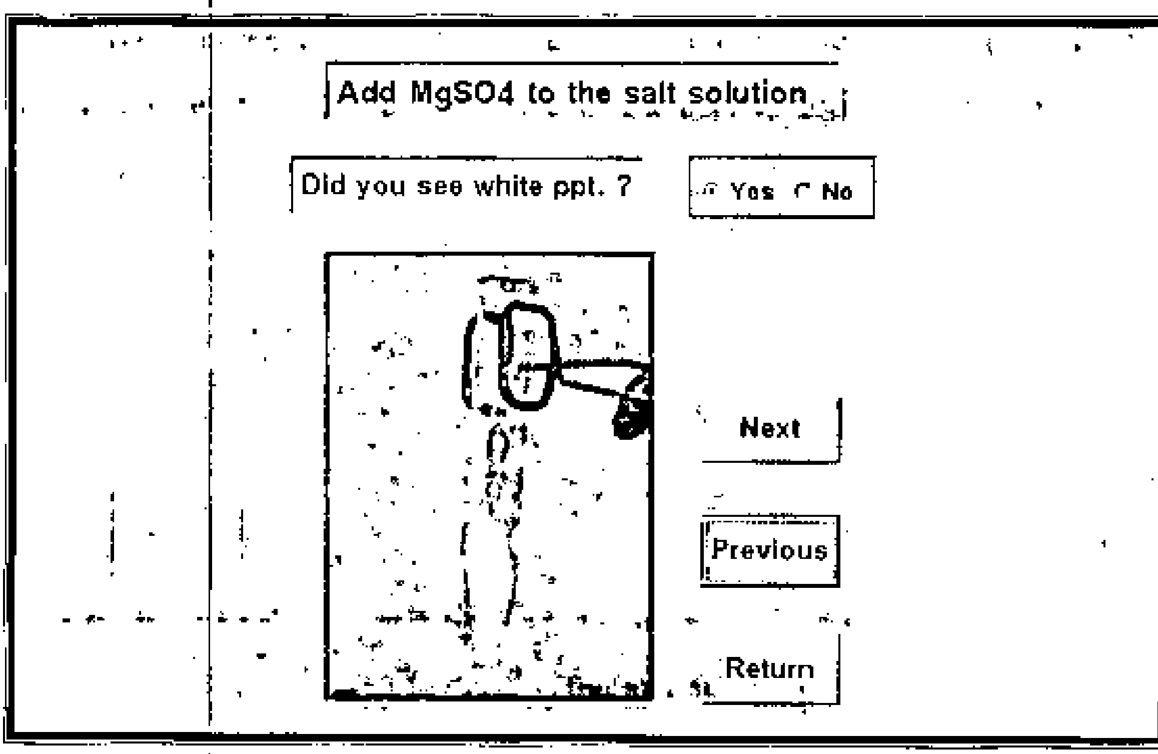


Figure (4.9) show the white precipitate.

When choosing the confirmatory test number two in figure(4.8), a new screen appears asking the user to add (HgCl2) to the salt solution and observe what happen as indicated in figure(4.10).The screen also asks user if he see white precipitate or not.

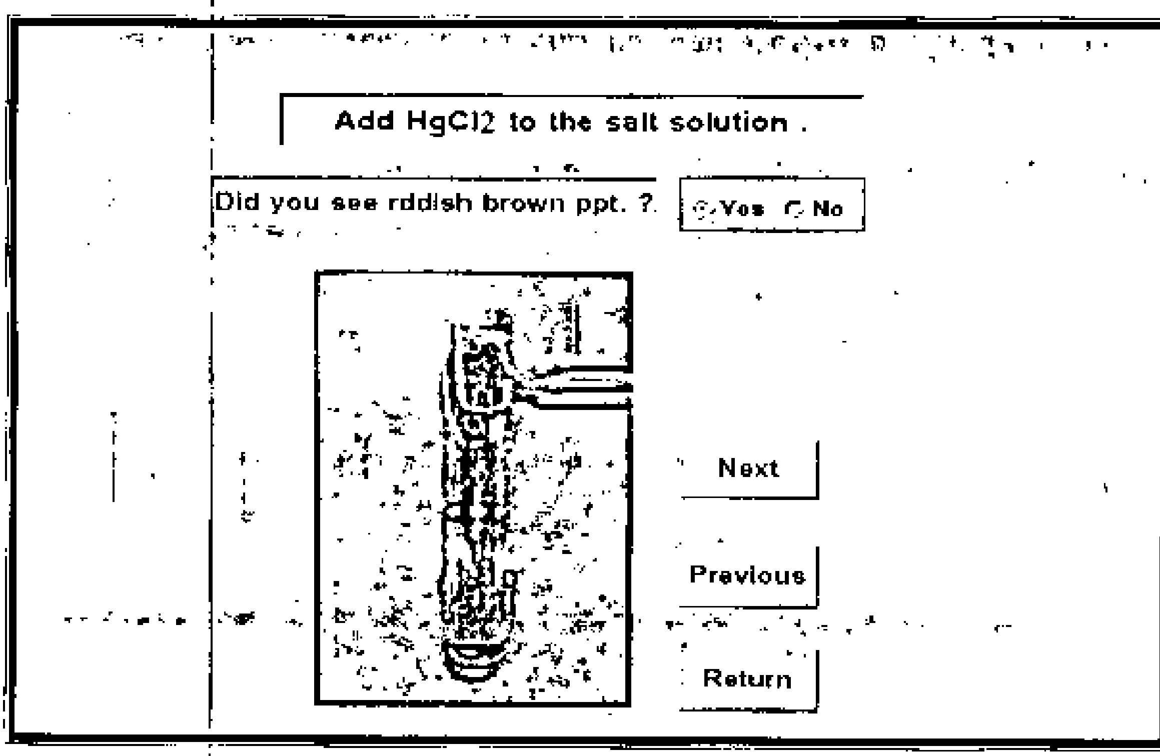


Figure (4.10) show the reddish brown precipitate.

If the user choosing the confirmatory test number three in figure(4.8), another window appears asking the user to add ($BaCl_2$) solution to the salt solution as indicated in figure(4.11).The screen also asks user if he see white precipitate or not.

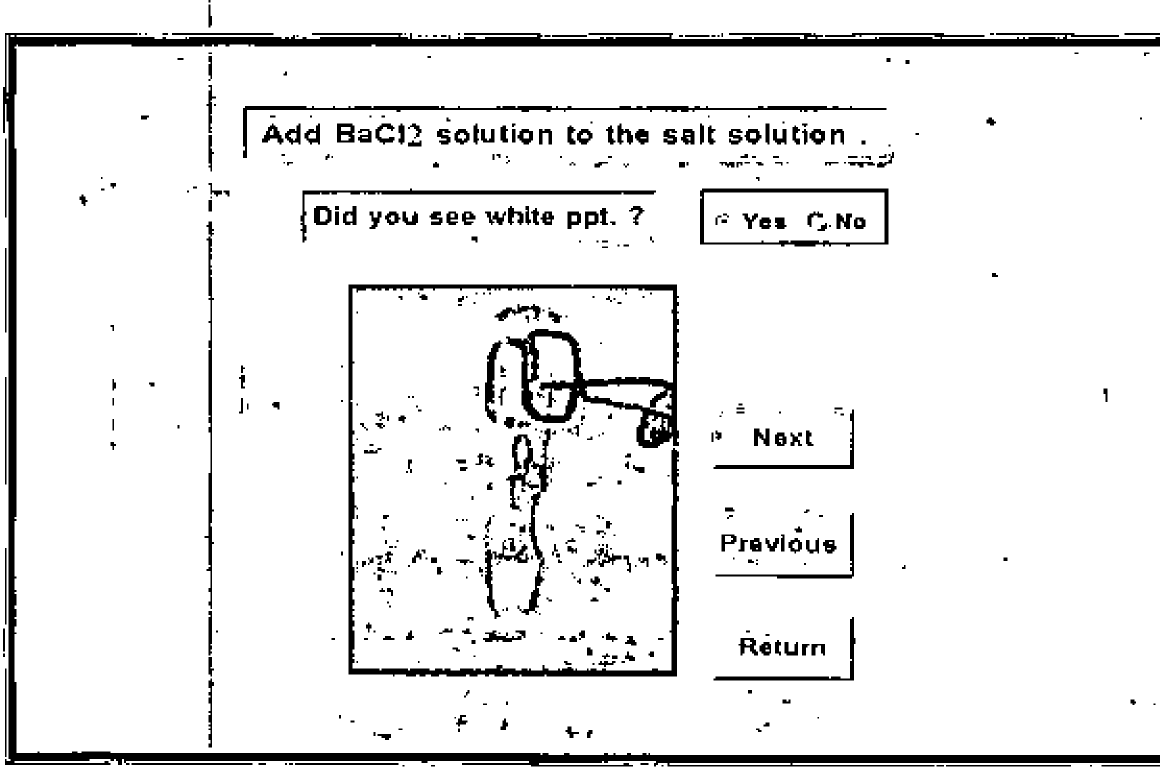


Figure (4.11) show the white precipitate.

When the user selects one of the confirmatory test (1,2,or3) from the window in figure(4.8) and then click on (Yes) in the windows show in figures (4.9),(4.10)or(4.11), a new window appears confirming that the salt is Carbonate and also gives the user options to aver the confirmatory tests or return to the beginning of the program as show in figure(4.12).

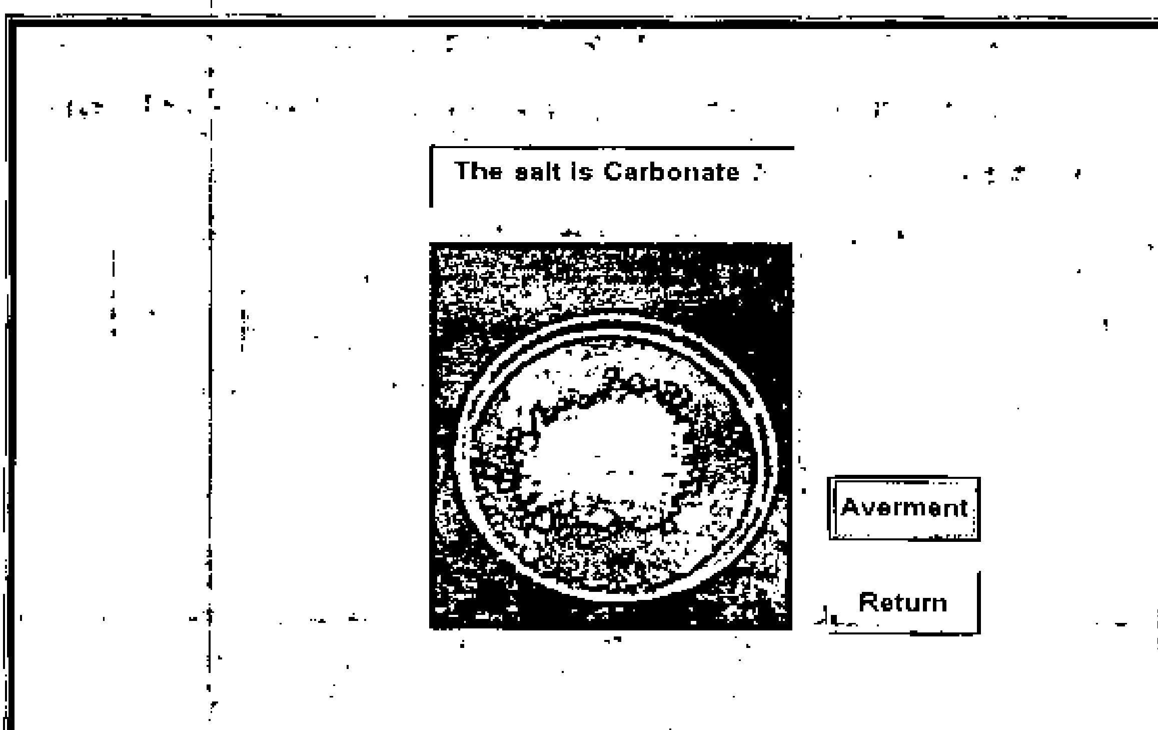


Figure (4.12) aver the salt is Carbonate.

If one of the confirmatory tests (1,2, or3) in the window show in figure(4.8) has selected and then clicking on (No) in one of the windows indicated in figure(4.9), (4.10) or (4.11), a window appears confirming that this salt is Bicarbonate and the ppt. will be formed after heating as show in figure(4.13). The window also gives the user options of averring the confirmatory testes or returning to the beginning of the program.

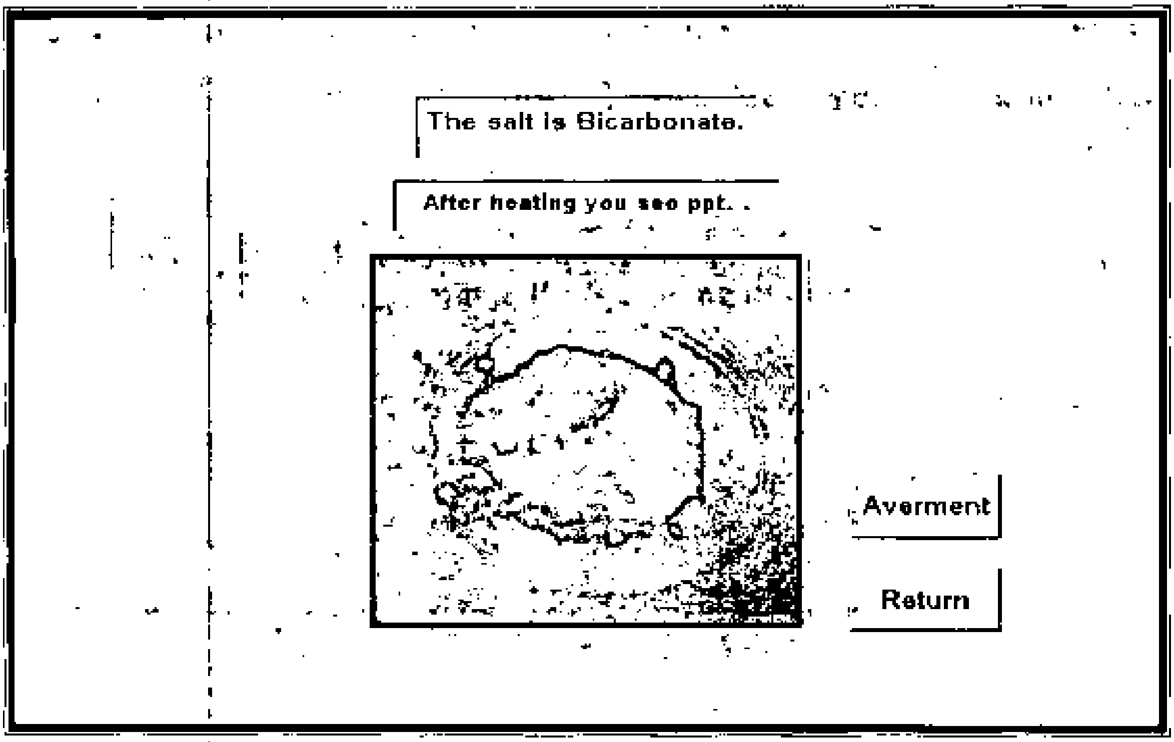


Figure (4.13) aver the salt is Bicarbonate.

When selected (No) and click (Next) in the window indicated in figure(4.7), a new window states that the salt is from Hydrochloric acid group. There is also a Yes or No question as indicated in figure(4.14).

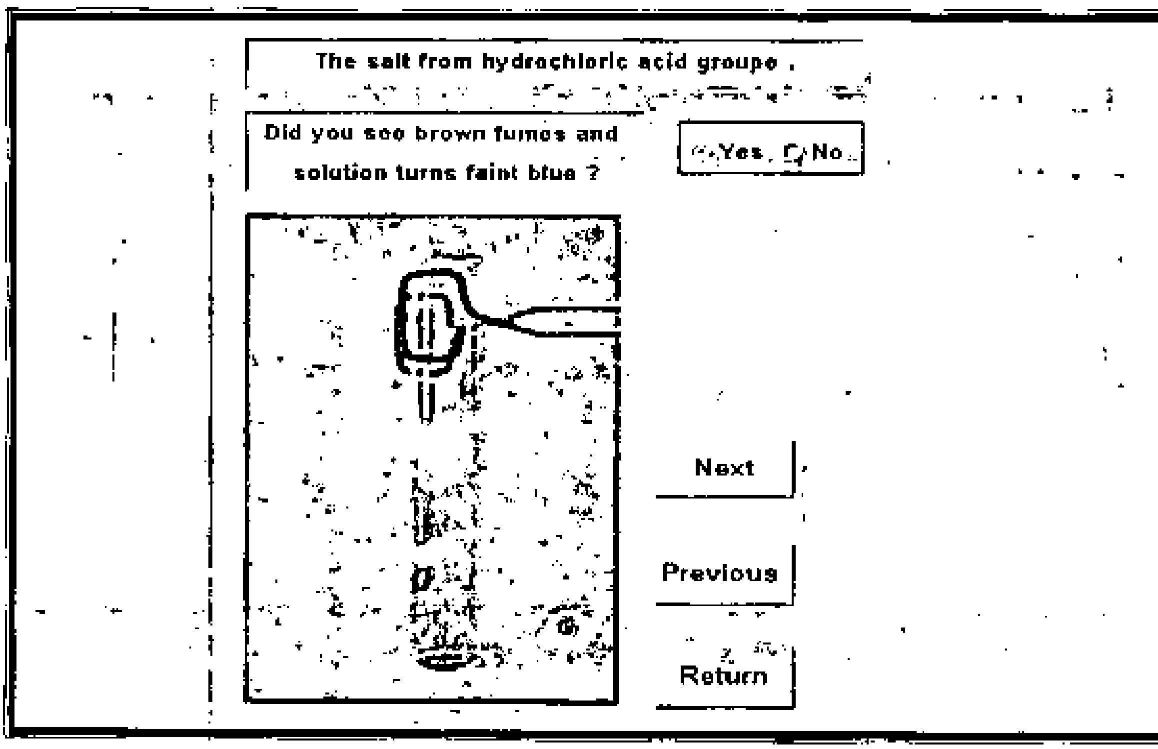


Figure (4.14) show run high brown fumes.

If the user selected (Yes) from the window indicated in figure(4.14) and then click (Next), a new window appears indicate that the salt may be Nitrite. There are also three choices to conduct the confirmatory tests as indicated in figure (4.15).

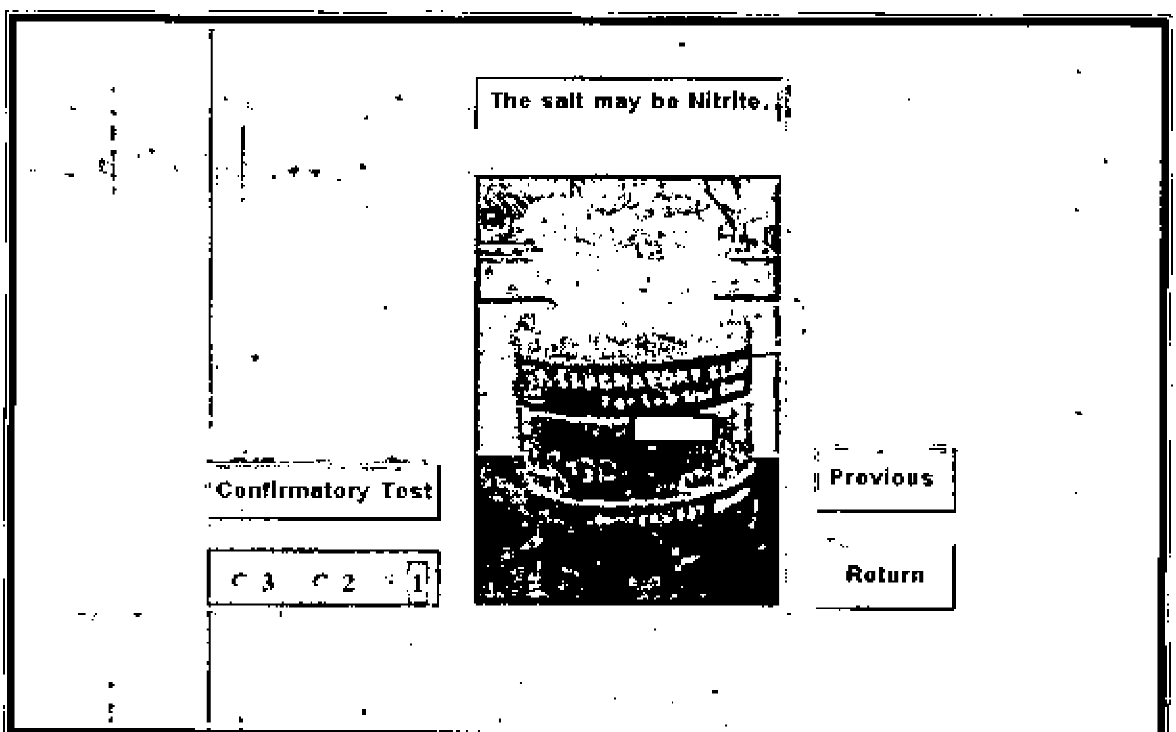


Figure (4.15) show the salt may be Nitrite.

If the user selects the confirmatory test number one from the window in figure(4.15), a new window appears asking the user to add ($AgNO_3$) solution to the salt solution and observe what will happen as indicated in figure(4.16). The window also asks user if he see white ppt. or not.

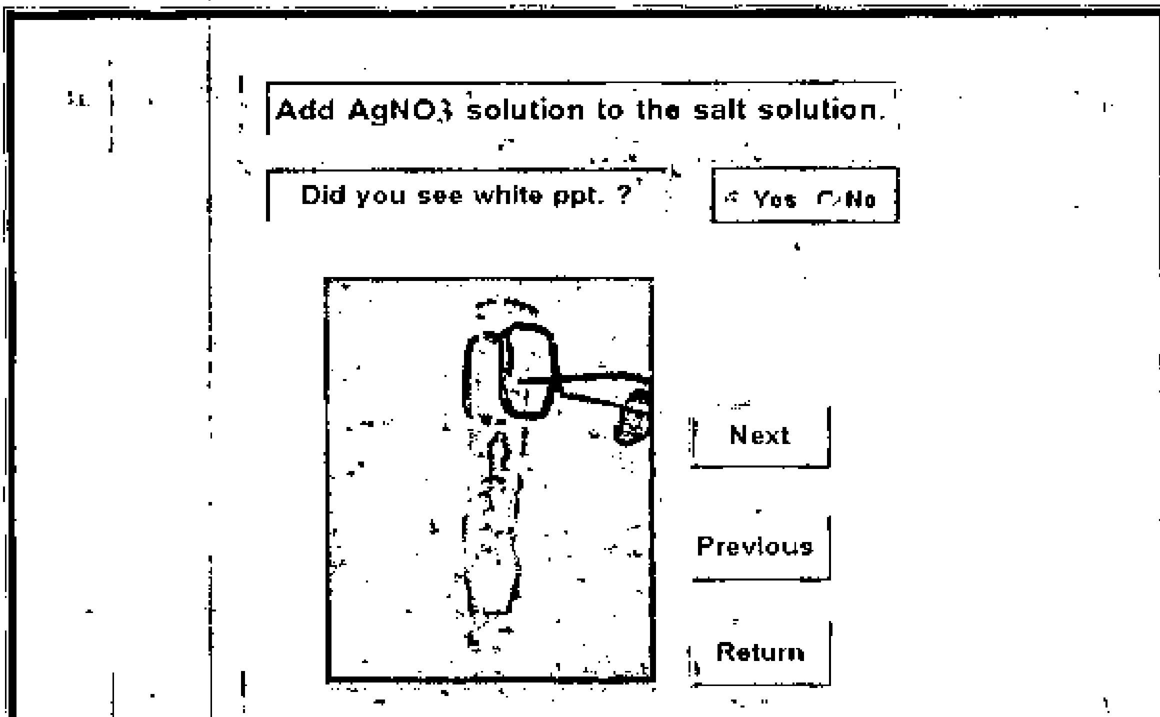


Figure (4.16) show the white precipitate.

If the user selects the confirmatory test number two from the window in figure(4.15) another window asks him to add (KI) solution to the salt solution and then add drops of dil. Hydrochloric acid and observe what the infliction as it is indicated in figure(4.17).

