

Full Length Research Paper

# Effects of project, inquiry and lecture-demonstration teaching methods on senior secondary students' achievement in separation of mixtures practical test

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This study assessed and compared the relative effectiveness of three methods for teaching and conducting experiments in separation of mixtures in chemistry. A pre-test, post-test experimental design with a control group was used. Two hundred and thirty three randomly selected Senior Secondary School I (SSS I) chemistry students were drawn from four Local Governments Areas of Osun State, Nigeria. The research instruments developed were a twenty-five item supply/select response questions used for the pre-test and post-test tagged Chemistry Achievement Test (CAT). Students were divided into three experimental and one control groups. Students in the three experimental groups were subjected to treatment using project, inquiry or lecture-demonstration method respectively while students in the control group were taught using the traditional method of teaching. The pre-test was administered to students in all the four groups before teaching commenced and after the teaching and the experiment, a post-test was then administered. The data was analyzed using t-test analysis, one way Analysis of Variance (ANOVA) and Scheffe post-hoc analysis. The results of ANOVA of the difference in the scores of the post-test of the project, inquiry, lecture-demonstration methods and control group showed a significant difference between the groups ( $F_c = 327.258 > F_t = 2.60$  at  $p < 0.05$ ,  $df = (3,229)$ ). Students taught with project method performed better in the Chemistry Achievement Test (CAT) than the students taught with lecture-demonstration method ( $t_c = 5.60 > t_t = 1.64$  at  $p < 0.05$ ,  $df = 127$ ), while those students taught with the lecture-demonstration method performed better than those taught with inquiry method ( $t_c = 6.39 > t_t = 1.64$  at  $p < 0.05$ ,  $df = 122$ ). Students taught with project method performed better than students taught with inquiry method ( $t_c = 9.22 > t_t = 1.64$  at  $p < 0.05$ ,  $df = 133$ ). The study concluded that the project method enhanced better performance in Chemistry practical better than either inquiry or lecture-demonstration method.

**Key words:** Lecture-demonstration, inquiry, project, chemistry practical, chemistry, chemistry achievement test, separation of mixtures.

## INTRODUCTION

One of the objectives of science education is to develop students' interest in science and technology, as today's society depends largely on development in science and technology. Teachers are expected to devise ways of making their students to develop positive attitudes towards science and science-related disciplines.

Chemistry, in particular, is central to many of the scientific fields of human endeavors; therefore, the teaching of chemistry should be given serious attention. Science teachers have always recognized the importance of practical work as a means of introducing learners to the scientific process of experimentation. To this end, the United Nations Educational Scientific and Cultural Organization (UNESCO) and the International Union of Pure and Applied Chemistry (IUPAC) have participated in numerous international meetings to promote inexpensive experimental-based teaching in Chemistry. Effective teaching of practical

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chemistry, which laid emphasis on bench-work, in Nigerian secondary schools, is of outmost importance to teachers, parents and the government (N.P.E., 1998). Chemistry teaching should develop in the students manipulative and experimental skills to make him or her competent and confident in conducting experiments and/or researches. Students should do practical work of conducting experiments, reporting their observations and making inferences or conclusions, thus, developing their scientific knowledge and experimental skills and at the same time arousing and maintaining interest of the students in the subject.

The poor performance of students in science subjects has assumed a dangerous dimension. In the light of this, science educators need to seek suitable ways of tackling the current mass failure if they are to halt the drifts of students to arts and social science subjects (WAEC Reports, 1999). The relevance and importance of chemistry amongst the science subjects is formidable, hence the need for proper teaching of the subject in the secondary schools so that students' scores in internal and external examinations will be high, thereby making the candidates' entrance into higher schools easier. According to Onwu (1981) teachers of chemistry are expected to make chemistry more relevant, enjoyable, easy and meaningful to students. Teaching methods need to be improved and appropriate teaching strategies employed as the teaching-learning situation may demand. Teaching methods such as inquiry, project, lecture-demonstration, lecture-performance, problem-solving, field trips, cooperative or group learning, excursion, remedial, laboratory and guided discussion and the use of audio-visual materials have been recommended for the teaching of science in schools (McDonald and Nelson, 1954; Webb, 1982; Rogus, 1985; Adedoyin, 1990; Ajewole, 1991, Newcomb et al., 1993; Ohio 4-H Program, 1994). There is however the need to understand that for different topics in science, the teaching approaches may differ depending on the complexity and structure of the topics. Teachers should be concerned with the use of variety of methods and procedures. The most enjoyable aspect of teaching and learning can occur when a variety of teaching methods are used.