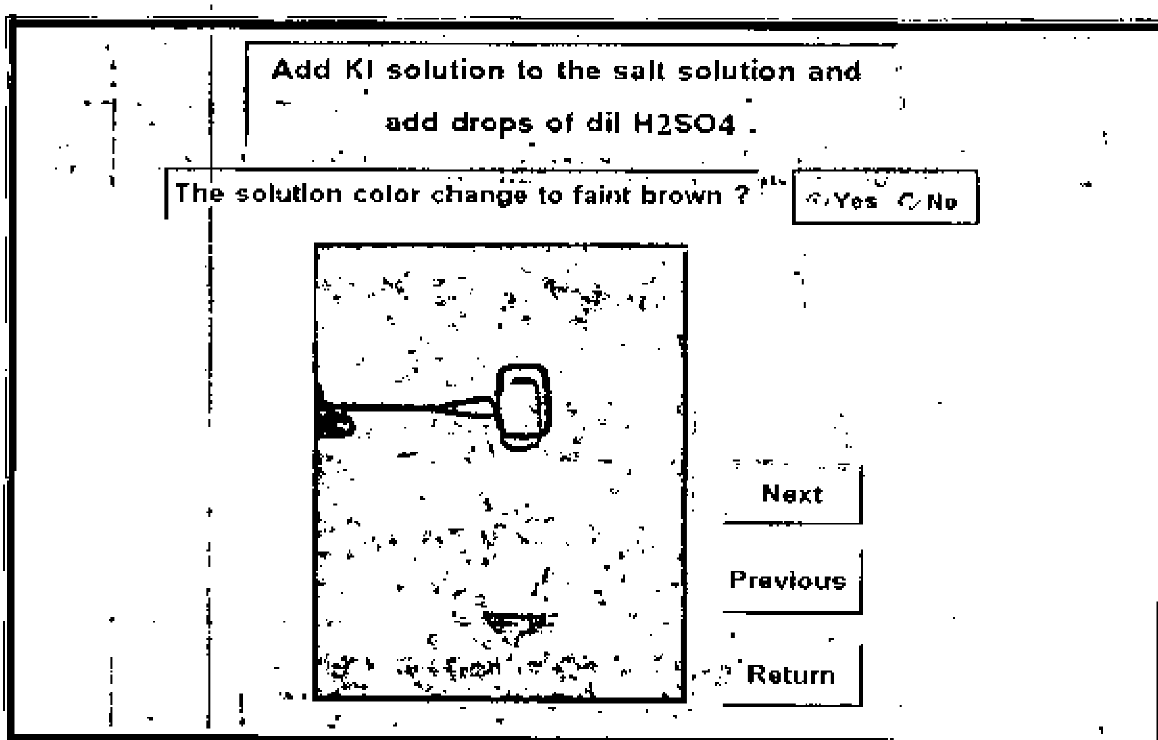


Figure (4.17) show change color of solution to faint brown.

When selecting confirmatory test number three indicated in window in figure(4.15), another window appears asking the user to add (FeSO4) solution with dil. (H2SO4) to the salt solution and observe what will happen as indicated in window in figure(4.18).

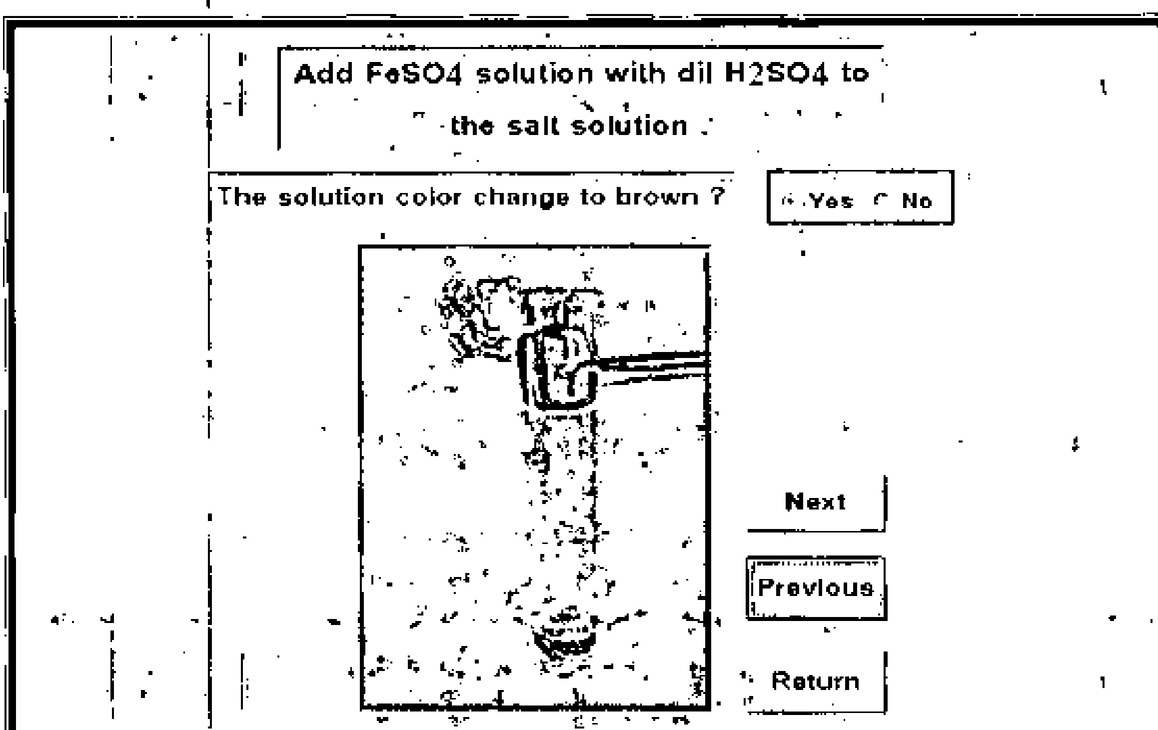


Figure (4.18) show change color of solution to brown.

If the user selected (Yes) and click (Next) in one of the three windows in figures (4.16), (4.17), or (4.18), another window appears shows that the salt is Nitrite. It also gives the user the possibility to move to the window of confirmatory tests or return to the beginning of the program as indicated in figure(4.19).

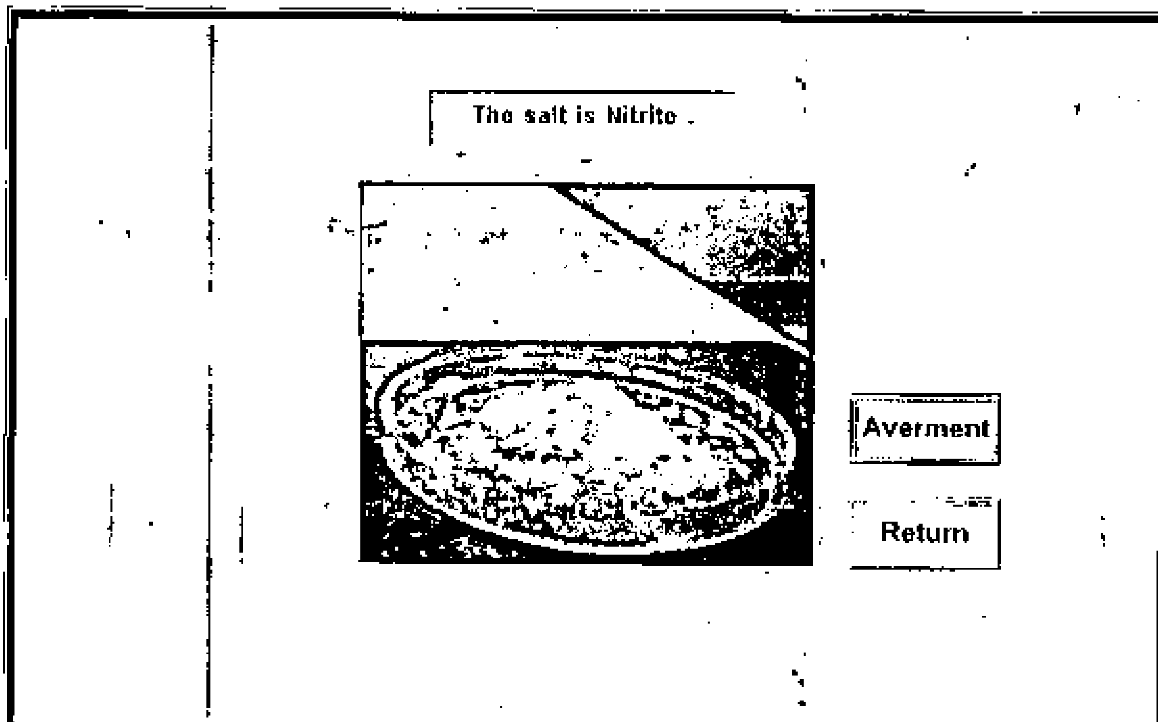


Figure (4.19) aver the salt is Nitrite.

When selected (No) and click (Next) in the window indicated in figure(4.14), a new window states that the salt is from Hydrochloric acid group. There is also a Yes or No question as indicated in figure(4.20).

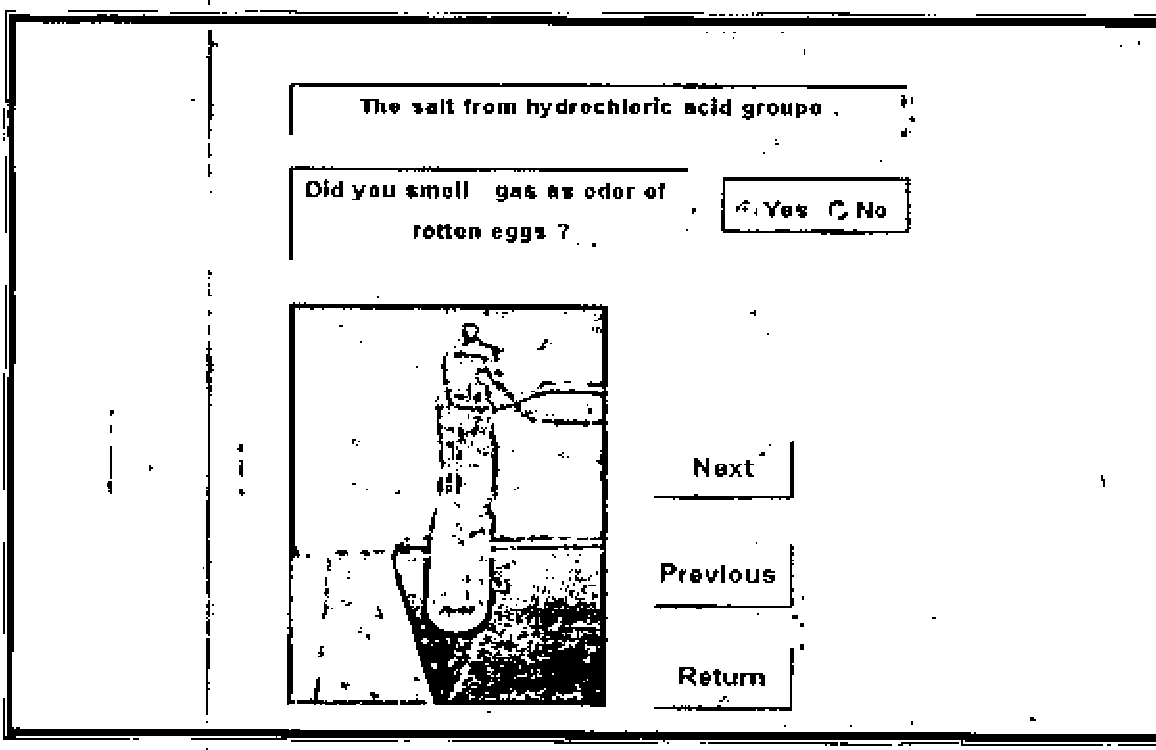


Figure (4.20) show run high gas its smell as rotten eggs odor.

If the user selected (Yes) from the window indicated in figure(4.20) and then click (Next), a new window appears indicate that the salt may be Sulphide. There are also three choices to conduct the confirmatory tests as indicated in the window in figure (4.21).

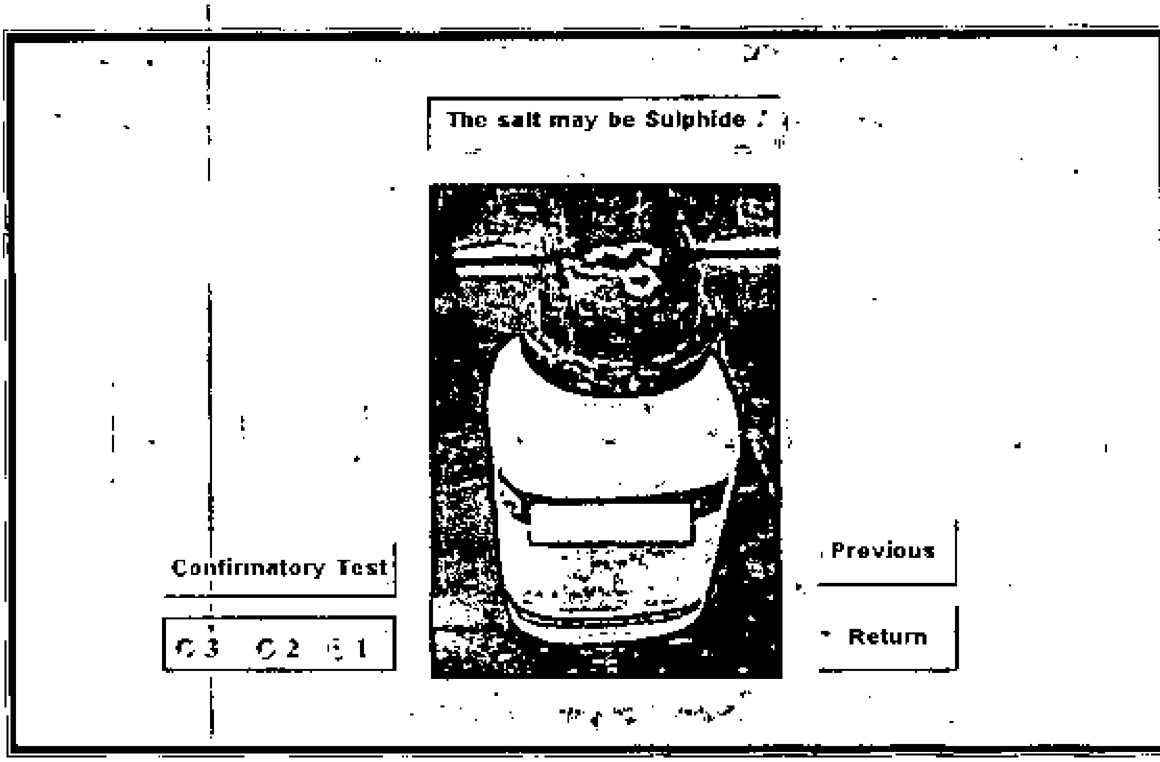


Figure (4.21) show the salt may be Sulphide.

If the user selects the confirmatory test number one from the window in figure(4.21), a new window appears asking the user to add (AgNO3) solution to the salt solution and observe what will happen as indicated in figure(4.22).

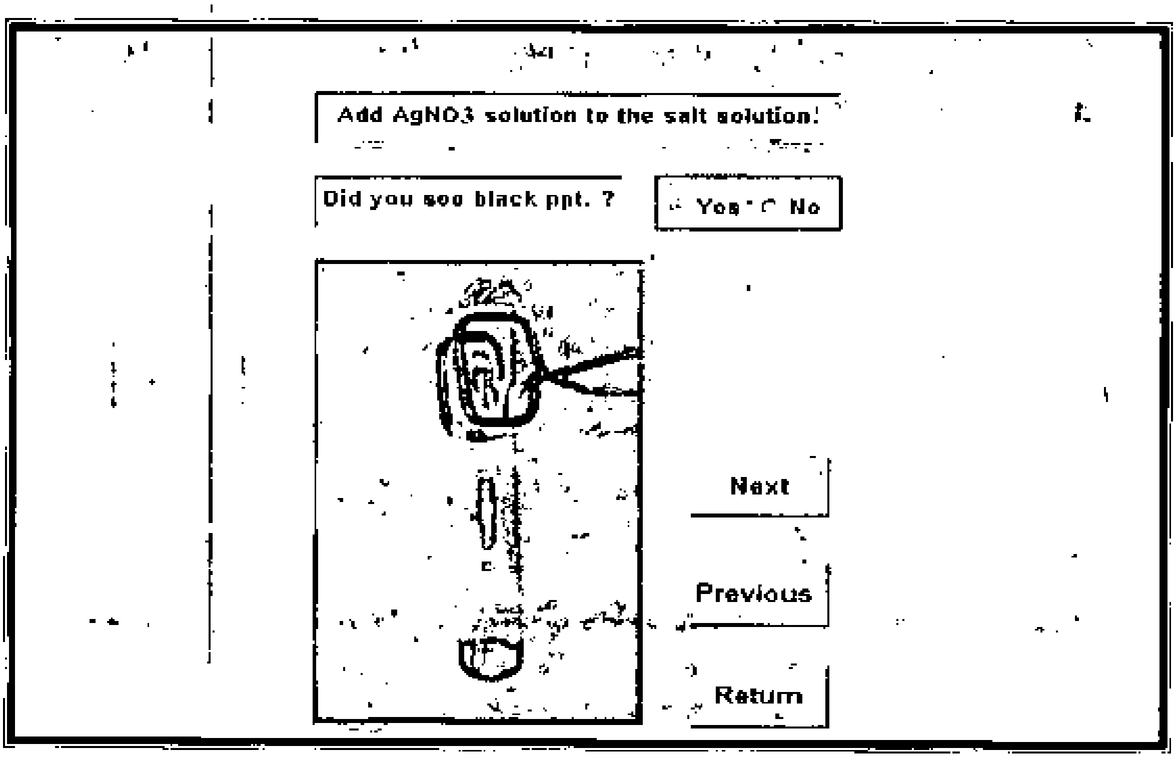


Figure (4.22) show the black precipitate.

If the user selects the confirmatory test number two from the window in figure(4.21), another window asks him to add ((CH3COO)2Pb) solution to the salt solution and observe what happen as it is indicated in figure(4.23).

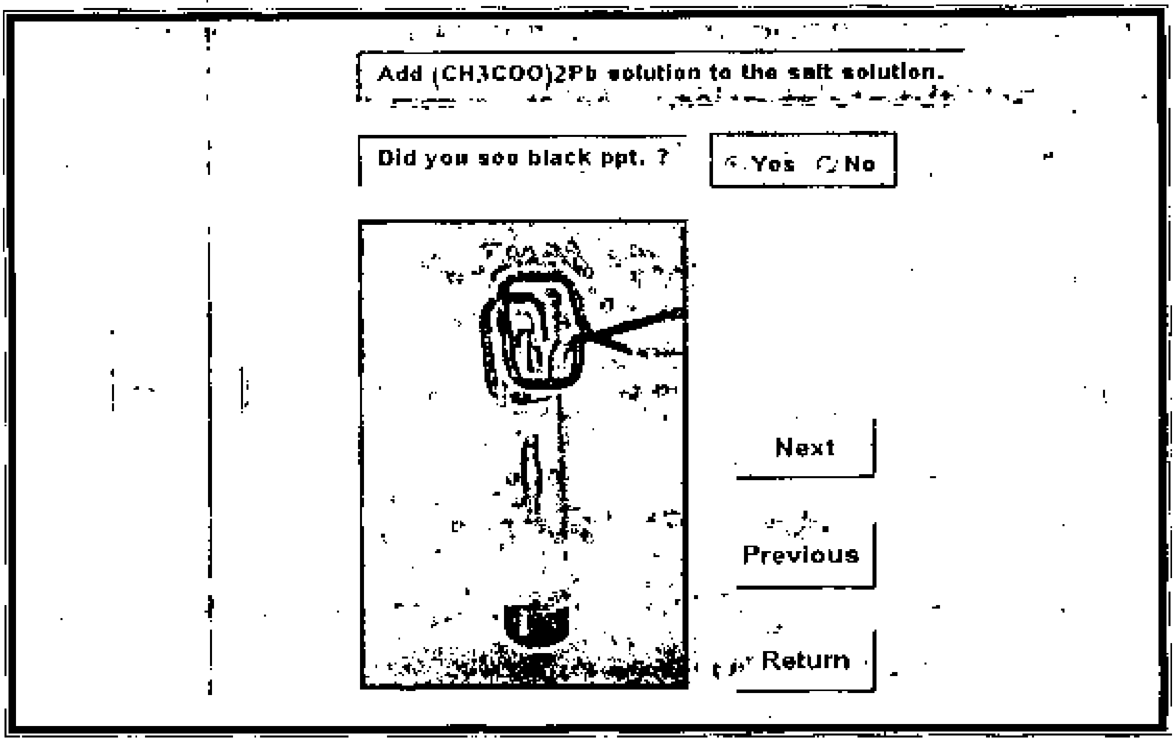


Figure (4.23) show the black precipitate.

If the user choosing the confirmatory test number three in figure(4.21), another window appears asking the user to add (Na2[Fe(CN)5NO]) solution to the salt solution as indicated in figure(4.24).

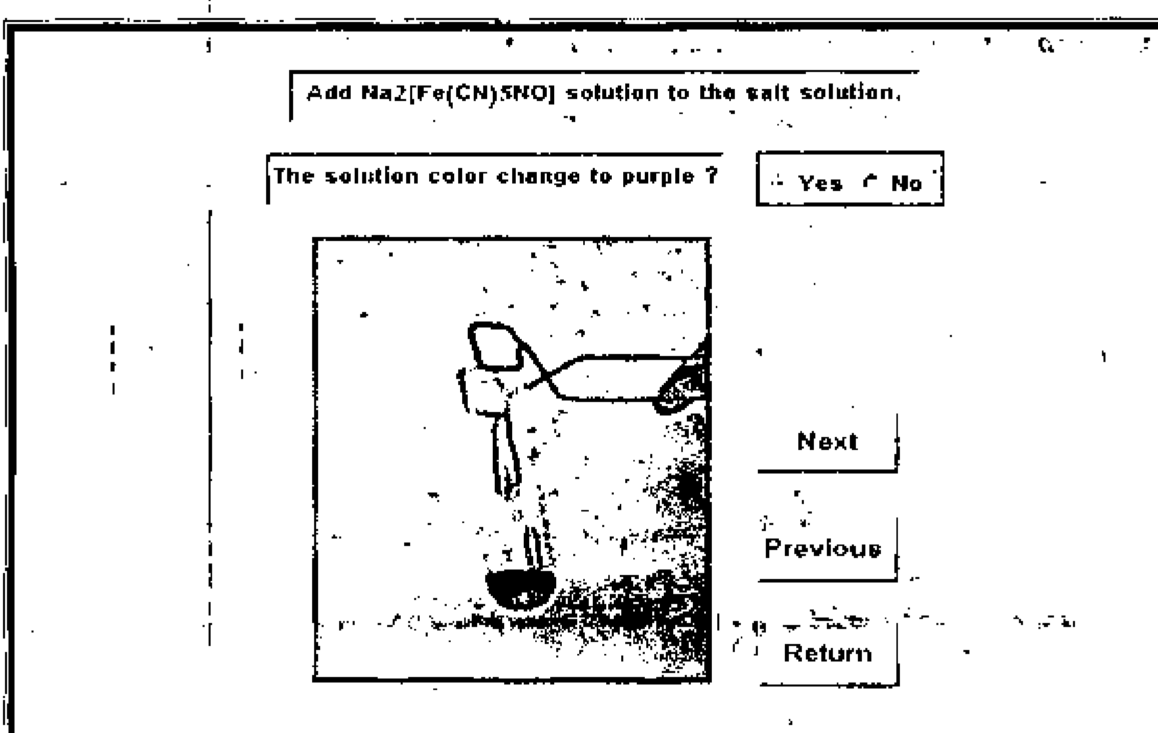


Figure (4.24) show change the color of solution to purple.

If the user selected (Yes) and click (Next) in one of the three windows in figures (4.22), (4.23), or (4.24), another window appears shows that the salt is Sulphide. It also gives the user the possibility to move to the window of confirmatory tests or return to the beginning of the program as indicated in figure(4.25).

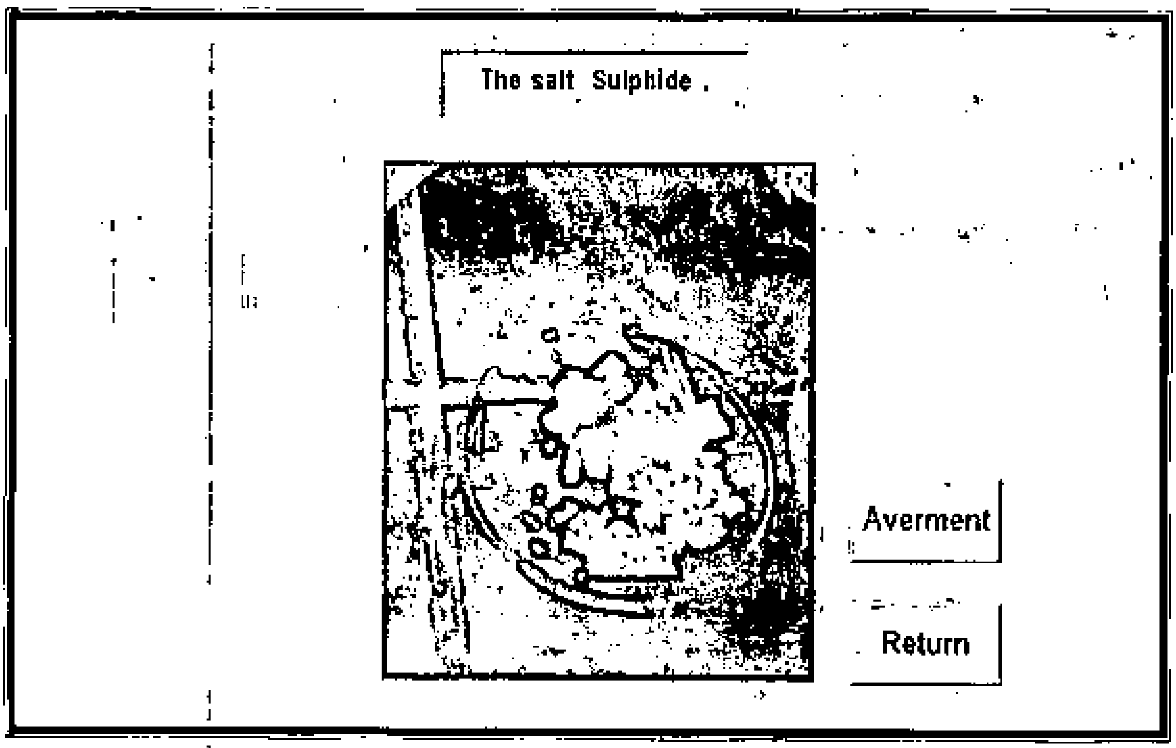


Figure (4.25) aver the salt is Sulphide.