In classroom around the world, teachers lecture, students take notes, and then students are tested on what they have learned. Today, experiential or "hands-on" learning is fast replacing or supplementing the traditional "chalk-talks". Through experiments, simulations, debate, and other participatory activities, students discover concepts on their own. Experiential learning increases retention, motivates students to learn and encourages group cooperation.

The Project method of teaching involves assigning a particular work to student or group of students to work on and complete at his/her/their spare time and report back to the teacher as when demanded. The project method provides an excellent opportunity for the complete act of

thinking by the students. Rogus (1985) saw it as a means of teaching the students self-discipline. In project method students have occasion to define the problem, plan his work, find appropriate resources, carry out his plan and draw conclusion. Inquiry is a style or method of teaching where the learner with minimum guidance from the teacher seeks to discover and create answers to a recognized problem through procedure of making a diligent search (Callahan and Clark, 1977; Adedoyin, 1990). Inquiry is a term used in science teaching that refers to a way of questioning, seeking knowledge or information, or finding out about phenomena. It involves investigation, searching, defining a problem, formulating hypothesis, gathering and interpreting data and arriving at a conclusion. In inquiry situation, students learn not only concepts and principles but self-direction, responsibility and social communication. It also permits students to assimilate and accommodate information. Inquiry is the way people learn when they're left alone. The lecture method is used primarily to introduce students to a new subject, but it is also a valuable method for summarizing ideas, showing relationships between theory and practice, and re-emphasizing main points. A lecture-demonstration method is a teaching technique that combines oral explanation with "doing" to communicate processes, concepts, and facts. It is particularly effective in teaching a skill that can be observed. A skilled educator may wish to both tell and show what steps to take in an educational process. A demonstration is usually accompanied by a thorough explanation, which is essentially a lecture. On the other hand, the demonstration-performance method of teaching is based on the simple but sound principle that we learn by "doing". Students learn physical or mental skills by actually performing those skills under supervision. In contrast to the lecture method, where the instructor provides information, the guided discussion method relies on the students to provide ideas, experiences, opinions, and information. Through the skillful use of "lead-off" type questions, the instructor "draws out" what the student knows, rather than spending the class period telling them. The cooperative or group learning method is an instructional strategy which organizes students into small groups so that they can work together to maximize their own and each other's learning (4-H Program, 1994).

The main purpose of this study is to assess the effectiveness of using project, inquiry and lecture-demonstration methods of teaching experimental aspects of chemistry in the senior secondary schools using separation of mixtures as a model.

### **Research hypotheses**

The following research hypotheses were generated for the study:

- 1) There is no significant difference in the performance of students taught separation of mixtures using lecture-

**Table 1.** Research design layout.

Schools	Treatment type	Number of Student
School of Science, Oluorogbo, Ile-Ife, Ife Central	LDM	59
School of Science, Ipetumodu, Ipetu, Ife North	PRM	70
School of Science, Ondo-Road, Ile- Ife, Ife East	IQM	65
Origbo Grammar School, Ipetumodu, Ife North	CG	39
Total		233

LDM: Lecture-Demonstration method, PRM: Project method, IQM: Inquiry method, CG: Control Group.

demonstration method (LDM) and those students taught separation of mixtures using project method (PRM).

2) There is no significant difference in the performance of students taught separation of mixtures using Inquiry method (IQM) and those students taught separation of mixtures using LDM.

3) There is no significant difference in the performance of students taught separation of mixtures using PRM and those students taught separation of mixtures using IQM.

4) There is no significant difference in the performance of students taught separation of mixtures using LDM, IQM, PRM and students in the control group (CG).

## METHODOLOGY

### Design and instrument

The design for the study is quasi-experimental pre-test post-test control group. The four groups, experimental and control groups were randomly assigned to the methods of teaching. The four groups were project, inquiry, lecture- demonstration and the control groups. The instruments used for the study were: Notes on separation of mixtures, reagents, apparatus and materials for the practical exercise and a twenty-five item supply response questions used for the pretest, post-test tagged Chemistry Achievement Test (CAT).

### Validation of research instruments

The research instruments used for the pretest, post-test was tagged Chemistry Achievement Test (CAT) 1 and 2. The test was validated by deriving the CAT from the National School Chemistry Curriculum given for secondary schools in combination with the West African Examination Council (WAEC) Syllabus and with the aid of chemistry past questions of West African Examination Council. The test was also given to two experienced senior secondary school teachers for vetting; this led to the modification and rejection of some items. The test items were derived from standardized tests and it was administered to twenty- four non-participating students but of the same cultural background offering chemistry as a subject, this was done to determine the difficulty level of the questions.

### Sampling method and sample

A total of two hundred and thirty three senior secondary school one (SSS I) science students constituted the subjects for the study. The schools were randomly assigned to four groups; the assignment of the schools to the groups is presented in Table 1.

### Data collection and analyses

The research involved two main stages, which were the administration of pre- test and post-test that contained the same questions arranged in different order. The study was conducted for a period of six weeks during which the topic, separation of mixtures, was covered. The pre-test was administered in the first week of the research exercise to the whole students before the experimental groups were subjected to treatments. All the practical sessions were held in the school laboratory with the materials provided by the school.

After the administration of the pre-test, students in Groups 1 (Project) were given the topic, separation of mixtures, by the researcher and were asked to find out various methods of separation; definition, importance, reagents and apparatus required for the experiments and how the practical is performed. In the second week, students in this group were divided into eight subgroups and assigned eight project topics on separation of mixtures. They were expected to work on two subtopics each week for four weeks: sieving and magnetic separation, sublimation and decantation, filtration and evaporation to dryness, and separating funnel method and paper chromatography method. When the project topics were completed, the researcher provided the students the opportunity to do oral presentation to compare notes as well as learn from each other. Student in this group learned cooperatively while the researcher moderated the activity of the group.

The second group (Group 2) was exposed to inquiry method during the second week of the research exercise. Students in this group were given one week to read about the topic and make the list of materials and apparatus required for the experiment. The group was also divided into eight subgroups and assigned two subtopics per week. The researcher taught the theory and the students carry out the practical exercise with the assistance and guidance from the researcher. Two practical exercises were carried out in a week. Questions were entertained during the practical sessions from the students.

The third group was students taught with the lecture-demonstration method. The students in this group were not given the topic ahead of the class and were not divided into subgroups. The researcher taught and demonstrated the practical aspect while the students watched while a few students were allowed to demonstrate a repeat of the experiment.

The fourth group comprised of students in the control group. They were taught both the theory and practical using traditional method of teaching.

The teaching process lasted for 4 weeks and a post -test was administered to all the students. The data collected were analyzed using t-test analysis to test the significance difference between two methods of teaching and One-way Analysis of Variance (ANOVA) to compare the means of the scores of the students and also Scheffe post-hoc analysis to identify the most effective method. The performances of the students in the two groups on Chemistry Achievement test (CAT 1) called pre-test were compared. This was

**Table 2.** Analysis of variance scores of the four groups on the pre-test scores.

Source of variation	Sum of squares	Degree of freedom (df)	Mean square	F <sub>c</sub>
Between groups	205.062	3	68.354	
Within groups	7242.412	219	33.07	2.07

$p > 0.05$ ,  $F_t = 2.62$

**Table 3.** T-test analysis of the performance of students in LDM and PRM groups.

Group	N	$\bar{X}$	S.D	df	t <sub>c</sub>
LDM	59	56.36	3.93		
PRM	70	62.91	3.60	127	5.60

$p < 0.05$ .