When selected (No) and click (Next) in the window indicated in figure(4.20), a new window states that the salt is from Hydrochloric acid group. There is also a Yes or No question as indicated in figure(4.26).

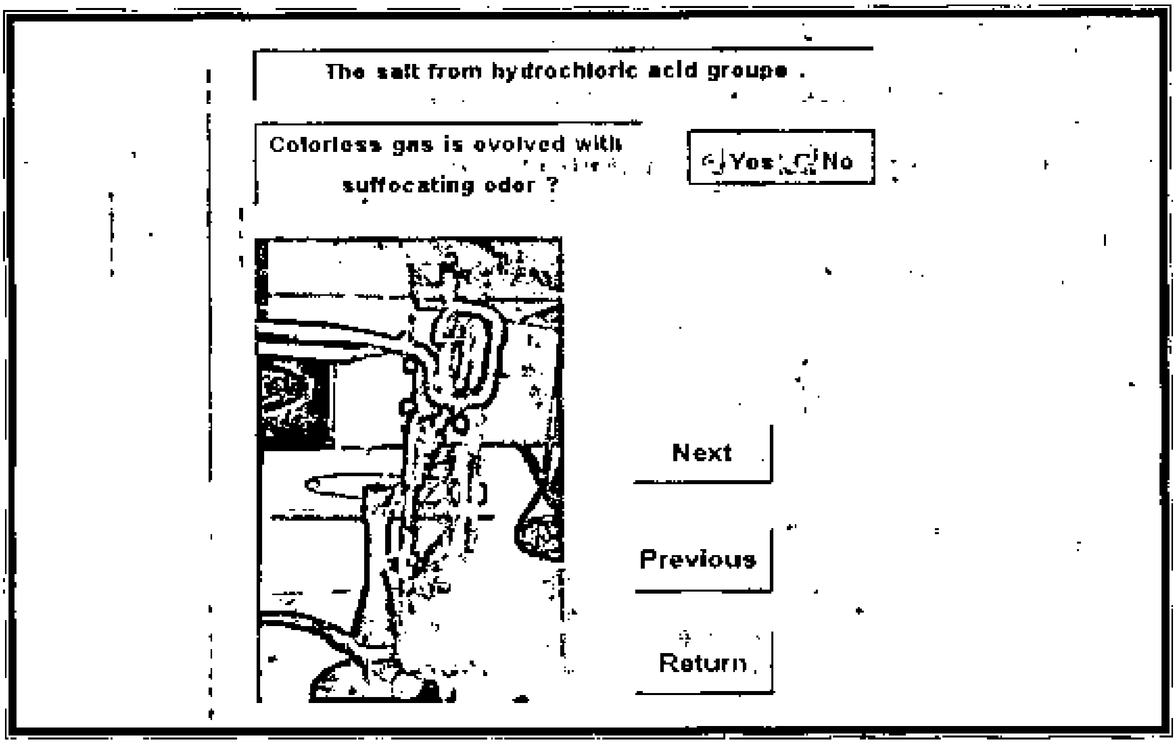


Figure (4.26) show run high gas with suffocating odor.

If the user selected (Yes) from the window indicated in figure(4.26) and then click (Next), a new window appears indicate that the salt may be Sulphite. There are also three choices to conduct the confirmatory tests as indicated in the window in figure (4.27).

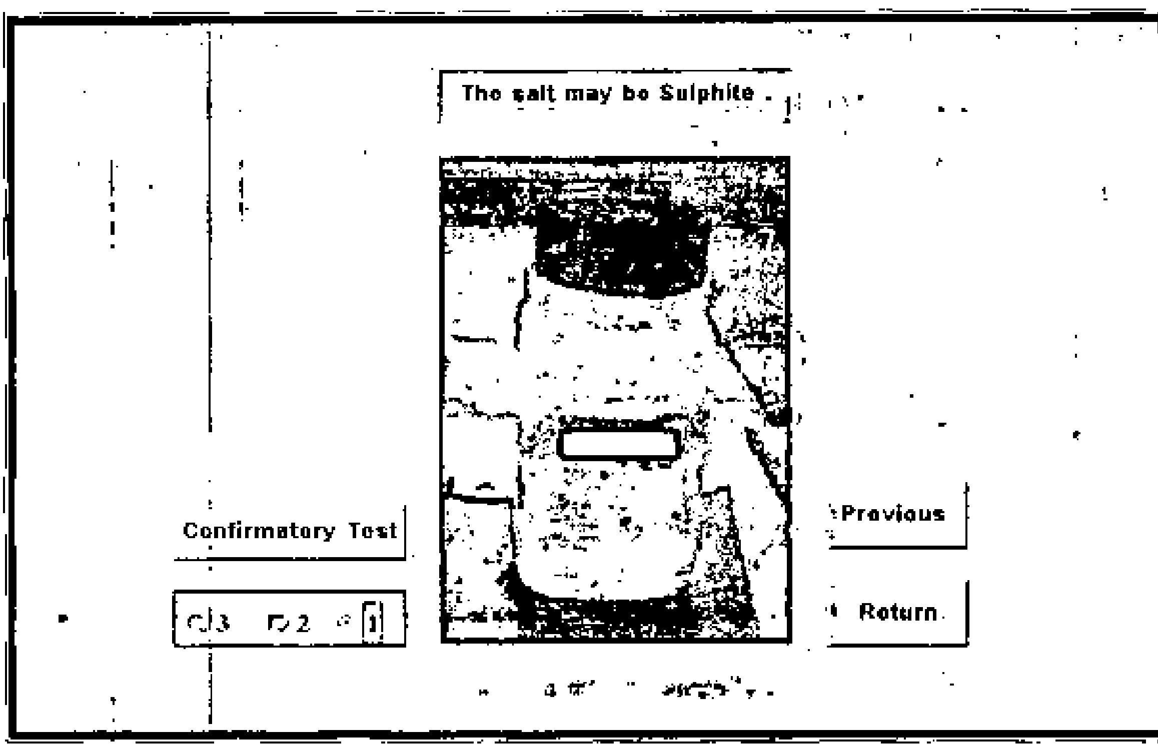


Figure (4.27) show the salt may be Sulphite.

If the user selects the confirmatory test number one from the window in figure(4.27), a new window appears asking the user to add (AgNO3) solution to the salt solution and observe what will happen as indicated in figure(4.28).

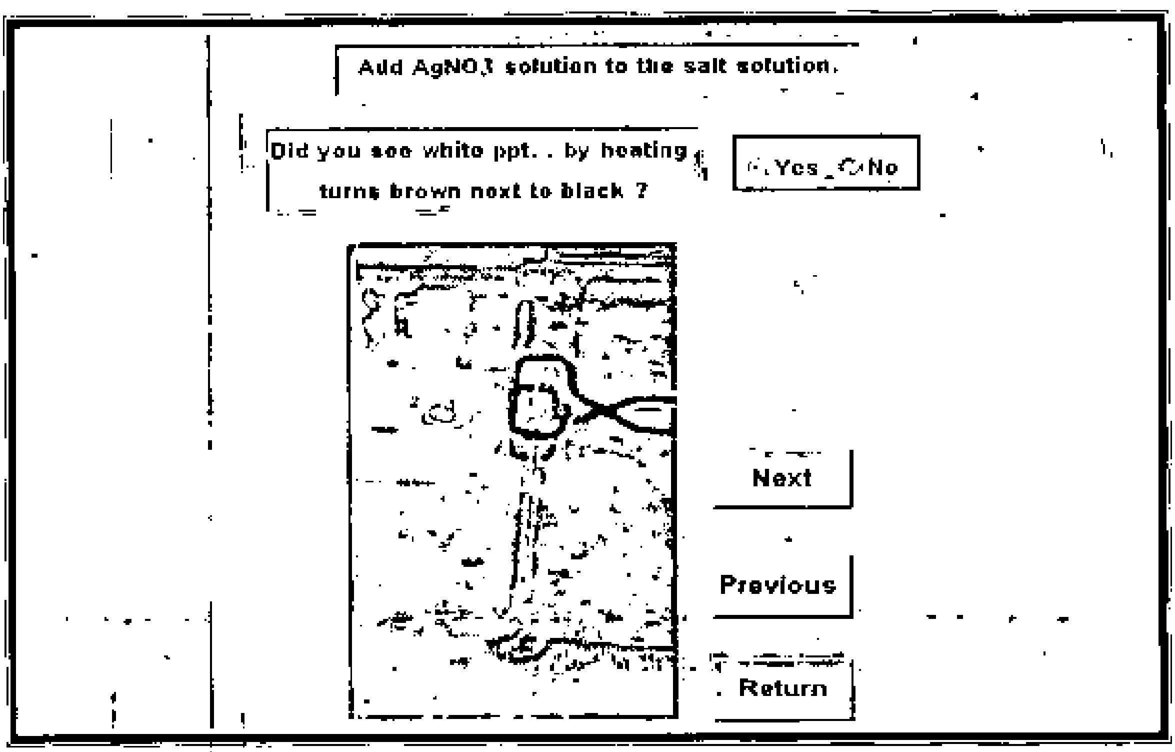


Figure (4.28) show the white precipitate change to brown .

If the user selects the confirmatory test number two from the window in figure(4.27), another window asks him to add (BaCl2) solution to the salt solution and observe what happen as it is indicated in figure(4.29).

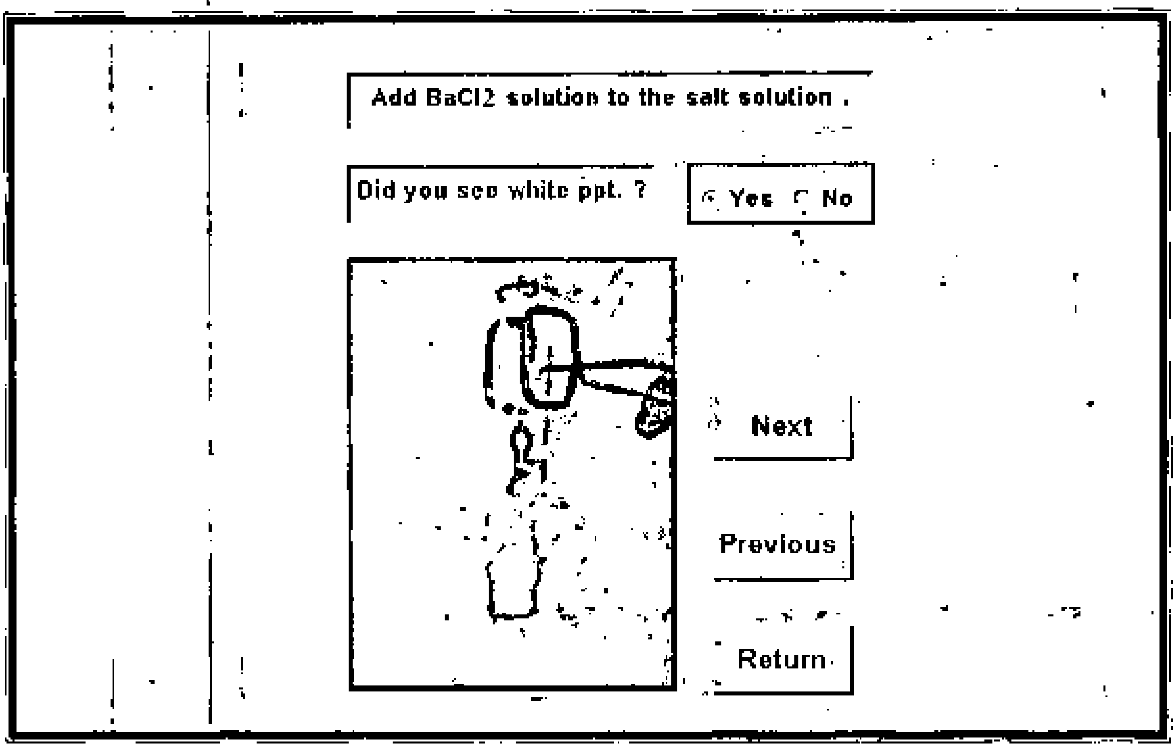


Figure (4.29) show the white precipitate.

If the user selects the confirmatory test number tree from the window in figure(4.27), another window asks him to add (I2) solution to the salt solution and observe what happen as it is indicated in figure(4.30).

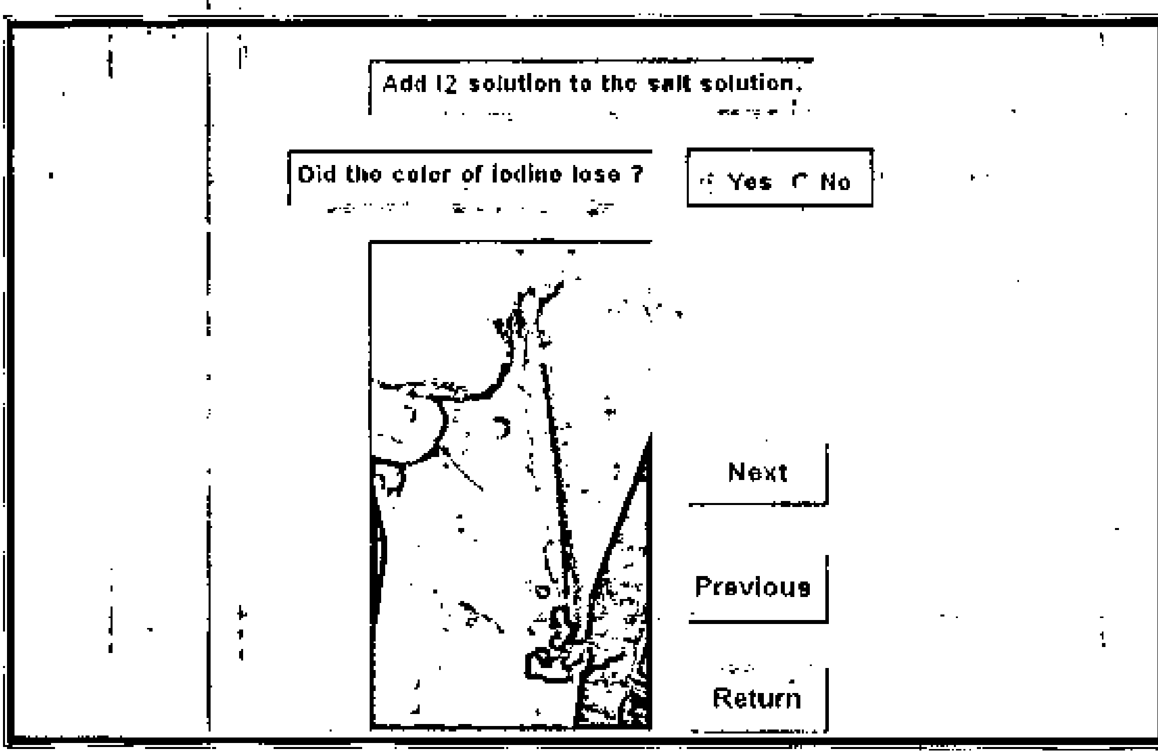


Figure (4.30) show lose the Iodide color.

If the user selected (Yes) and click (Next) in one of the three windows in figures (4.28), (4.29), or (4.30), another window appears shows that the salt is Sulphite. It also gives the user the possibility to move to the window of confirmatory tests or return to the beginning of the program as indicated in figure(4.31).

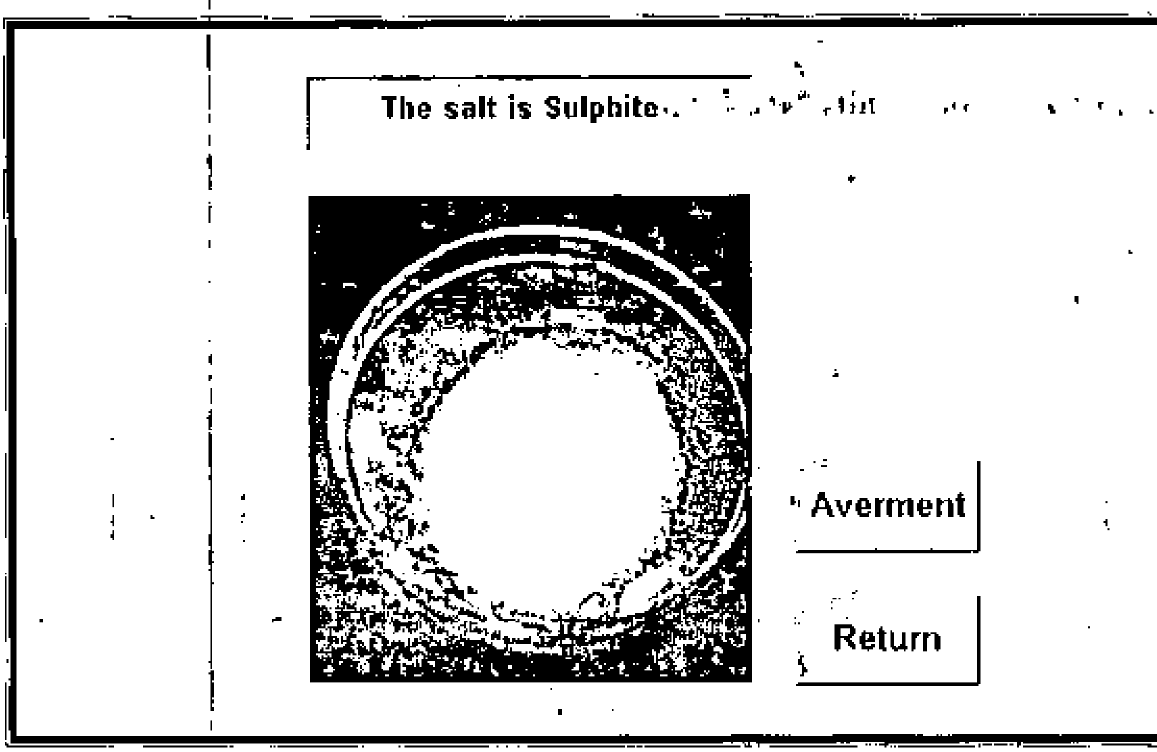


Figure (4.31) aver the salt is Sulphite.

When selected (No) and click (Next) in the window indicated in figure(4.26), a new window states that the user will be see a yellow colloidal precipitation and the salt may be Thiosulphate. There are also three choices to conduct the confirmatory tests as indicated in the window in figure (4.32).

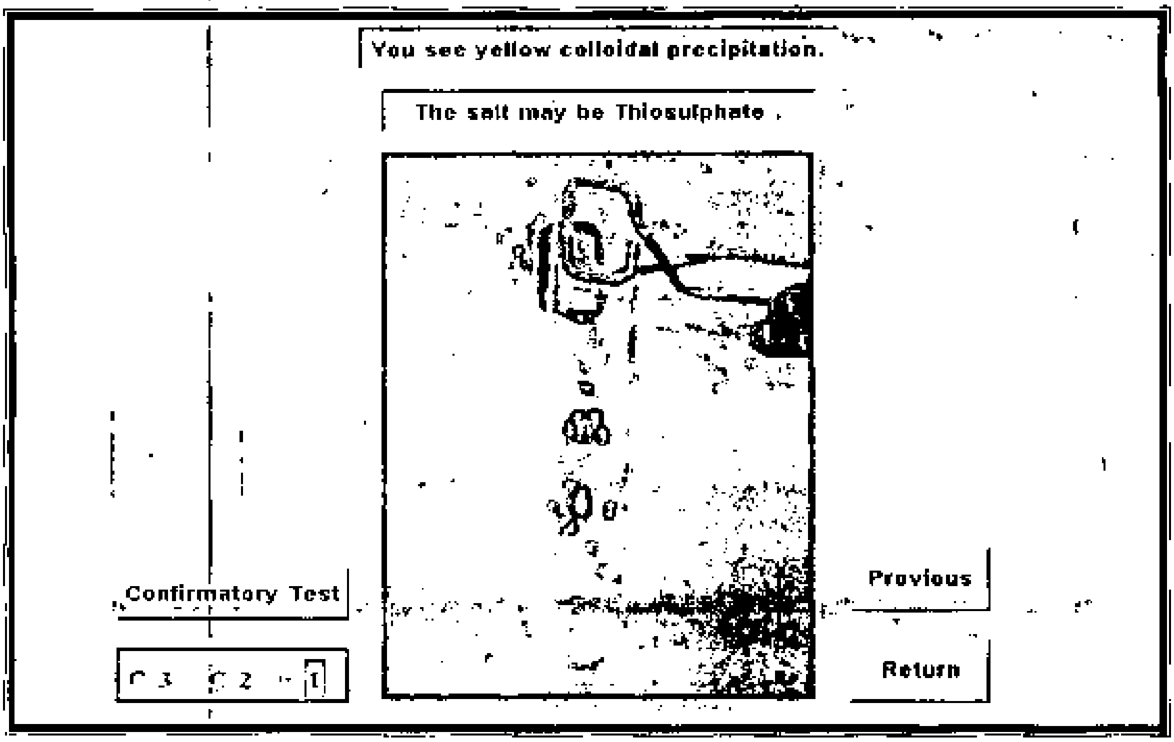


Figure (4.32) show the salt may be Thiosulphate.

If the user selects the confirmatory test number one from the window in figure(4.32), a new window appears asking the user to add (AgNO3) solution to the salt solution and observe what will happen as indicated in figure(4.33).

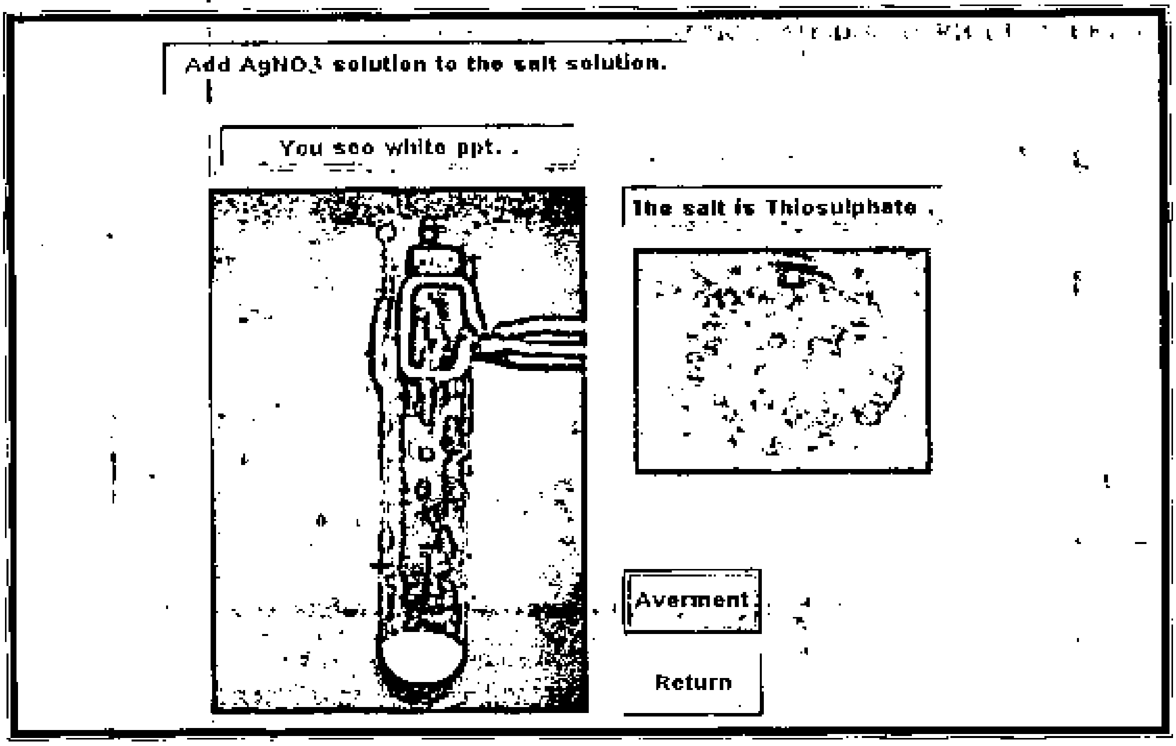


Figure (4.33) show the white precipitate and aver the salt is Thiosulphate.

If the user selects the confirmatory test number two from the window in figure(4.32), a new window appears asking the user to add (($(CH_3COO)_2Pb$)) solution to the salt solution and observe what will happen as indicated in figure(4.34).

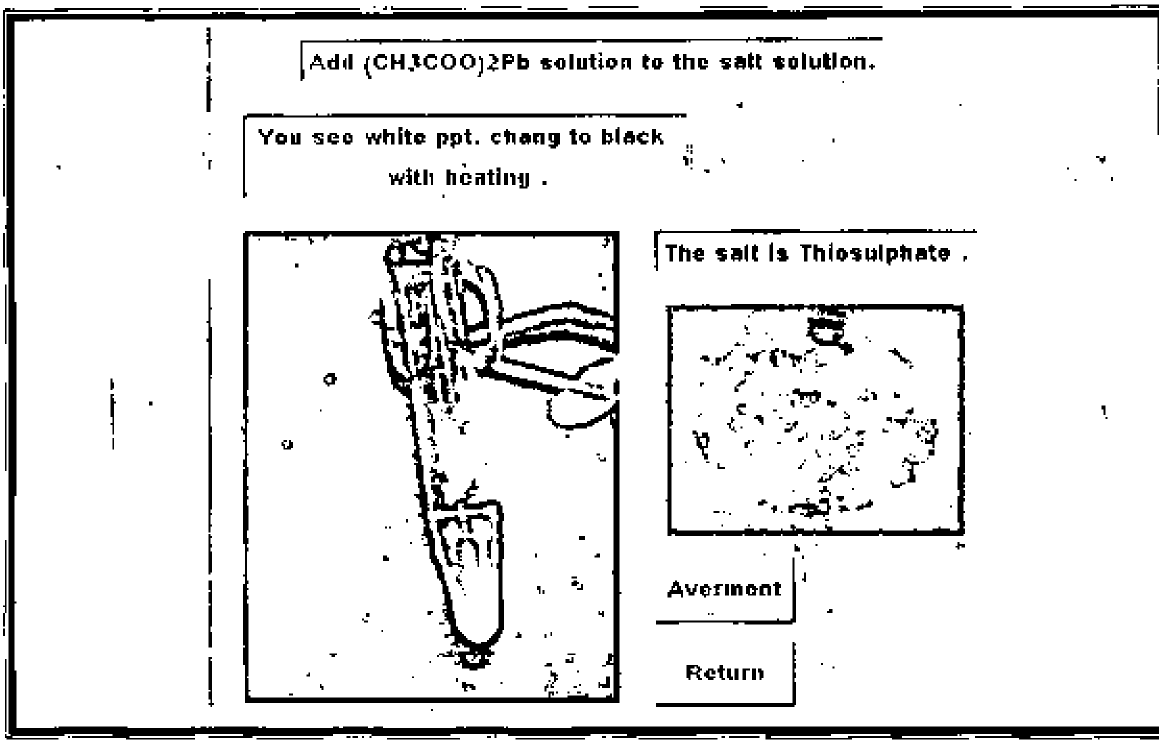


Figure (4.34) show the white precipitate and aver the salt is Thiosulphate.

If the user selects the confirmatory test number tree from the window in figure(4.32), a new window appears asking the user to add ($FeCl_3$) solution to the salt solution and observe what will happen as indicated in figure(4.35).

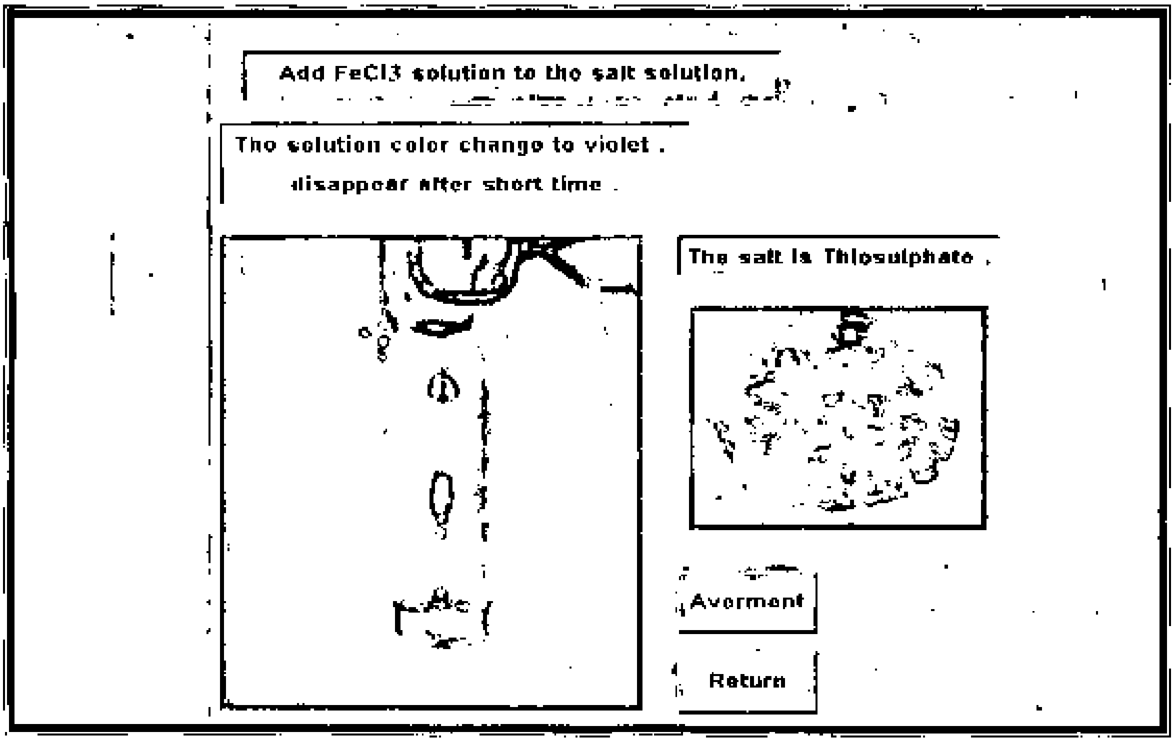


Figure (4.35) show change the color of solution to violet and aver the salt is Thiosulphate.

When selected (No) and click (Next) in the window indicated in figure(4.6), a new window appears as show in figure(4.36). It asks the user to put one gram of an unknown salt in a test tube and add one ml. of Sulphuric acid (H_2SO_4) and observe what would happen. The window contains the question (If you see effervescence or not?). The user may click on (Yes) or (No) then click on (Next) to move to the next step. The user may move back to the previous screen by clicking on (Previous) or return to the beginning of the program by click on (Return).

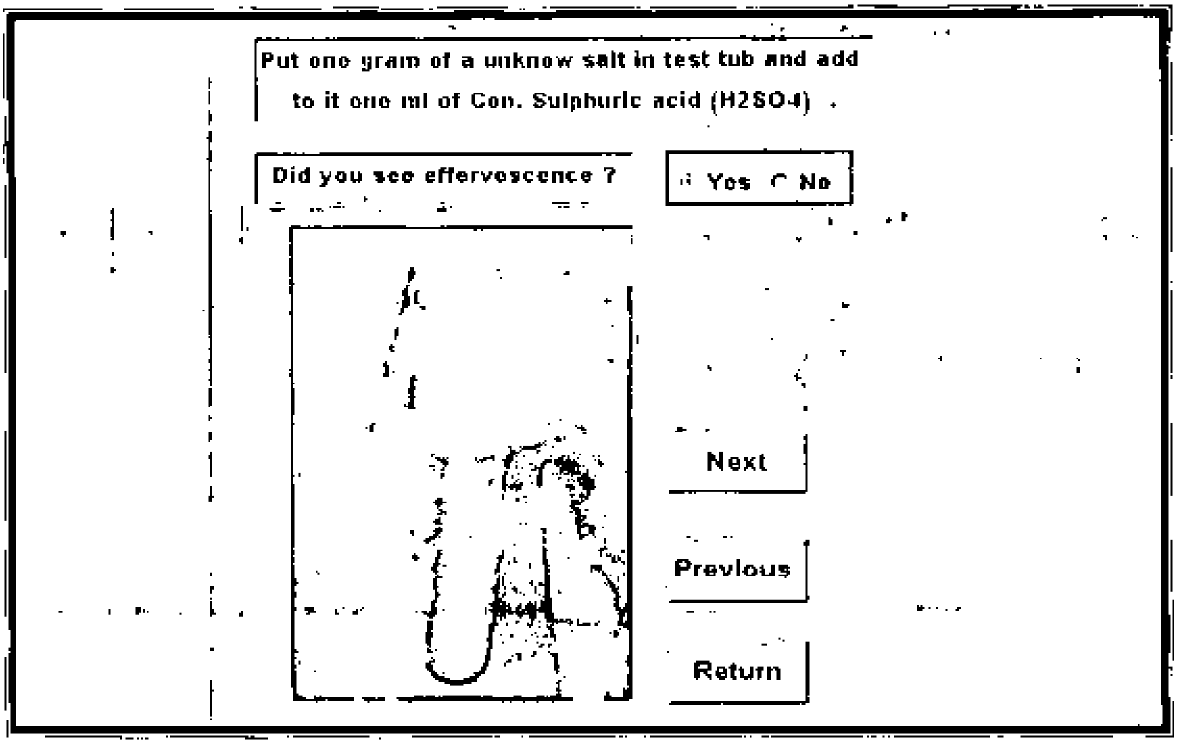


Figure (4.36) show the effervescence when add Sulphuric acid to unknown salt.

When the user choose (yes) and then click (Next) in the previous window in figure(4.36), a new window appears as show in figure (4.37). The window shows to the user that this salt is Sulphuric acid group. It also asks the user if he see hard odor gas evolved or not. The user may choose (Yes) or (No) then click on (Next).

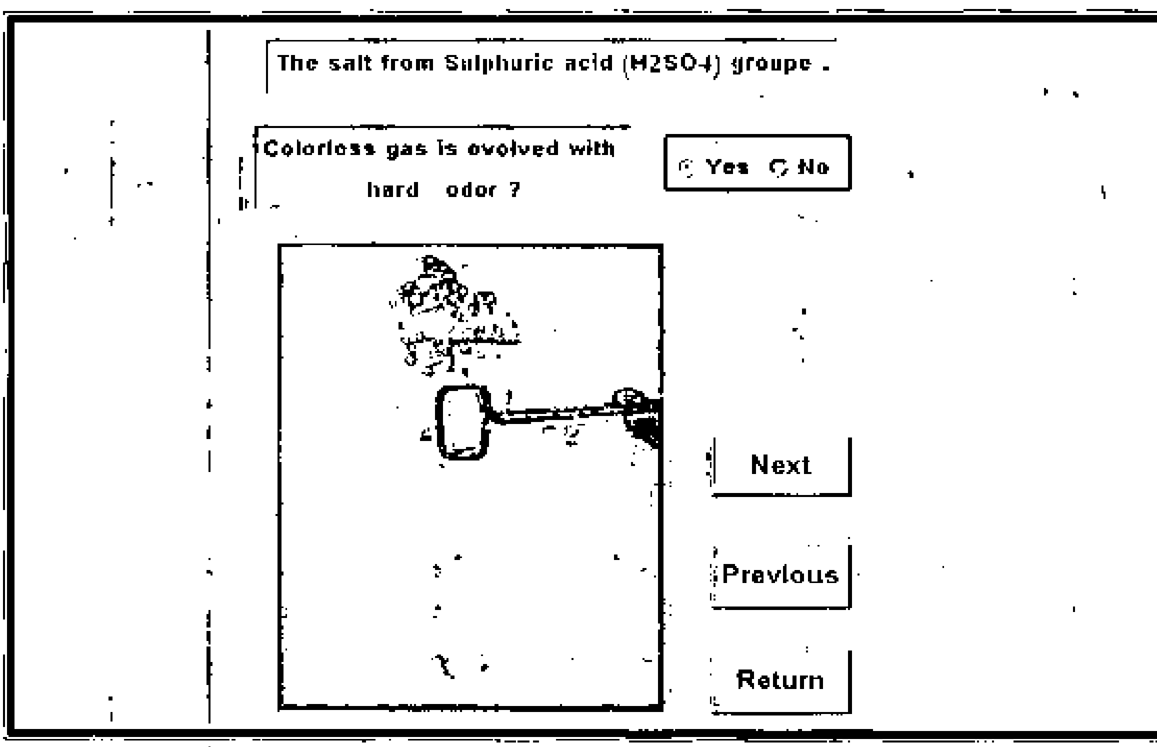


Figure (4.37) show run high gas with hard odor.

If the user selected (Yes) from the window indicated in figure(4.37) and then click (Next). a new window appears indicate that the salt may be Chloride. There are also three choices to conduct the confirmatory tests as indicated in the window in figure (4.38).

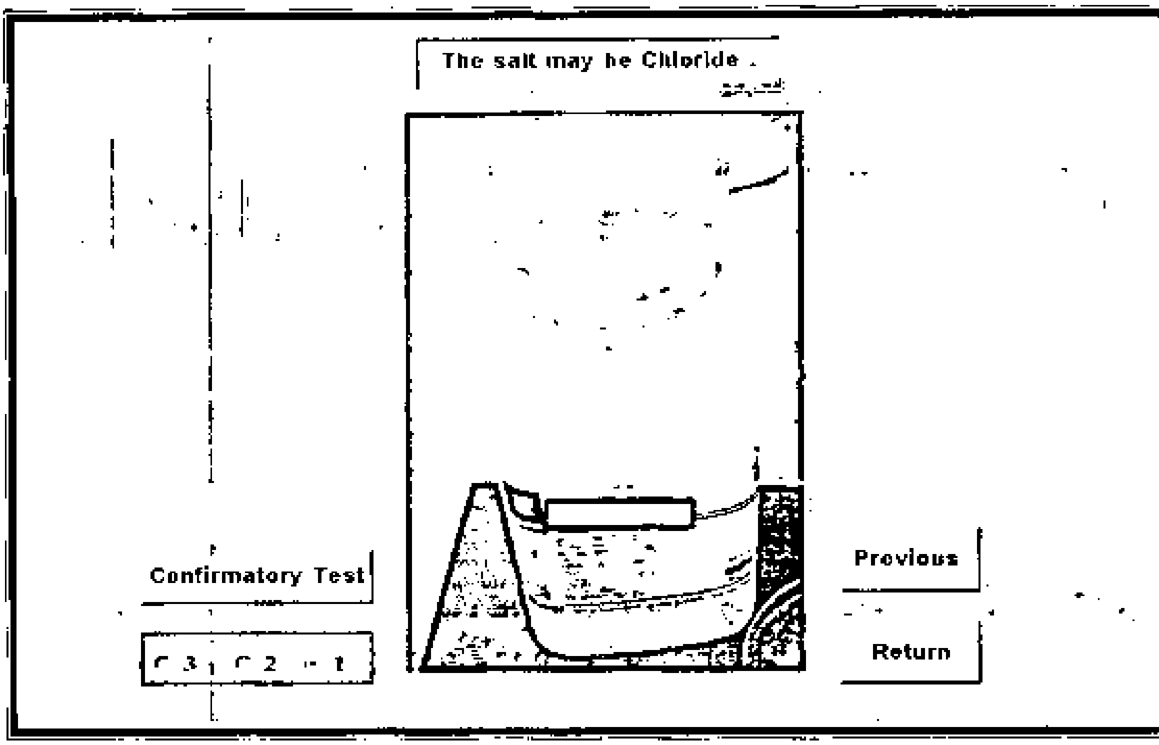


Figure (4.38) show the salt may be Chloride.

If the user selects the confirmatory test number one from the window in figure(4.38), a new window appears asking the user to add ($AgNO_3$) solution to the salt solution and observe what will happen as indicated in figure(4.39).

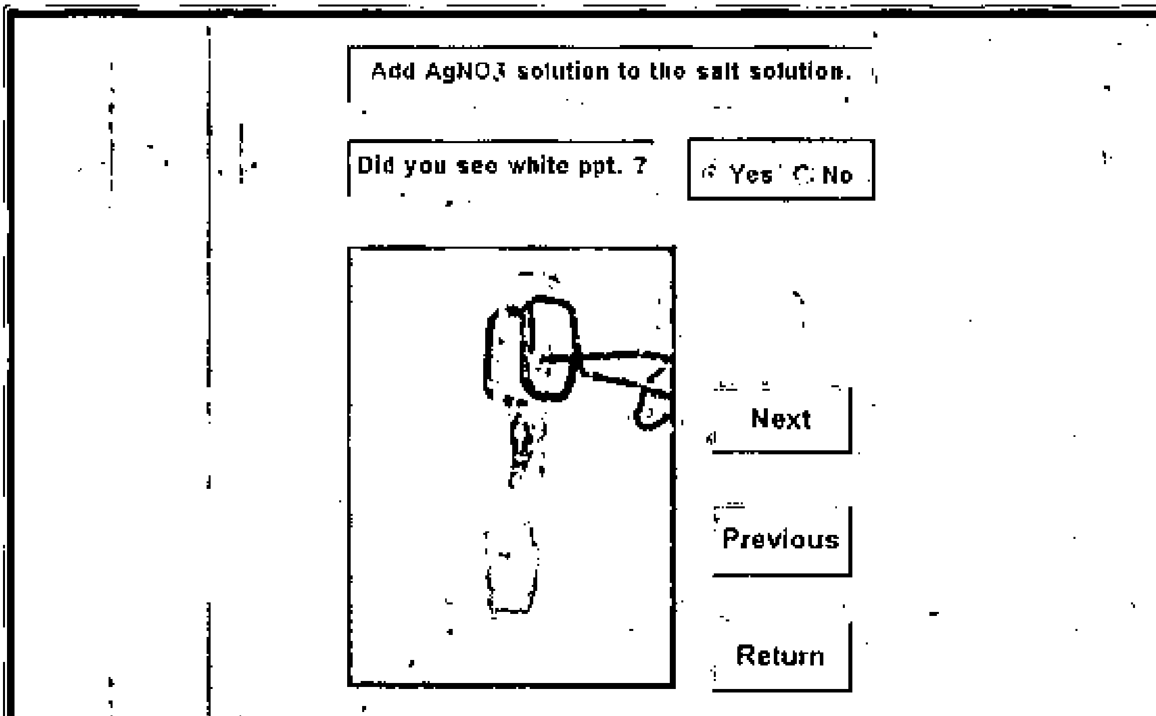


Figure (4.39) show the white precipitate.

If the user selects the confirmatory test number two from the window in figure(4.38), a new window appears asking the user to add ((CH3OO)2Pb) solution to the salt solution and observe what will happen as indicated in figure(4.40).

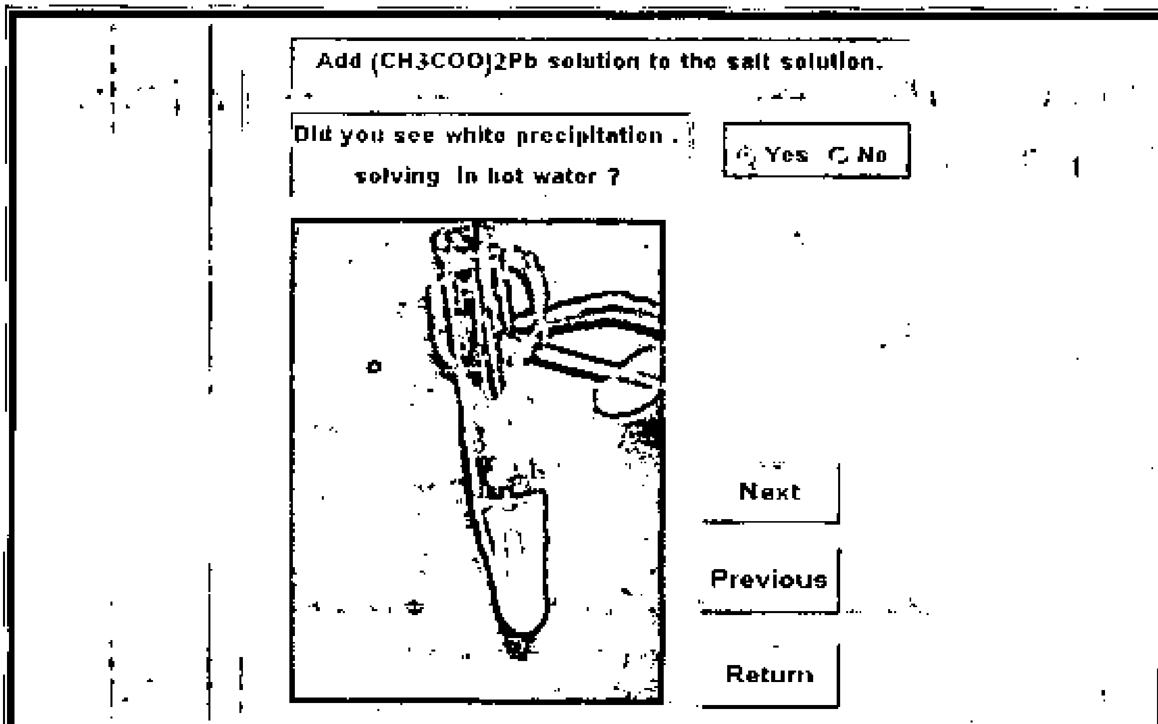


Figure (4.40) show the white precipitate.

If the user selects the confirmatory test number tree from the window in figure(4.38), a new window appears asking the user to add(MnO_2) and con. H_2SO_4 to the sold salt and observe what will happen as indicated in figure(4.41).

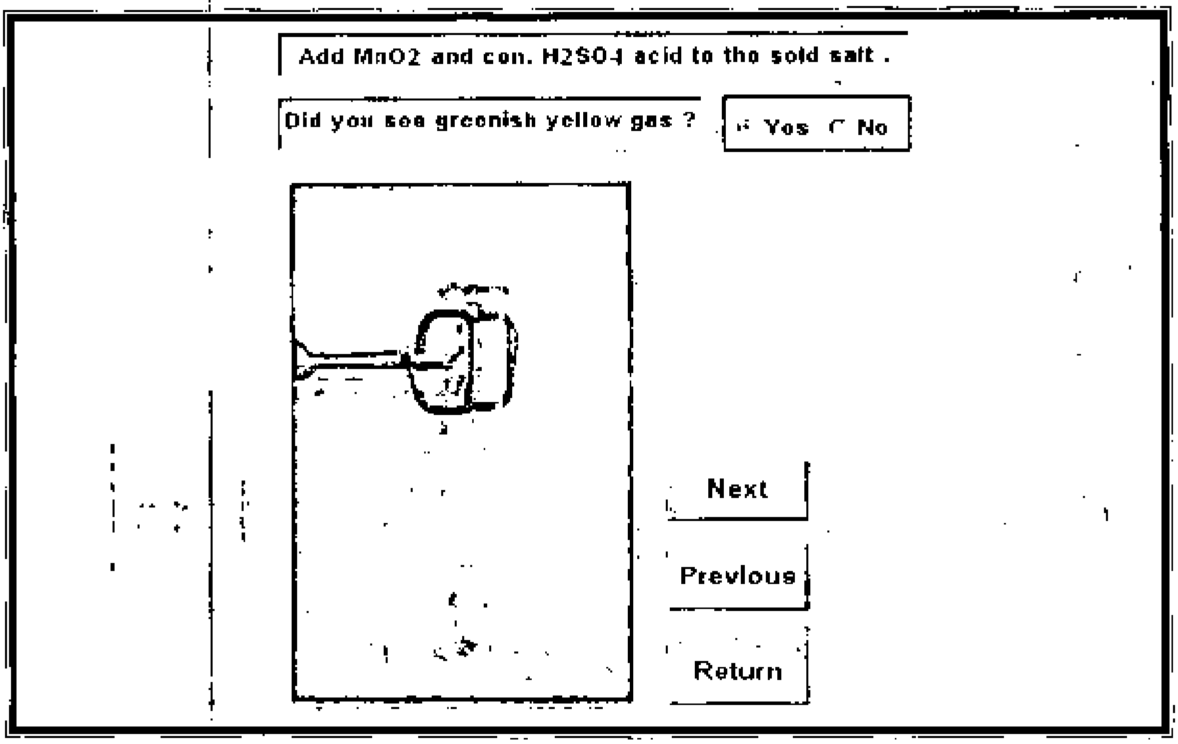


Figure (4.41) show run high greenish yellow gas.

If the user selected (Yes) and click (Next) in one of the three windows in figures (4.39), (4.40), or (4.41), another window appears shows that the salt is Chloride. It also gives the user the possibility to move to the window of confirmatory tests or return to the beginning of the program as indicated in figure(4.25).

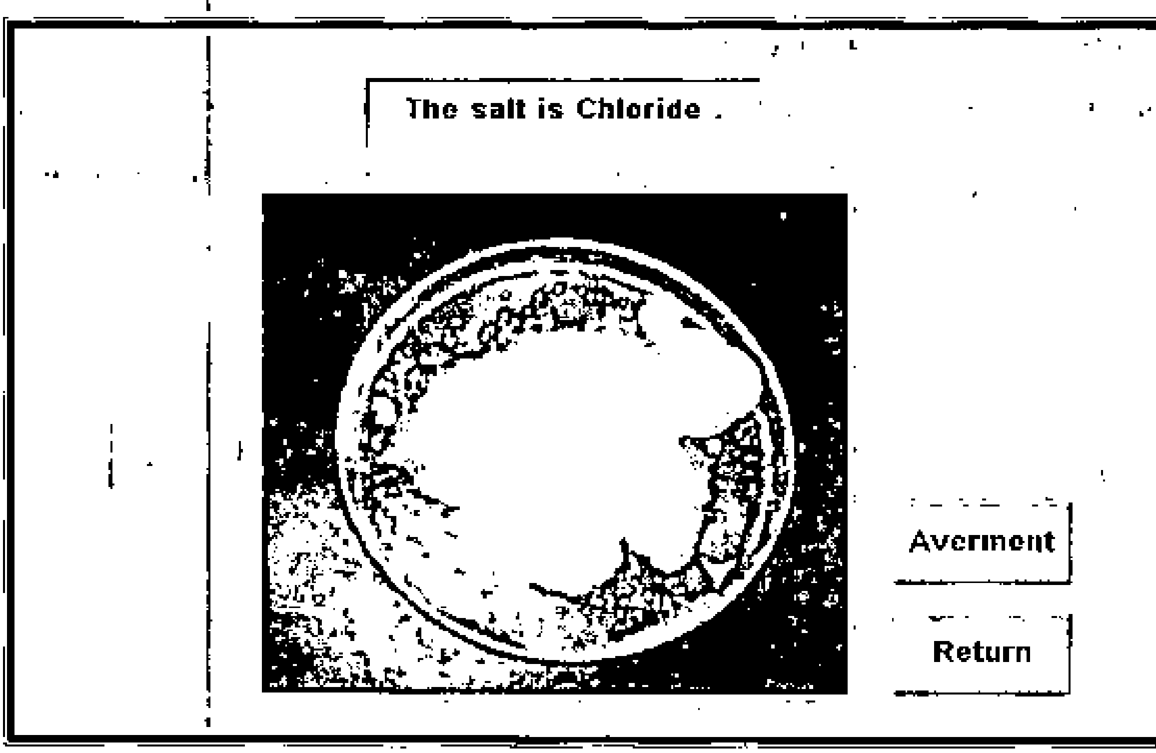


Figure (4.42) aver the salt is Chloride.

When the user select (No) and click (Next) in the window indicated in figure(4.37), a new window states that the salt is from Sulphuric acid group. There is also a Yes or No question as indicated in figure(4.43).

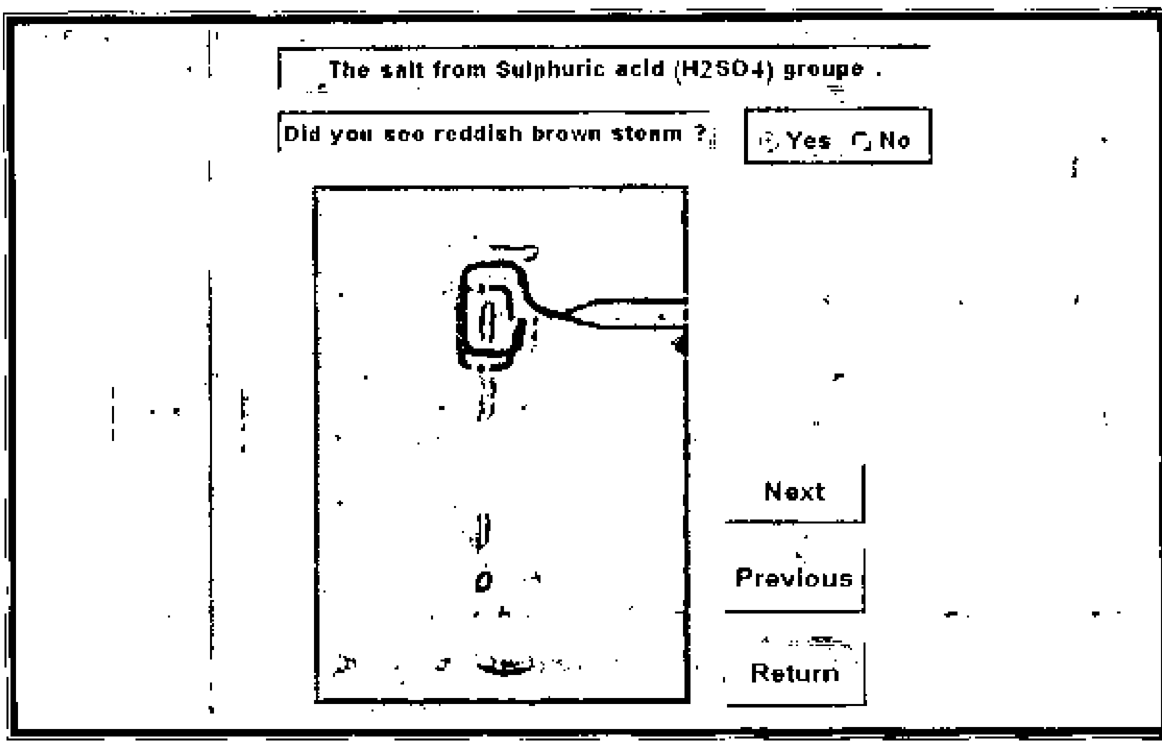


Figure (4.43) show run high reddish brown steam.

If the user selected (Yes) from the window indicated in figure(4.43) and then click (Next), a new window appears indicate that the salt may be Bromide. There are also three choices to conduct the confirmatory tests as indicated in the window in figure (4.44).

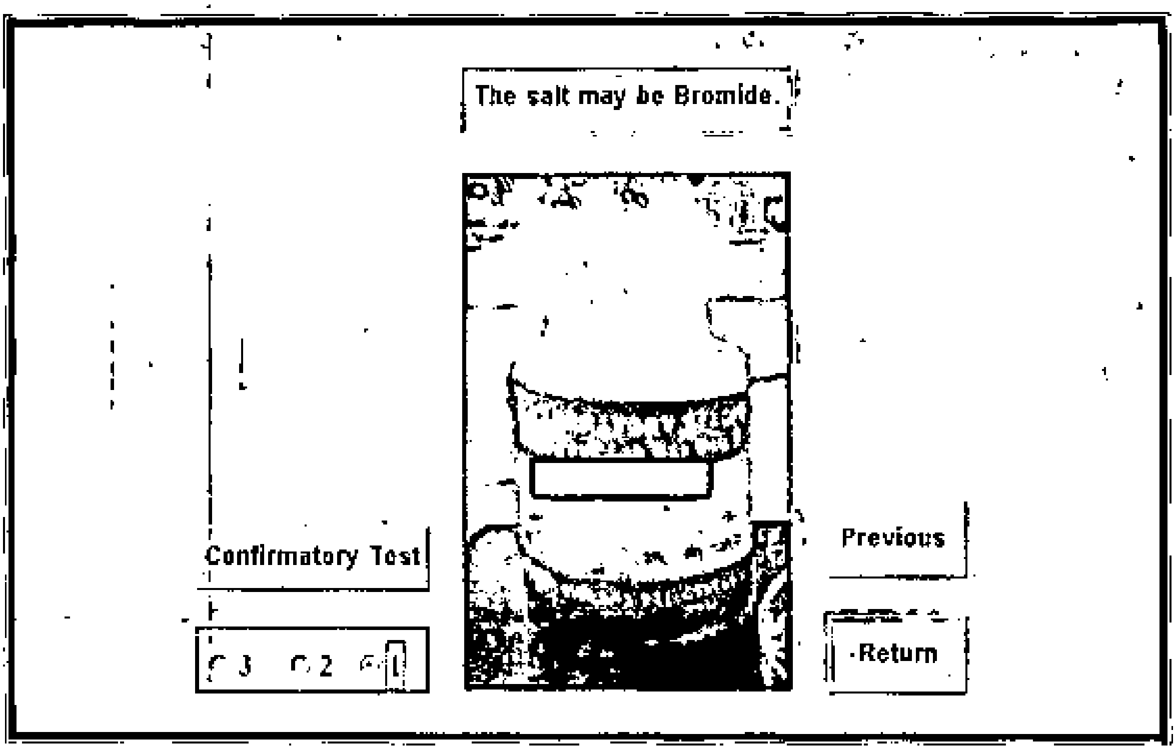


Figure (4.44) show the salt may be Bromide.

If the user selects the confirmatory test number one from the window in figure(4.44), a new window appears asking the user to add (AgNO3) solution to the salt solution and observe what will happen as indicated in figure(4.45).

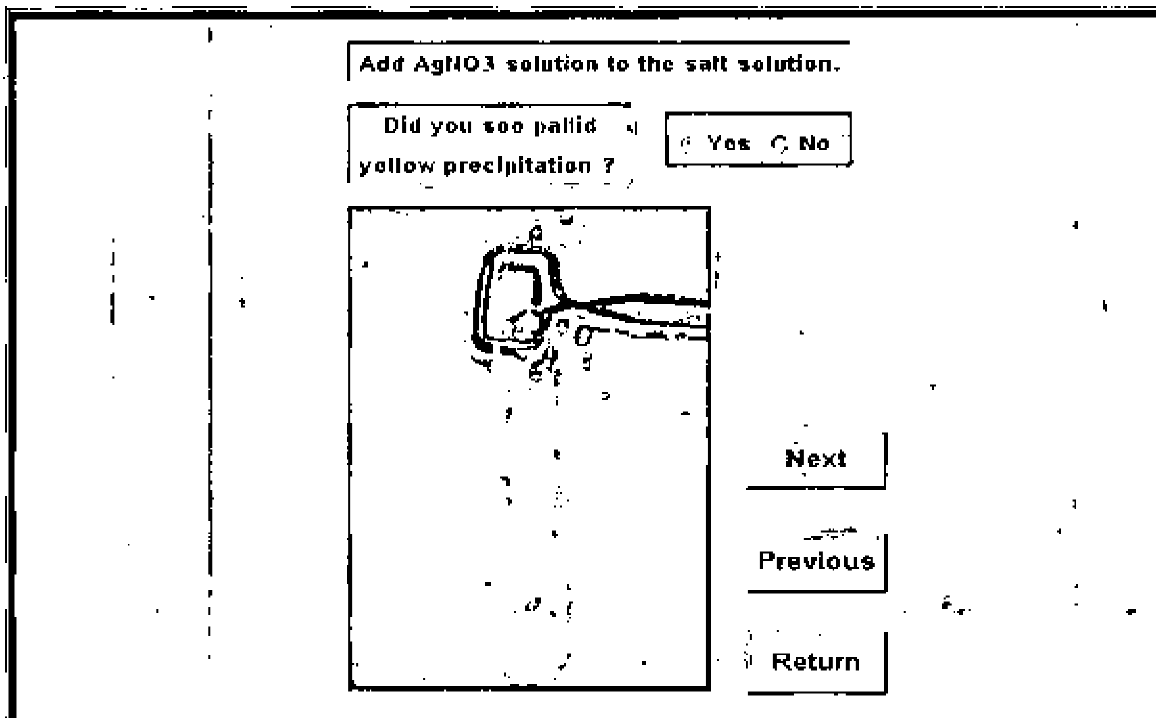


Figure (4.45) show the pallid yellow precipitate.

If the user selects the confirmatory test number two from the window in figure(4.44), a new window appears asking the user to add ((CH3COO)2Pb) solution to the salt solution and observe what will happen as indicated in figure(4.46).

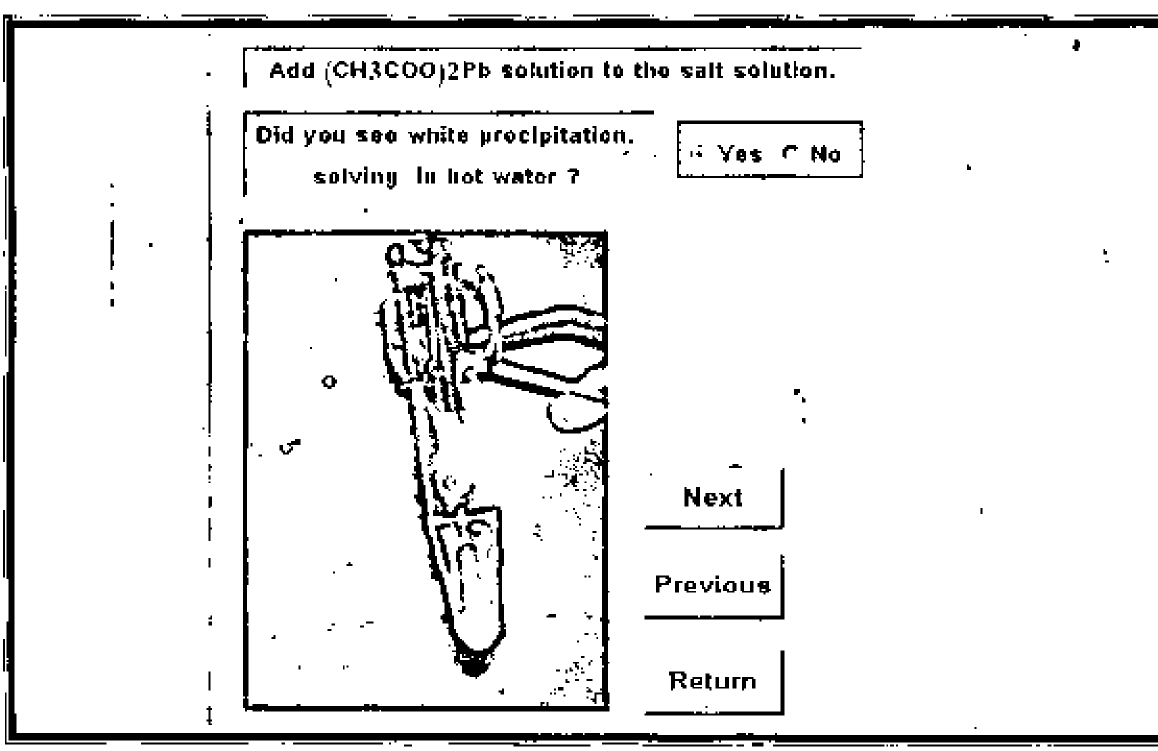


Figure (4.46) show the white precipitate.

If the user selects the confirmatory test number three from the window in figure(4.44), a new window appears asking the user to add drops from chlorwater and chloroform to the salt solution and observe what will happen as indicated in figure(4.47).

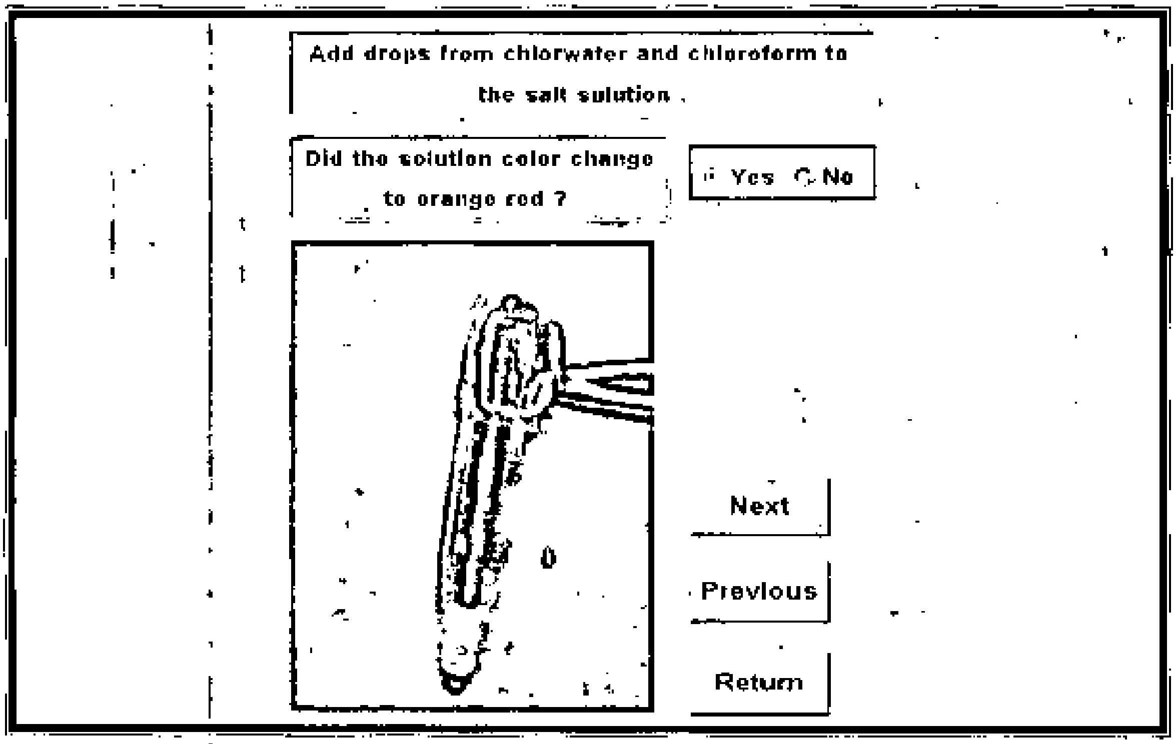


Figure (4.47) show change the color of solution to orange.

If the user selected (Yes) and click (Next) in one of the three windows in figures (4.45), (4.46), or (4.47), another window appears shows that the salt is Bromide. It also gives the user the possibility to move to the window of confirmatory tests or return to the beginning of the program as indicated in figure(4.48).

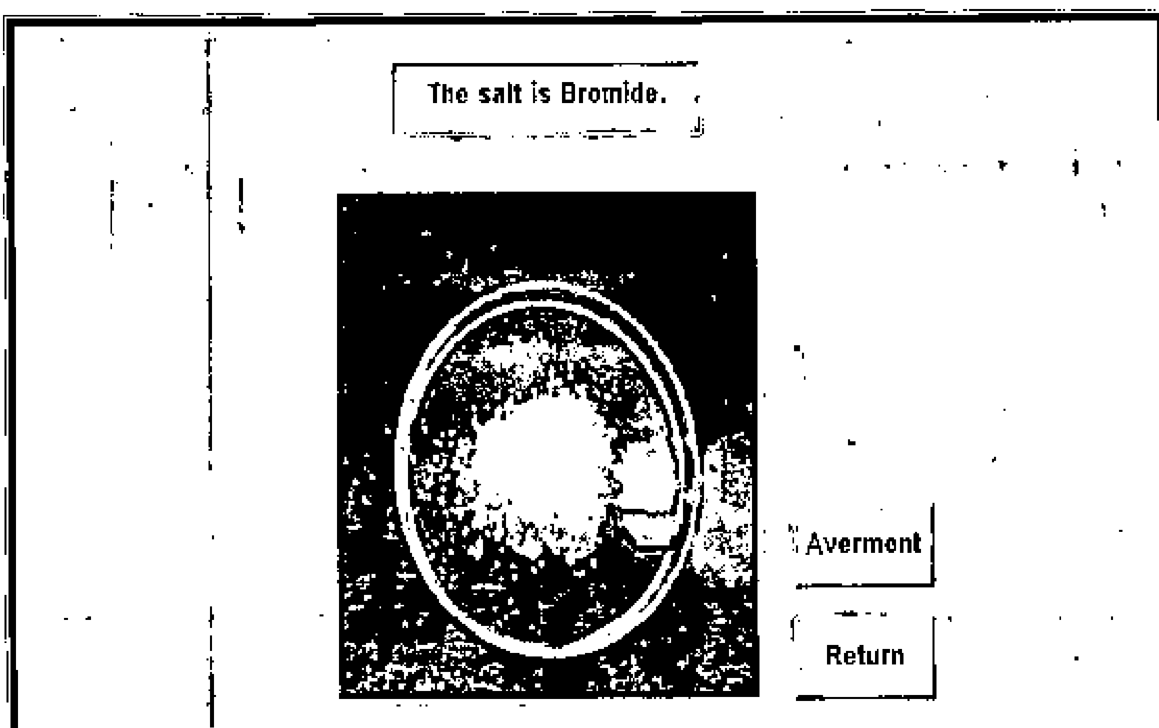


Figure (4.48) aver the salt is Bromide.

When the user select (No) and click (Next) in the window indicated in figure(4.43), a new window states that the salt is from Sulphuric acid group. There is also a Yes or No question as indicated in figure(4.49).

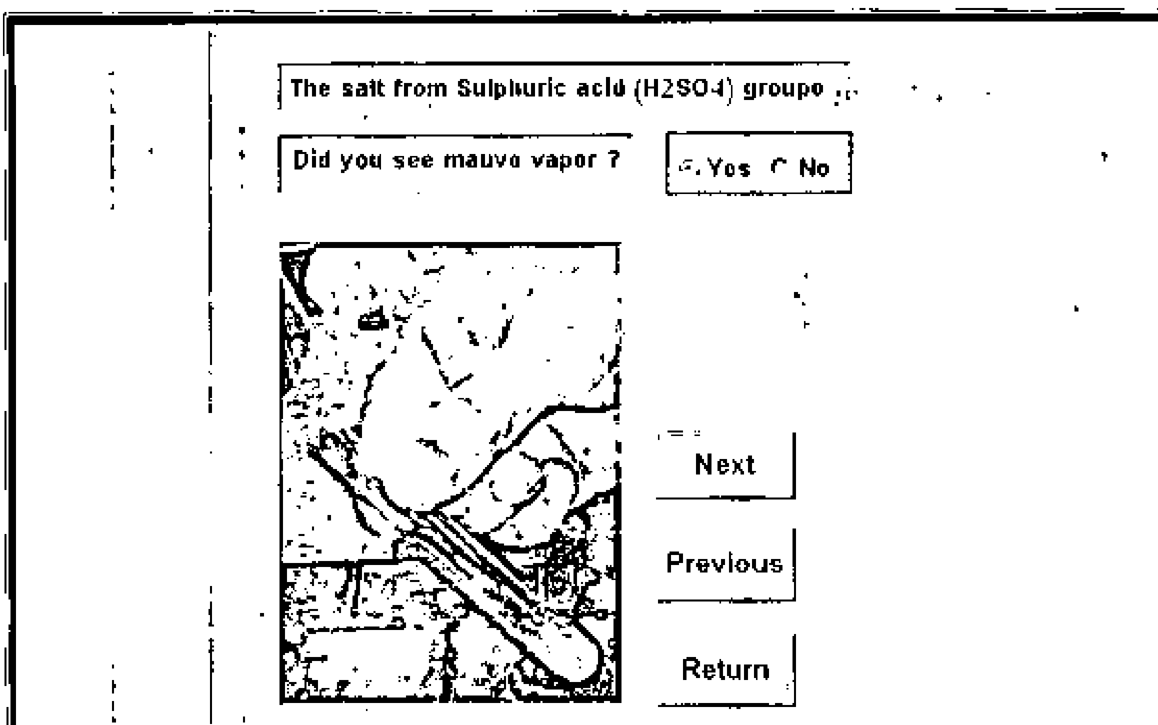


Figure (4.49) show run high mauve vapor.

If the user selected (Yes) from the window indicated in figure(4.49) and then click (Next), a new window appears indicate that the salt may be Iodide. There are also four choices to conduct the confirmatory tests as indicated in the window in figure (4.50).

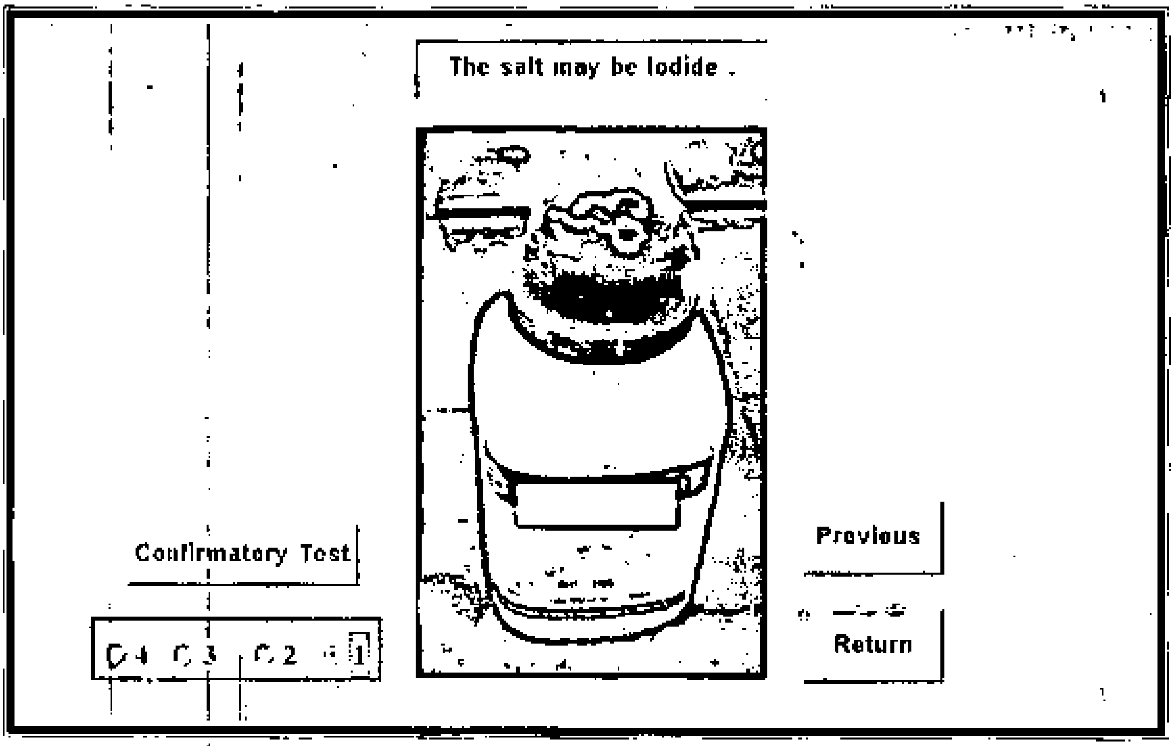


Figure (4.50) show the salt may be Iodide.

If the user selects the confirmatory test number one from the window in figure(4.50), a new window appears asking the user to add (AgNO3) solution to the salt solution and observe what will happen as indicated in figure(4.51).

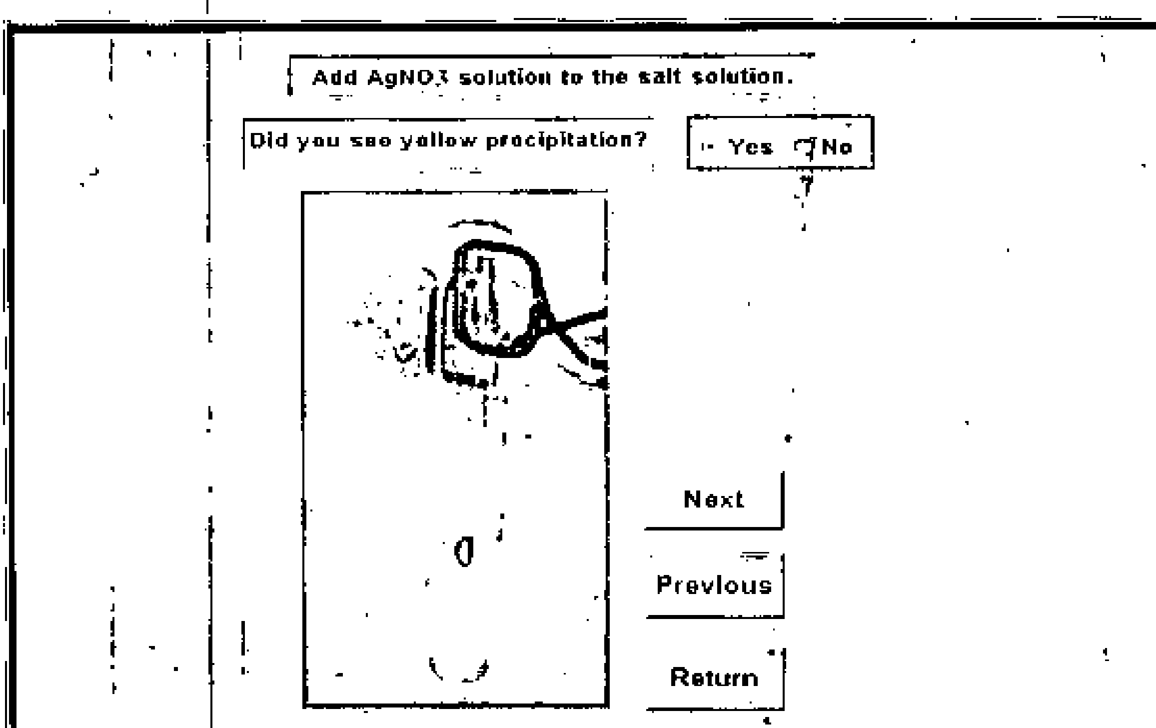


Figure (4.51) show the yellow precipitate.

If the user selects the confirmatory test number two from the window in figure(4.50), a new window appears asking the user to add ((CH3COO)2Pb) solution to the salt solution and observe what will happen as indicated in figure(4.52).

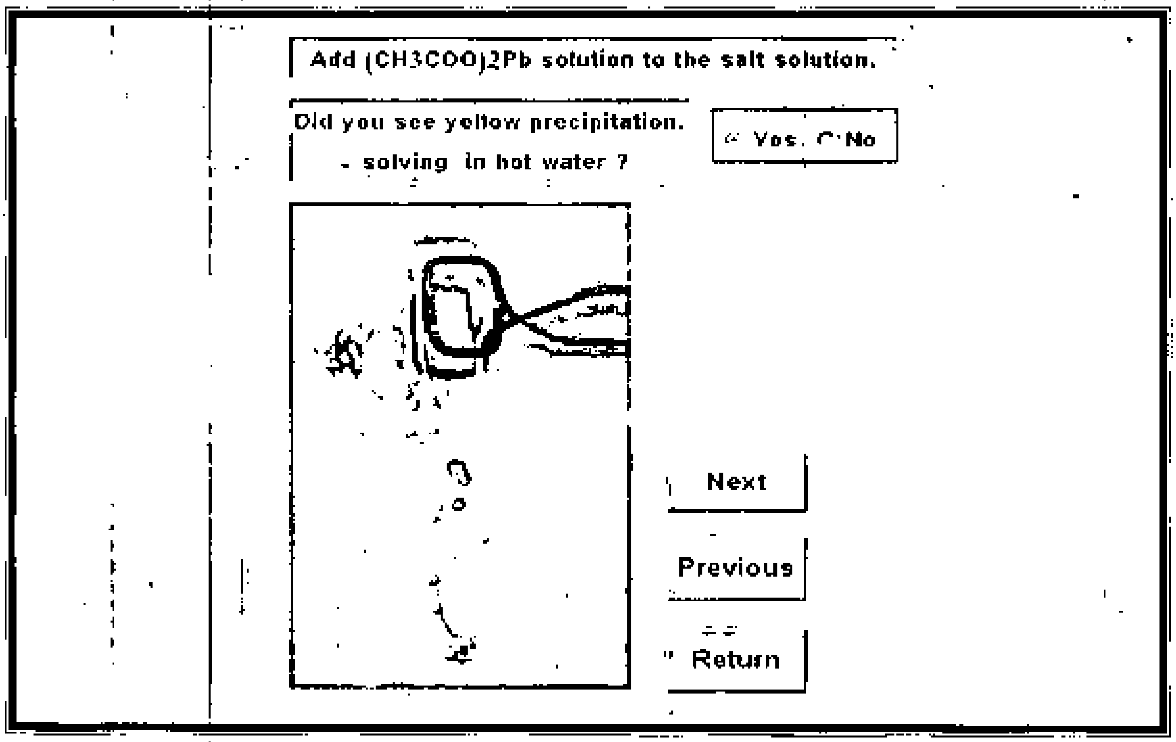


Figure (4.52) show the yellow precipitate.

If the user selects the confirmatory test number three from the window in figure(4.50), a new window appears asking the user to add drops from chlorwater and chloroform to the salt solution and observe what will happen as indicated in figure(4.53).

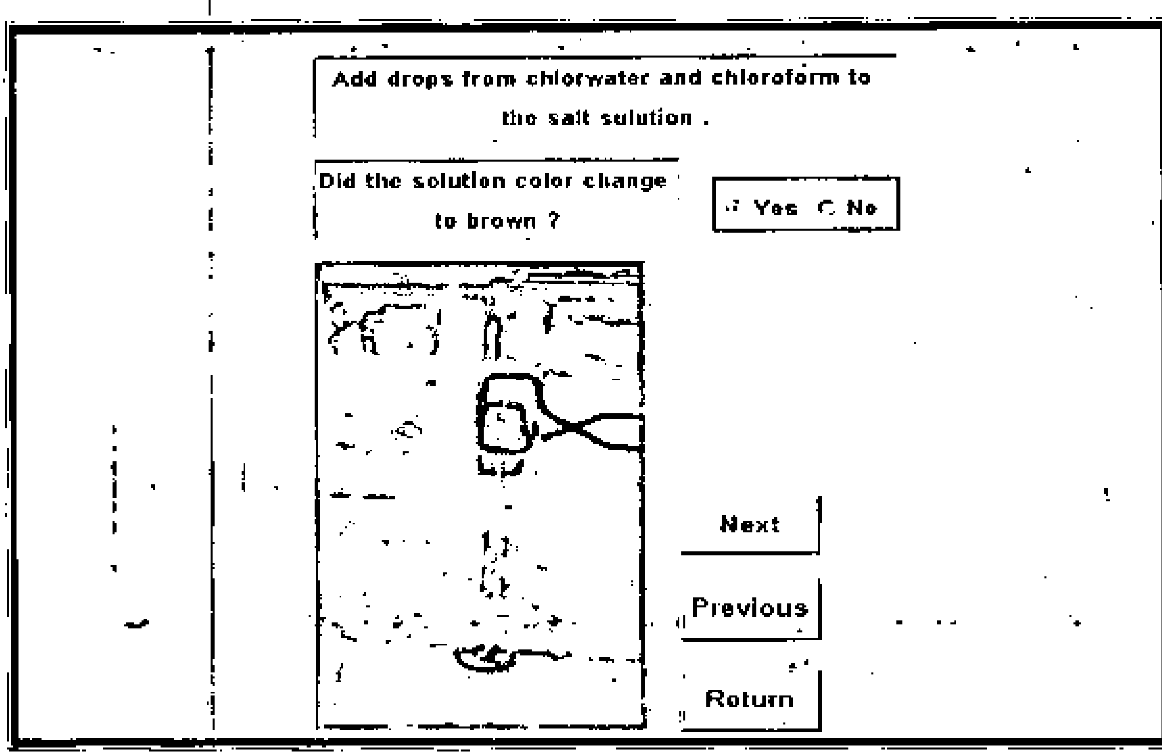


Figure (4.53) show change the color of solution to brown.

If the user selects the confirmatory test number four from the window in figure(4.50), a new window appears asking the user to add (CuSO4) solution to the salt solution and observe what will happen as indicated in figure(4.54).

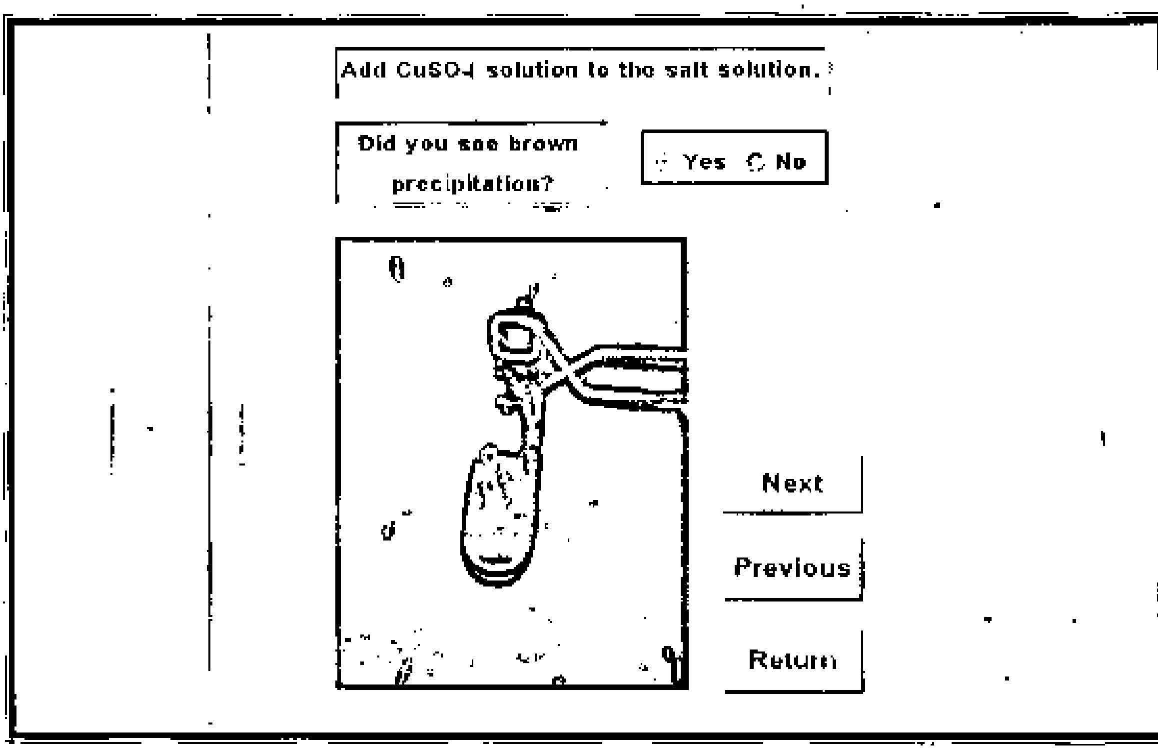


Figure (4.54) show the brown precipitate.

If the user selected (Yes) and click (Next) in one of the four windows in figures (4.51), (4.52),(4.53), or (4.54), another window appears shows that the salt is Iodide. It also gives the user the possibility to move to the window of confirmatory tests or return to the beginning of the program as indicated in figure(4.55).

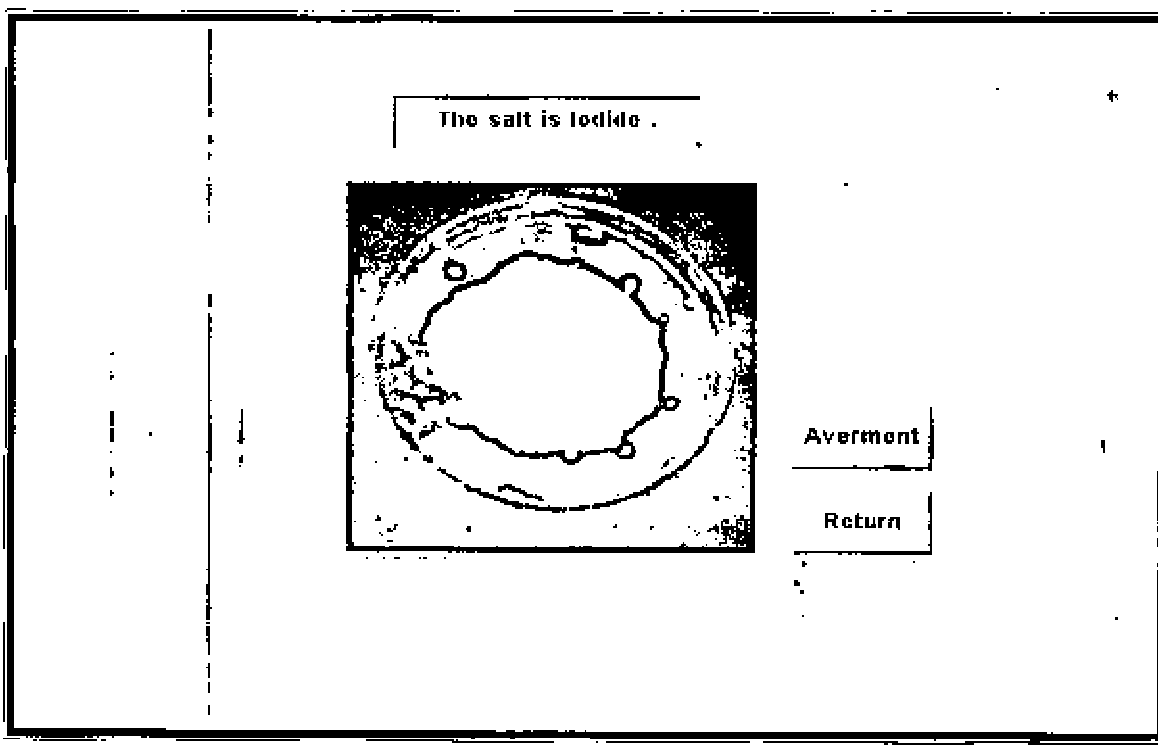


Figure (4.55) aver the salt is Iodide.

When the user selected (No) and click (Next) in the window indicated in figure(4.49), a new window states that the user will be see a brown fumes with suffocating odor, and the salt may be Nitrate. There are also two choices to conduct the confirmatory tests as indicated in the window in figure (4.56).

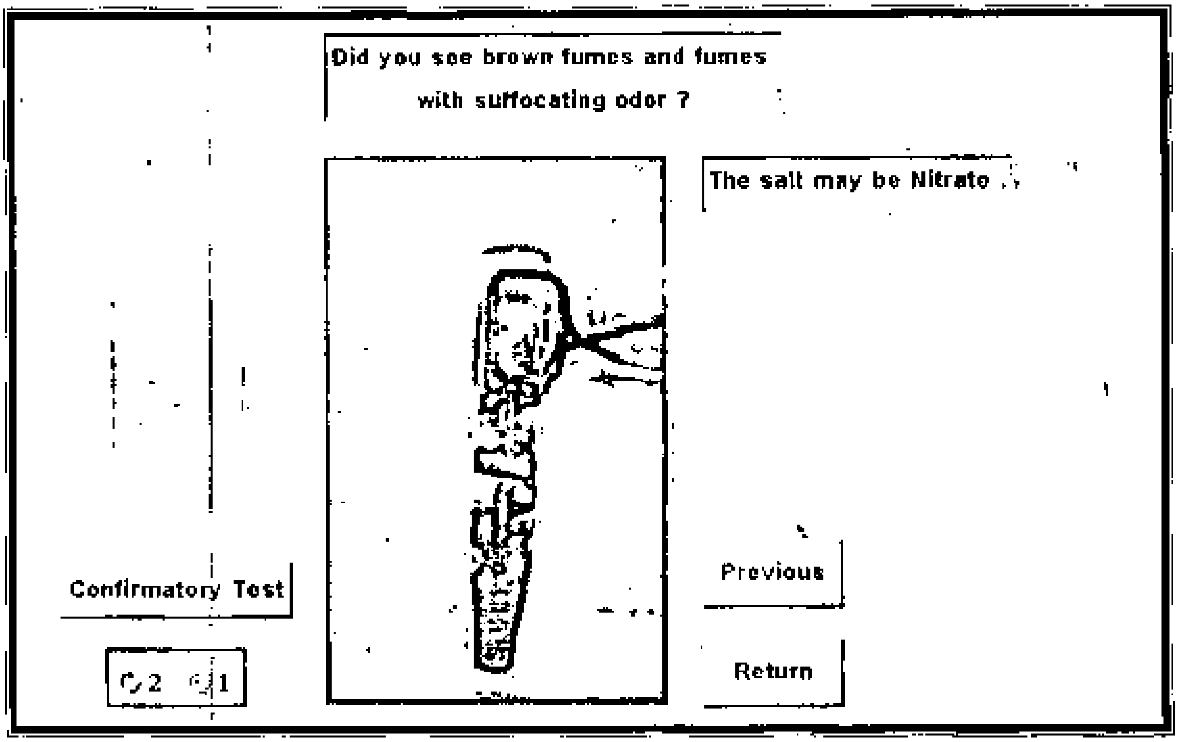


Figure (4.56) show run high brown fumes and the salt may be Nitrate.

If the user selects the confirmatory test number one from the window in figure(4.56), a new window appears asking the user to add con. Sulphuric acid with copper turnings to the salt solution and observe what will happen as indicated in figure(4.57).

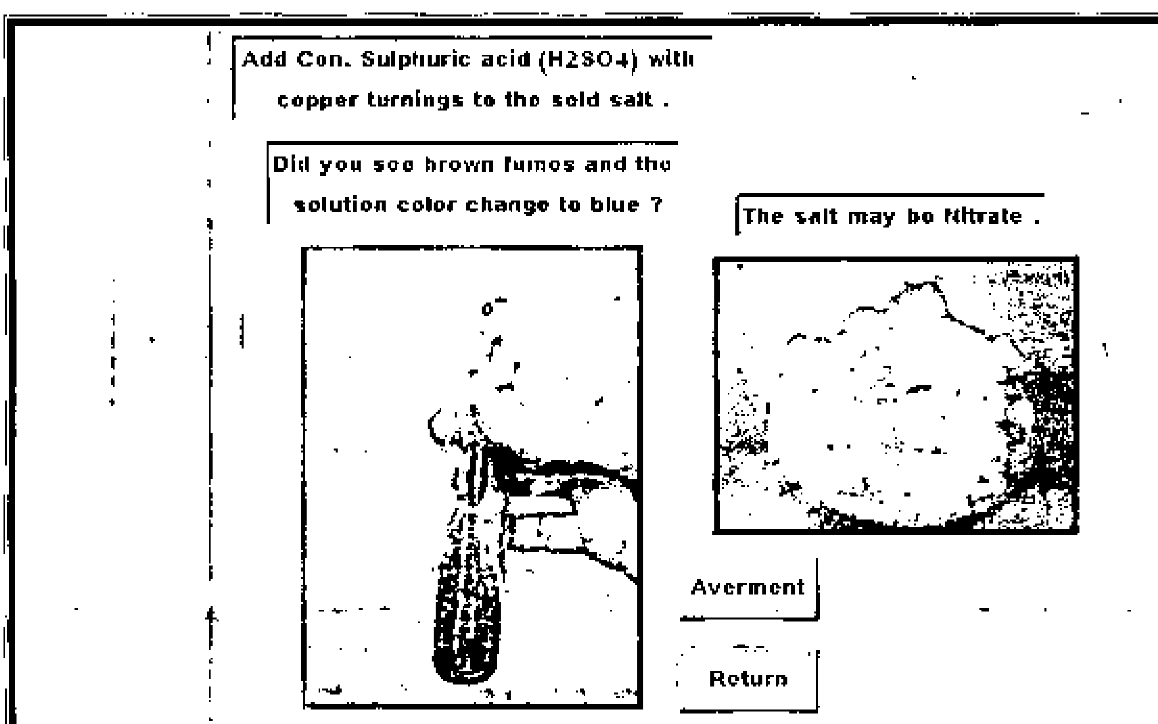


Figure (4.57) show run high brown fumes and the salt is Nitrate.

If the user selects the confirmatory test number two from the window in figure(4.56), a new window appears asking the user to add (FeSO4) and con. Sulphuric acid to the salt solution and observe what will happen as indicated in figure(4.58).

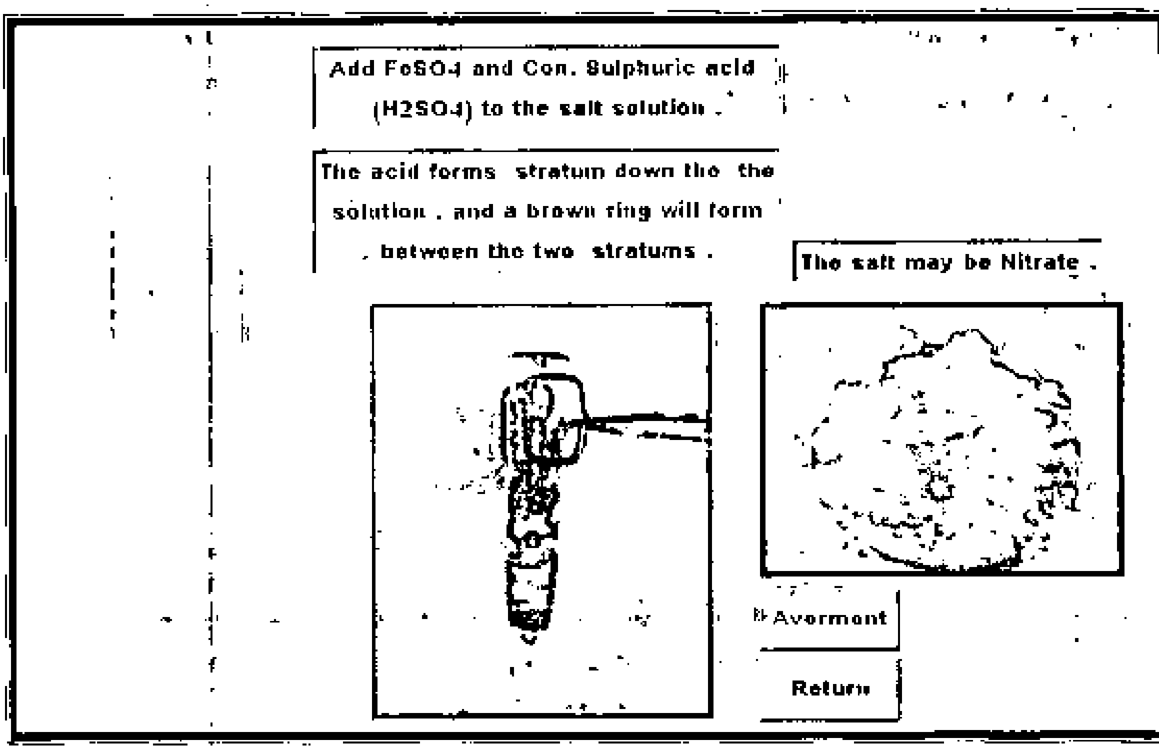


Figure (4.58) show the brown ring and the salt is Nitrate .

When the user select (No) and click (Next) in the window indicated in figure(4.36), a new window states that the salt is from precipitation group and asks the user to add BaCl2 solution to the salt solution. There is also a Yes or No question as indicated in figure(4.59).

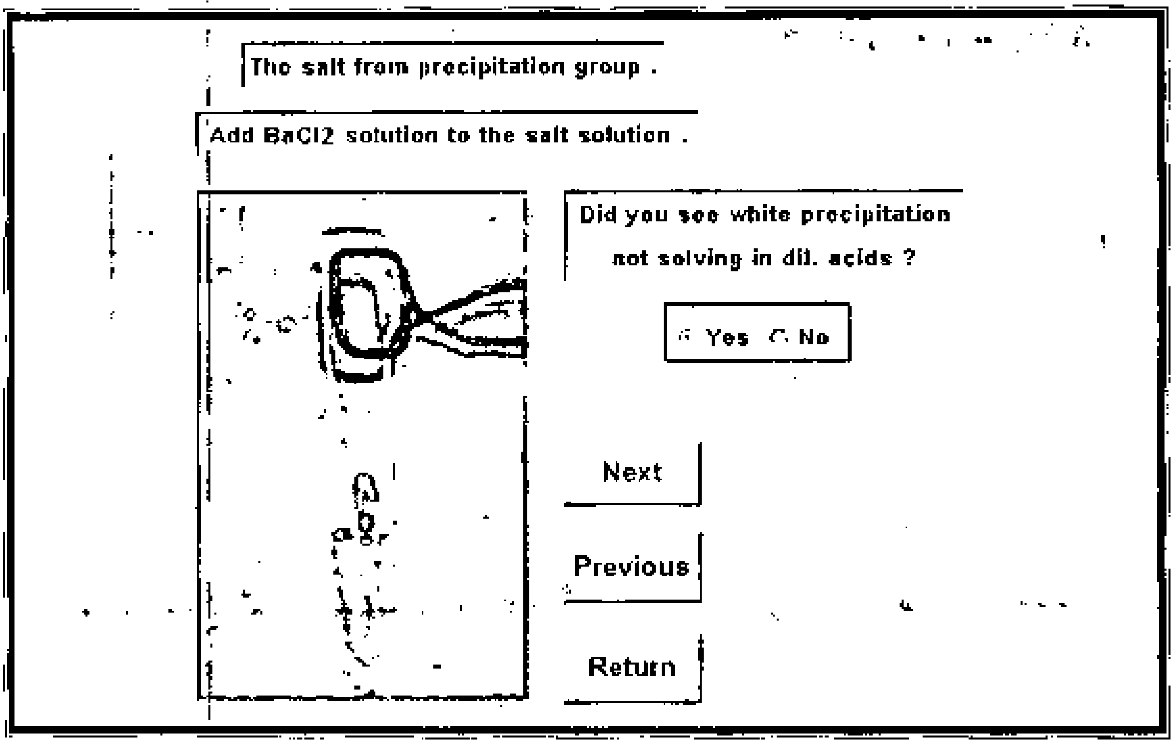


Figure (4.59) show the white precipitate.

If the user selected (Yes) from the window indicated in figure(4.59) and then click (Next), a new window appears indicate that the salt may be Sulphate. There are also two choices to conduct the confirmatory tests as indicated in the window in figure (4.60).

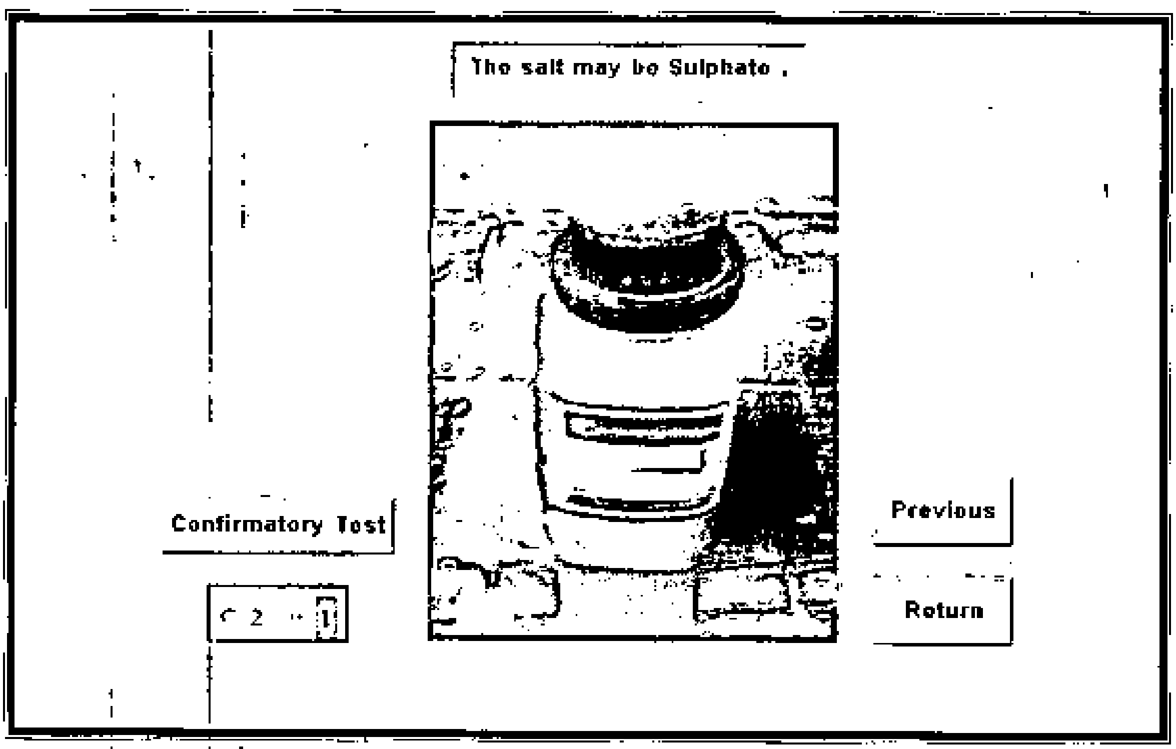


Figure (4.60) show the salt may be Sulphate.

If the user selects the confirmatory test number one from the window in figure(4.60), a new window appears asking the user to add ($AgNO_3$) solution to the salt solution and observe what will happen as indicated in figure(4.61).

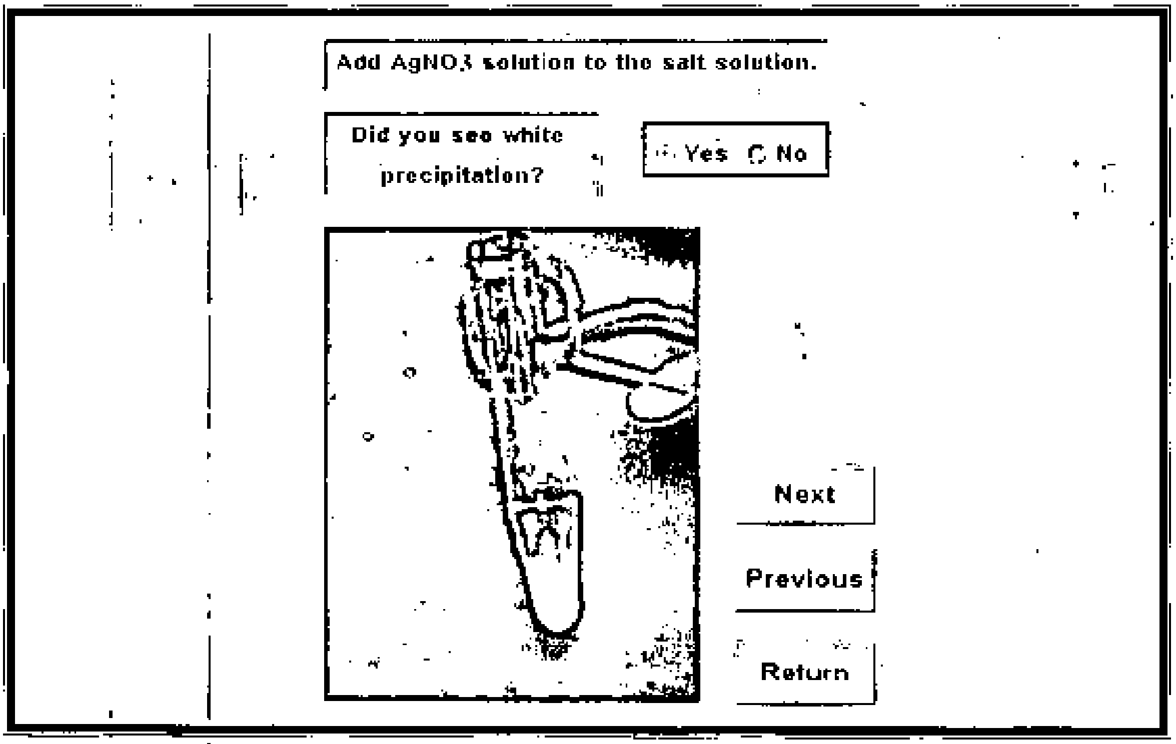


Figure (4.61) show the white precipitate.

If the user selects the confirmatory test number two from the window in figure(4.60), a new window appears asking the user to add ($(CH_3COO)_2Pb$) solution to the salt solution and observe what will happen as indicated in figure(4.62).

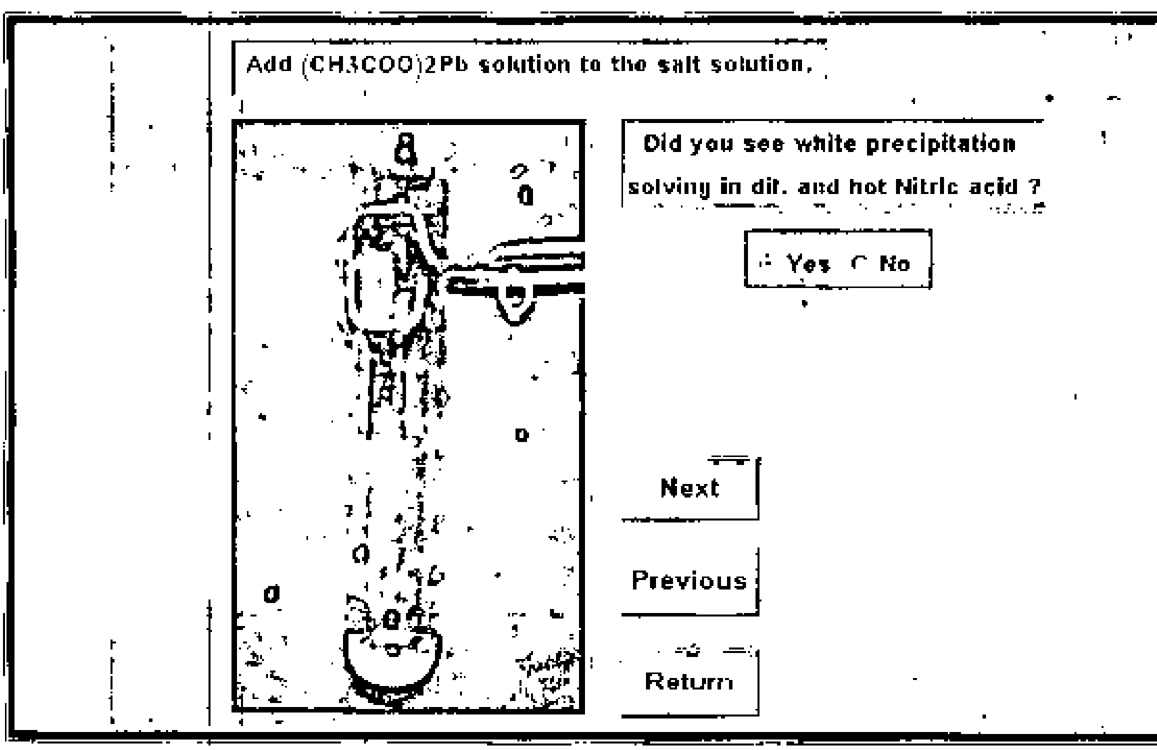


Figure (4.62) show the white precipitate.

If the user selected (Yes) and click (Next) in one of the two windows in figures (4.61).or (4.62). another window appears shows that the salt is Sulphate. It also gives the user the possibility to move to the window of confirmatory tests or return to the beginning of the program as indicated in figure(4.63).

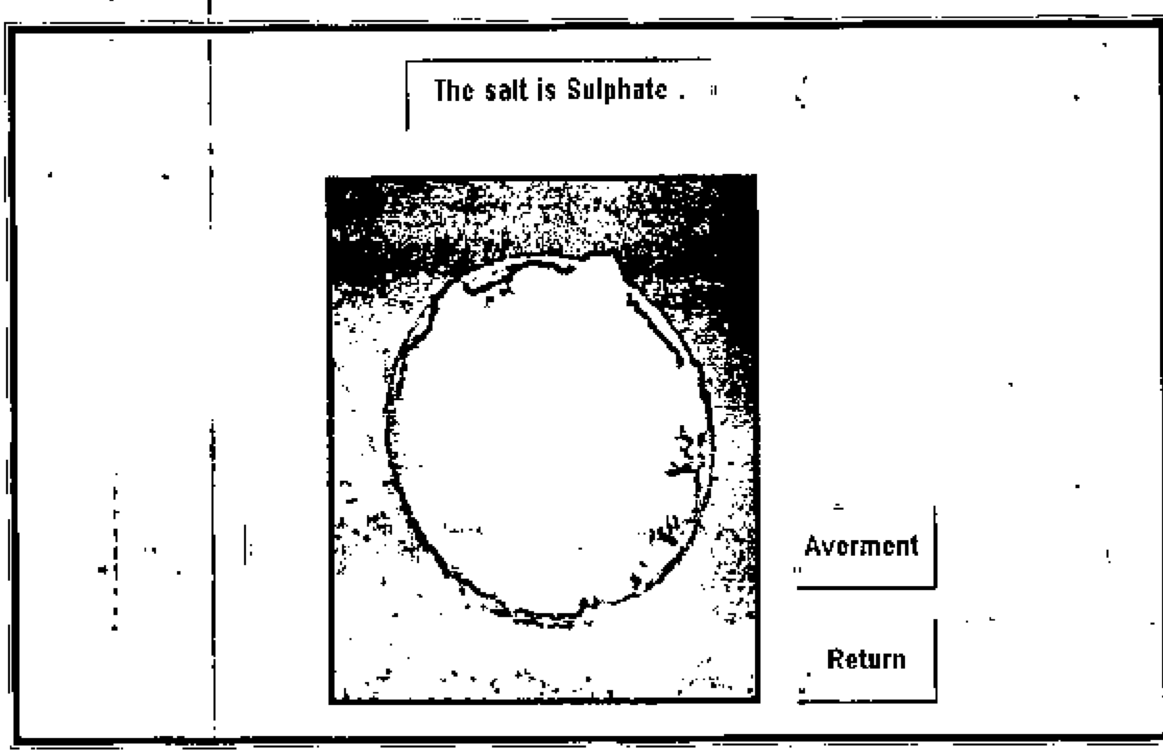


Figure (4.63) aver the salt is Sulphate.

When the user select (No) and click (Next) in the window indicated in figure(4.59), a new window states that the salt is from precipitation group and asks the user If He/She see white precipitation. There is also a Yes or No question as indicated in figure(4.64).

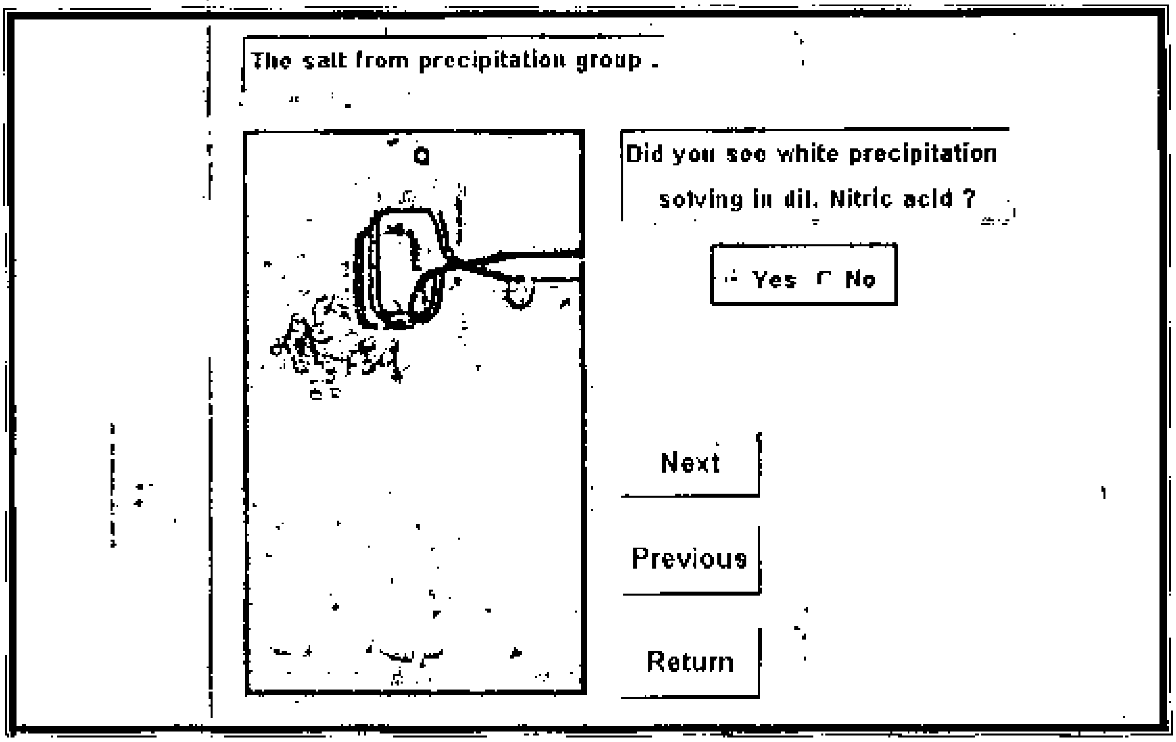


Figure (4.64) show the white precipitate.

If the user selected (Yes) from the window indicated in figure(4.64) and then click (Next), a new window appears indicate that the salt may be Phosphate. There are also two choices to conduct the confirmatory tests as indicated in the window in figure (4.65).

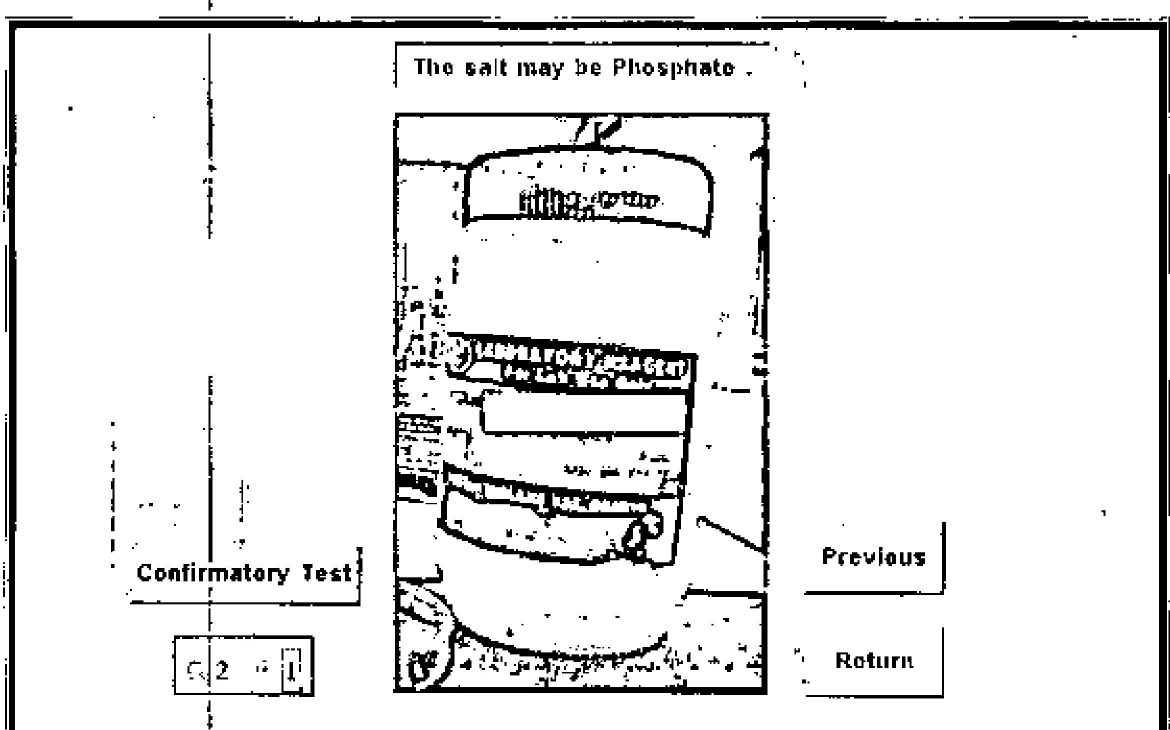


Figure (4.65) show the salt may be Phosphate.

If the user selects the confirmatory test number one from the window in figure(4.65), a new window appears asking the user to add ($AgNO_3$) solution to the salt solution and observe what will happen as indicated in figure(4.66).

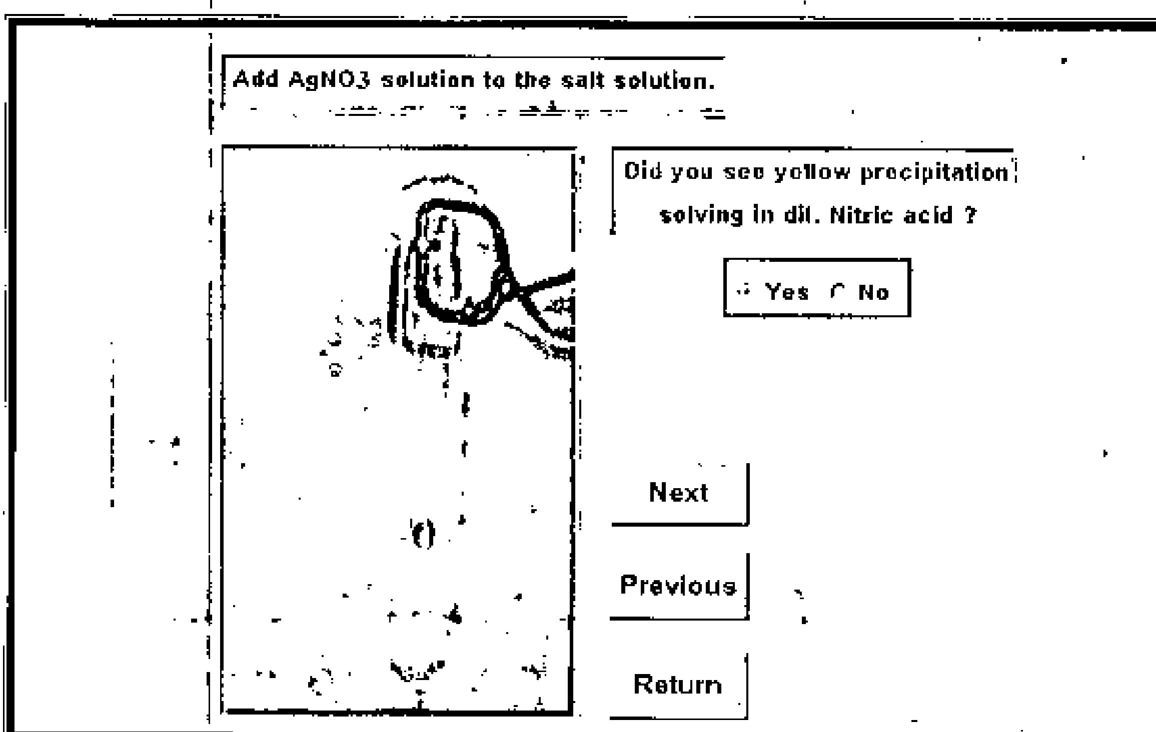


Figure (4.66) show the yellow precipitate.

If the user selects the confirmatory test number two from the window in figure(4.65), a new window appears asking the user to add (AgNO3) solution to the salt solution and observe what will happen as indicated in figure(4.67).

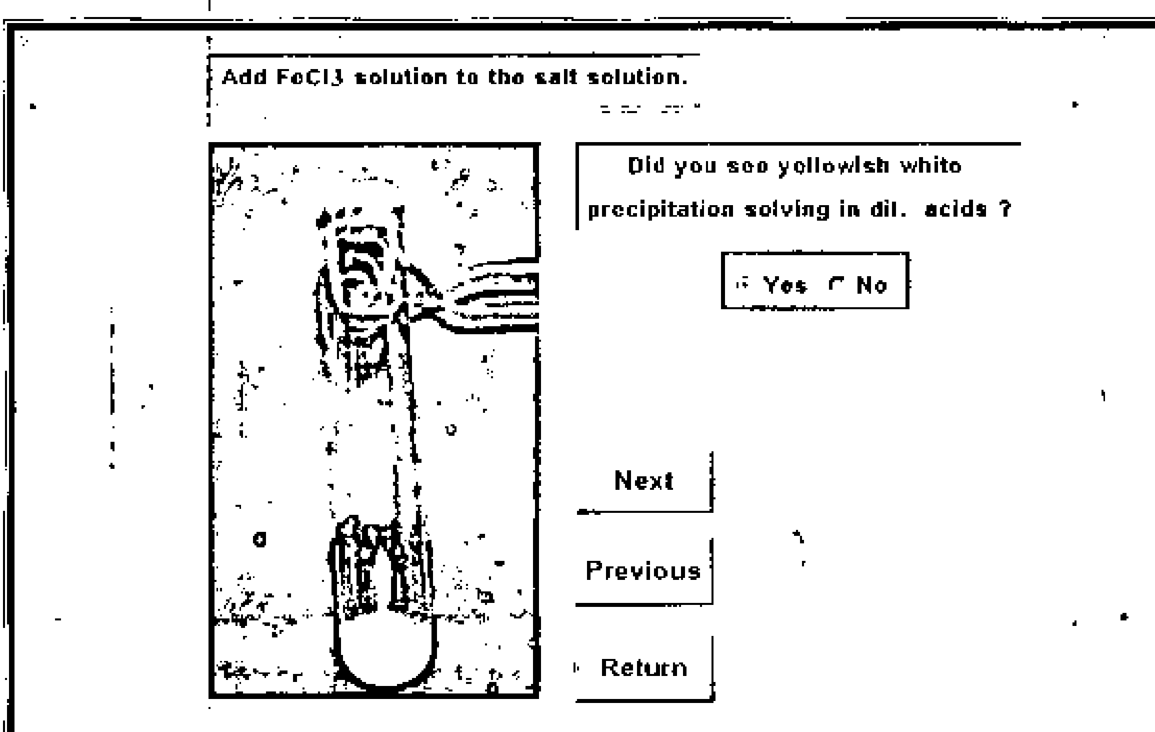


Figure (4.67) show the yellowish white precipitate.

If the user selected (Yes) and click (Next) in one of the two windows in figures (4.66),or (4.67), another window appears shows that the salt is Phosphate. It also gives the user the possibility to move to the window of confirmatory tests or return to the beginning of the program as indicated in figure(4.68).

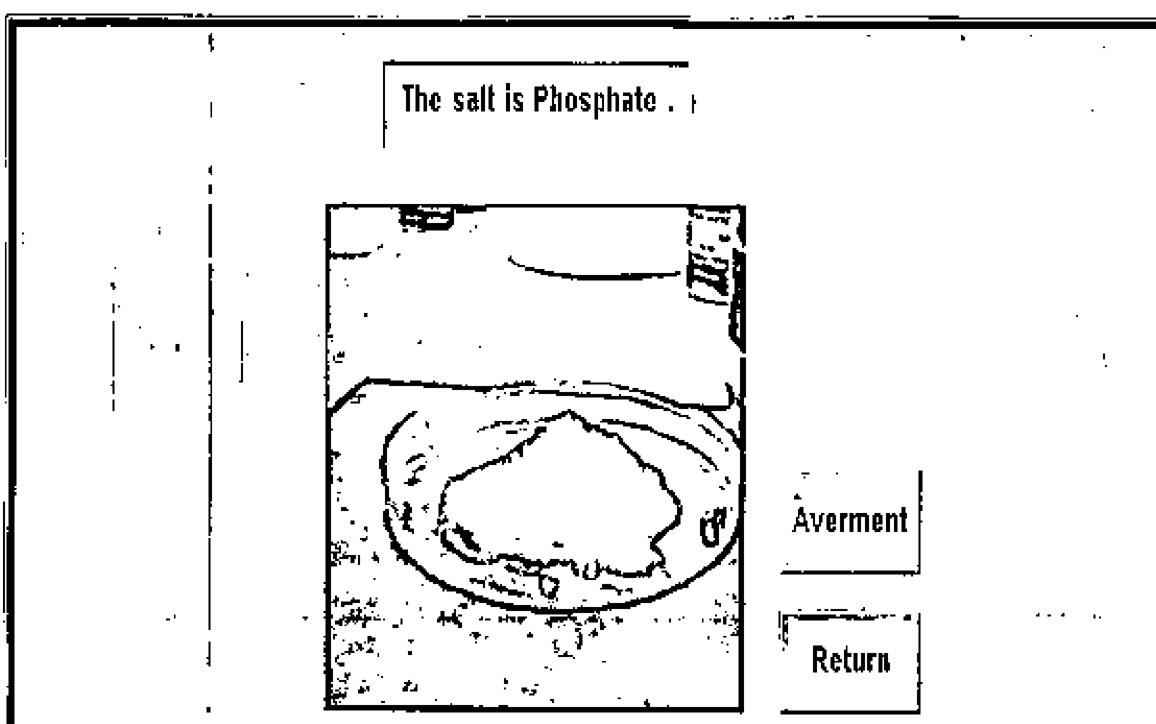


Figure (4.68) aver the salt is Phosphate.

When the user select (No) and click (Next) in the window indicated in figure(4.64), a new window appears indicate that the salt may be Borate. There are also two choices to conduct the confirmatory tests as indicated in the window in figure(4.69).

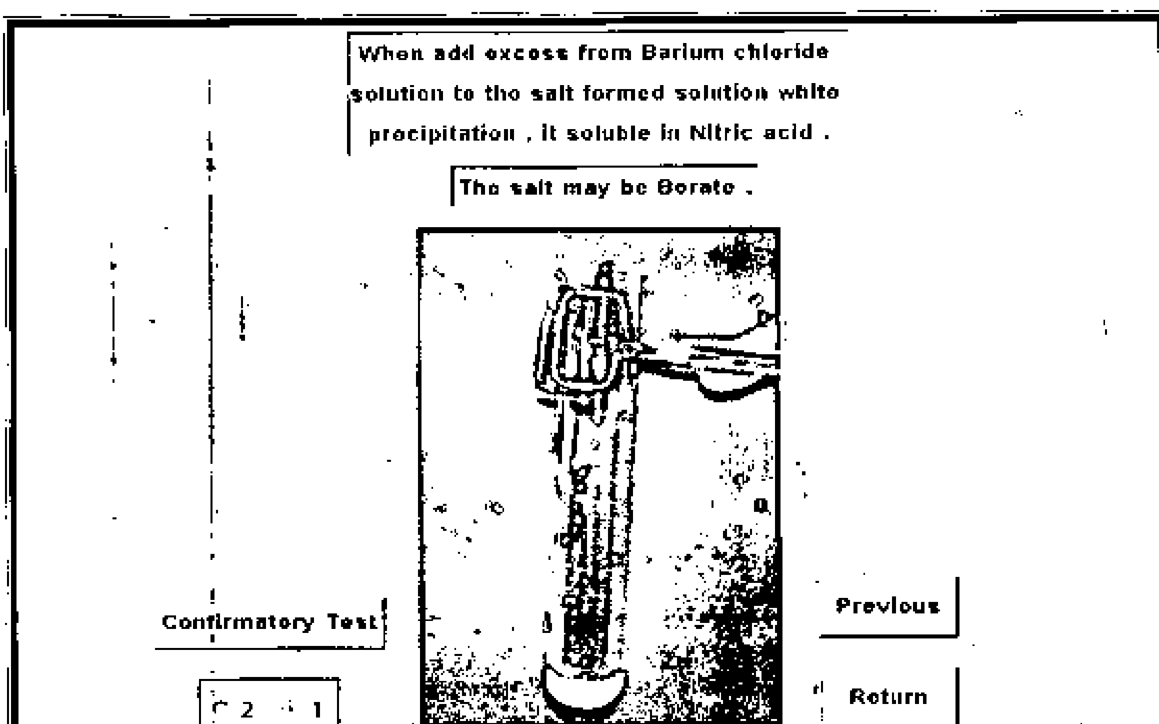


Figure (4.69) show the white precipitate.

If the user selects the confirmatory test number one from the window in figure(4.69), a new window appears to aver that the salt is Borate as indicated in figure(4.70).

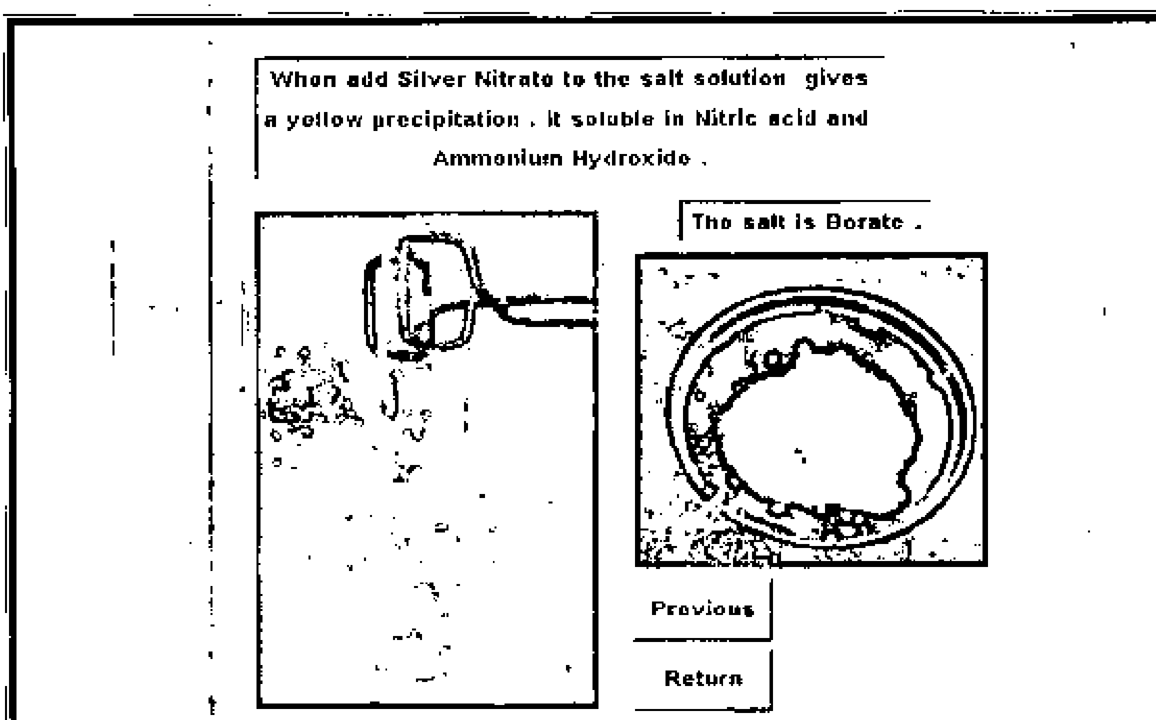


Figure (4.70) show the yellow precipitate and aver the salt is Borate.

If the user selects the confirmatory test number two from the window in figure(4.69), a new window appears to aver that the salt is Borate as indicated in figure(4.71).

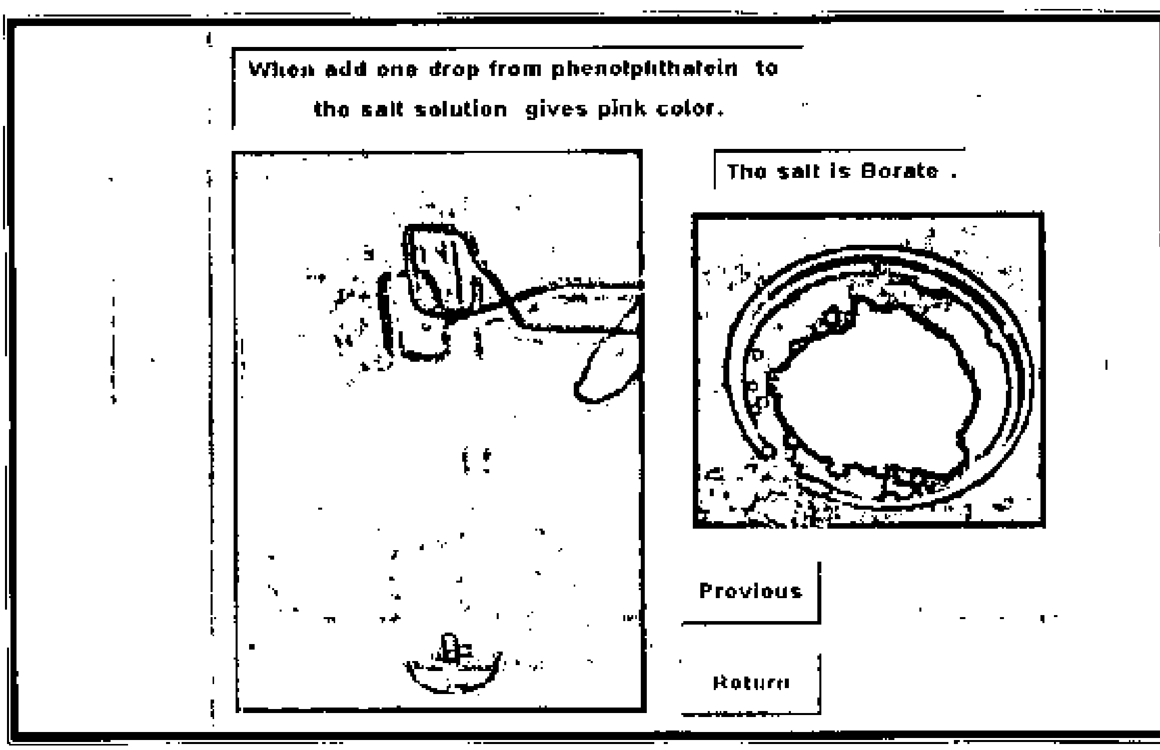


Figure (4.71) show change the color of solution to pink and aver the salt is Borate.

CHAPTER FIVE
CONCLUSIONS

5- Conclusions :

The importance of this system lies in :

1- The treatment of all the needed experiments to discover salts acidic part by the same way conducted by human experts.

2- To make confirmative experiments which are made to assure the results of an experiment.

3- The system will be within the reach of students to apply it on an ordinary computer. They also will be save from the resulted gas and vapor .

Education institutions in which chemistry is teached can save lots of money . I have conducted this study for five years, from 2000 to 2005, in order to know the students' number, the quantity of used materials, and to estimate the expenses as well. I found out that the students' number is about 9998 at Science College of Benghazi, Faculty of Arts and Science of Al-Marj, Faculty of Teachers preparing in Al-Marj , and Al-Marj Medical Institute .

The amount of used materials is 639872 grams, and the price of these materials is about 206,998.59 dollars.

5.1- Students' number in Sciences College of Benghazi :-

N.	Department	-2000 2001	-2001 2002	-2002 2003	-2003 2004	-2004 2005	-2005 2006
1-	Physics	1762	1050	1061	500	584	554
2-	Chemistry						
3-	Biology						
4-	Medicine						
	Totall	5511					

5.2- Students' number in Faculty of Arts & Sciences of Al-Marj :-

N.	Department	-2000 2001	-2001 2002	-2002 2003	-2003 2004	-2004 2005	-2005 2006
1-	Physics	730	652	814	818	398	491
2-	Chemistry						
3-	Biology						
4-	Mathematics						
5-	Statistic						
6-	Medicine						
7-	Engineering						
	Total.	3903					

5.3- Students' number in Faculty of Teachers preparing of Al-Marj :-

N.	Department	-2000 2001	-2001 2002	-2002 2003	-2003 2004	-2004 2005	-2005 2006
1-	Physics	95	104	80	38	--	7
2-	Chemistry						
3-	Biology						
	Total	324					

5.4- Students' number in Al-Marj Medical Institute :-

N.	Department	-2000 2001	-2001 2002	-2002 2003	-2003 2004	-2004 2005	-2005 2006
1	Laboratory	--	--	--	--	--	260
2	Pharmacy						
	Total	260					

5.5- Table to show material cost price in five years :-

(Amount of material used in single experiment is on gram)

N.	Material	Number of confirmative experiment	Number of students	Total of the quantity	Gram price	Cost price
1-	Carbonate	4	9998	39991	0.01$	199.96 $
2-	Bicarbonate	4	9998	39991	0.01$	399.92 $
3-	Nitrite	4	9998	39991	0.12$	4,799.04 $
4-	Sulphide	4	9998	39991	0.03$	1,199.76 $
5-	Sulphite	4	9998	39991	1.20$	47,990.40 $
6-	Thiosulphate	4	9998	39991	0.05$	1.999.60 $
7-	Chloride	4	9998	39991	0.03$	1,119.78 $
8-	Bromide	4	9998	39991	0.02$	719.86 $
9-	Iodide	4	9998	39991	0.10$	3,999.20 $
10-	Nitrates	4	9998	39991	0.12$	4,799.04 $
11-	Sulphate	4	9998	39991	1.20$	47,990.40 $
12-	Borate	4	9998	39991	0.02$	599.88 $
13-	Phosphate	4	9998	39991	0.08$	3,199.36 $
14-	Sulphuric acid	4	9998	39991	0.50$	19,996.00 $
15-	Silver nitrate	4	9998	39991	1.20$	47,990.40 $
16-	Hydrochloric acid	4	9998	39991	0.50$	19,996.00 $
Total			159968	639872	5.18 $	206,998.59$

I selected sample of thirty male and thirty female they studying the course of general chemistry , and I distributed them into two groups. The first group applies the experiments directly in the laboratory while the second group works according to the proposed system; then it applies the experiments in the laboratory. I tried to divide each group as follows :

Level / Sex	Normal	Middle	High
Male	5	5	5
Female	5	5	5

I registered the result as follow :

The first group worked without the proposed system :

N.	Material	Number of confirmative experiment	Number of students	Total of the quantity	Gram price	Cost price
1-	Carbonate	7	30	210	0.01$	$2.10
2-	Bicarbonate	7	30	210	0.01$	$2.10
3-	Nitrite	7	30	210	0.12$	$25.20
4-	Sulphide	7	30	210	0.03$	$6.30
5-	Sulphite	7	30	210	1.20$	$252.00
6-	Thiosulphate	7	30	210	0.05$	$10.50
7-	Chloride	7	30	210	0.03$	$6.30
8-	Bromide	7	30	210	0.02$	$4.20
9-	Iodide	7	30	210	0.10$	$21.00
10-	Nitrates	7	30	210	0.12$	$25.20
11-	Sulphate	7	30	210	1.20$	$252.00
12-	Borate	7	30	210	0.02$	$4.20
13-	Phosphate	7	30	210	0.08$	$16.80
14-	Sulphuric acid	7	30	210	0.50$	$105.00
15-	Silver nitrate	7	30	210	1.20$	$252.00
16-	Hydrochloric acid	7	30	210	0.50$	$105.00
	Total			3360	$5.19	$1,089.90

The second group worked with the proposed system :

N.	Material	Number of confirmative experiment	Number of students	Total of the quantity	Gram price	Cost price
1-	Carbonate	3	30	90	0.01$	$0.90
2-	Bicarbonate	3	30	90	0.01$	$0.90
3-	Nitrite	3	30	90	0.12$	$10.80
4-	Sulphide	3	30	90	0.03$	$2.70
5-	Sulphite	3	30	90	1.20$	$108.0
6-	Thiosulphate	3	30	90	0.05$	$4.50
7-	Chloride	3	30	90	0.03$	$2.70
8-	Bromide	3	30	90	0.02$	$1.80
9-	Iodide	3	30	90	0.10$	$9.0
10-	Nitrates	3	30	90	0.12$	$10.80
11-	Sulphate	3	30	90	1.20$	$108.0
12-	Borate	3	30	90	0.02$	$1.80
13-	Phosphate	3	30	90	0.08$	$7.20
14-	Sulphuric acid	3	30	90	0.50$	$45.0
15-	Silver nitrate	3	30	90	1.20$	$108.0
16-	Hydrochloric acid	3	30	90	0.50$	$45.0
	Total			1440	$5.19	$467.10

From previous study I saw the group who used the propósed system worked easily and quickly, and we can save money as above we saved 622.8$.

5.6- Future Work :

The work in the practical part of chemistry at identification of the salt radicals is divided into two parts .

One is the subject of this research which relates to identification of acid radical as I am discuss in my work at this research.

The other is the identification of base radical, may be considered in future work to complete the process of practical part of chemistry at identification of the salt radicals.

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الملخص

تتــناول هــذه الرسالة استخدام النظم الخبيره في تطبيق التجارب الكيميائية المقــررة علي طلبة السنة الأولى من التعليم الجامعي والمتعلقة بالكشف عن الشق الحامضي للاملاح .

وتجــدر الإشـــارة إلـــي أن مثل هذه التجارب تحتاج إلي عنصر الخبرة لذا كانت الأنظمة الخبيرة والتي تعتبر واحدة من أهم تطبيقات الذكاء الاصطناعي هي البديل العلمـــي والفعـــال في تطبيق مثل هذه التجارب لما تتمتع به من قدرة عالية على إعطـــاء المشورة والتوضيح كما تستطيع أن تعمل أسرع من الخبير البشري . فقد أخــذت فـــي الاعتبار العناصر الاساسية للنظم الخبيرة وقمت بكتابة رسالتي التي تهــدف إلي تصميم نظام خبير للكشف عن الشق الحامضي للاملاح مدعوم بقاعدة معـــرفه تحتوي علي العديد من القواعد التي تصف ما يحدث للاملاح عند إضافة بعــض الكواشـــف لهـــا هـــذا إلي جانب احتواء النظام علي واجهات تسهل علي المستخدم التعامل مع النظام .

وتتكون الرسالة من خمسة فصول وفيما يلي عرض ملخص لها:

الفصل الأول: المقدمة .

يعرض الفصل الأول نظره عامه عن الذكاء الصناعي حيث ناقشة تعريف الـــذكاء الـــصناعي وقمت بتوضيح فروع الذكاء الصناعي وبعض لغات البرمجه المستخدمه في كتابة برامج الذكاء الصناعي. كما قمت بعرض اهداف هذا البحث والاســـهام العلمـــي لـــبحث. وقمت بتوضيح المشكلة الكيميائية التي تناول البحث طرح حل لها وفي نهاية الفصل قمت بعرض باقي محتويات الرسالة .

الفصل الثاني : الدراسات السابقة .

في هذا الفصل قمت بعرض بعض الدراسات المتعلقة بموضوع هذا البحث والتـــي تحـــصلت علـــيها مـــن خلال شبكة المعلومات العالمية و بعض المكتبات الجامعية.

الفصل الثالث : النظم الخبيرة .

قمـت في هذا الفصل باعطاء نبذه تاريخيه عن موضوع البحث وهو النظم الخبيـرة كمـا قمـت بعـرض بعض تعريفات النظم الخبيرة وبعض خصائصه ومكوناتها وهيكلية النظم الخبيرة وكيفية اكتساب المعرفة وتمثيلها في قاعدة معرفة واستنتاج الحلول منها . كما قمت بعرض بعض انواع النظم الخبيرة وفريق العمل الذي يعمل علي تطوير النظم الخبيرة وقمت أيضاً بشرح كيفية بناء النظم الخبيرة وفـوائد اسـتخدامها كمـا قمت بعرض مجالات تطبيق النظم الخبيرة حيث قمت باعطاء مثل علي كل مجال من هذه المجالات .

الفصل الرابع : حالة الدراسة .

تـناولت في هذا الفصل شرح وتحليل خطوات تصميم وتنفيذ النظام الخبير المـتعلق بمـشكلة البحث كما قمت بتوضيح المنهجية التي اتبعتها في تصميم هذا الـنظام ثـم قمـت بعـرض مكونات النظام الرئسية مثل قاعدة المعرفه ومحرك الاستدلال والواجهات الناتجة عن تنفيذ النظام .

الفصل الخامس : الاستنتاجات .

فـي هـذا الفصل قمت بعرض اهمية تطبيق النظم الخبيرة في معامل علم الكيمـياء كما قمت بعرض احصائيات لأعداد الطلبة في بعض الكليات التي تدرس مادة الكيمياء العامة وكمية المواد التي تم صرفها خلال خمس سنوات وتكلفت هذه المواد. وأخيراً قمت بإعطاء بعض المقترحات للبحث المستقبلي.

الجماهيرية العربية الليبية
الشعبية الاشتراكية العظمى

شعبية سرت

جامعة التحدي

كليـــة العلــــوم

قســـم الحاســـوب

عنـــوان البحـــث

((نظـــام خبيـــر للكشـــف عـــن الشـــق الحامضـــي للأمـــلاح))

مقدمـــة مـــن الطـــالب

إدريـــس إبراهيـــم محمـــد الذرعانـــي

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جامعة التحدي

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رسالة ماجستير بعنوان :

نظام خبير للكشف عن الشق الحامضي للأملاح

هذه الرسالة جزء من متطلبات نيل درجة الماجستير

في علم الحاسب الآلي

مقدمه من الطالب :

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تحت إشراف الدكتور :

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