**Table 4.** T-test analysis of the performance of students in LDM and IQM groups.

Group	N	X	S.D	df	t <sub>c</sub>
LDM	59	56.36	3.93		
IQM	65	52.70	3.60	122	6.39

$p > 0.05$

**Table 5.** T-test analysis of the performance of students in PRM and IQM groups.

Group	N	$\bar{X}$	S.D	df	t <sub>c</sub>
PRM	70	62.91	8.24		
IQM	65	52.69	3.60	133	9.22

also done for CAT 2, that is, the post-test. The analyses of the results were carried out at  $p = 0.05$  level of significance.

## RESULT

The result in Table 2 shows that there was no significant difference in the mean scores of the four groups in the chemistry achievement test on the pre-test. This is an indication that the performance of the subjects used for the study in the four groups was not significantly different.

### Research question one

There is no significant difference between the performance of students taught separation of mixtures using LDM and those taught with PRM.

The scores obtained in the post-test were subjected to t-test analysis and the result is presented in Table 3. From Table 4,  $t_c = 5.60$  while  $t_t = 1.64$ , at  $p < 0.05$ ,  $df = 127$  that is,  $t_c = 5.60 > t_t = 1.64$  which implies that subjecting the students at certain relevant experiences enhance better performance.

### Research question two

There is no significant difference in the performance of students taught with LDM and those taught with IQM.

To test this hypothesis, it was also subjected to t-test analysis (Table 4).

From the table  $t_c = 6.39$  while  $t_t = 1.64$  at  $p > 0.05$ ,  $df = 122$  i.e  $t_c > t_t$  which implies that a significant difference exists which is in favour of the LDM.

### Research question three

There is no significant difference performance of students taught with PRM and those taught with IQM. This hypothesis was tested using t-test analysis (Table 5).

From the Table 6  $t_c = 9.22$  while  $t_t = 1.64$  at  $p < 0.05$ ,  $df = 133$  that is,  $t_c > t_t$ .

### Research question four

There is no significant difference in the performance of students in the three experimental groups, that is (LDM, IQM, PRM) and those in the control group.

**Table 6.** Analysis of variance of the difference in the scores of the post-test of students in LDM, IQM, PRM groups and control group.

Source of variation	Sum of squares	Degree of freedom	Mean square	F <sub>c</sub>
Between groups	4215.211	3	14051.737	
Within groups	9832.755	229	42.938	327.258

$p < 0.05$

**Table 7.** Scheffe values for means of post-test scores of LDM, IQM and PRM groups

Research groups		Means difference	Standard error	Sig	95% confidence level	
LDM	PRM	-6.3458	1.0402	.000	-8.9121	-3.7794
	IQM	-4.3004	1.0584	.000	1.6893	6.9115
PRM	LDM	6.3458	1.0402	.000	3.7794	8.9121
	IQM	106462	1.0138	.000	8.1449	13.1474
IQM	LDM	-4.3004	1.0584	.000	-6.9115	-1.6893
	PRM	-10.6462	1.0138	.000	-3.1474	-8.1449

The mean difference is significant at 0.05.

To test this hypothesis, Analysis of Variance (ANOVA) test was carried out on Chemistry Achievement Test results. The result is presented in Table 6.

Results from Table 7 shows that  $F_c = 327.258$  while  $F_t = 2.60$  at  $p < 0.05$ ,  $df = (3, 229)$  that is,  $F_c > F_t$  which shows that there is a significant difference in the performance of students in the four groups.

Also, Scheffe test for data snooping was performed on the group means to detect the significant comparisons among the three means. The result is presented in Table 7.

## DISCUSSION

The analyses and results of this study showed that the project method brings about a significant difference in the achievement of the experiments of subjects in the experimental groups when compared with those exposed to inquiry and lecture- demonstration method of teaching separation of mixtures as a model of experimental aspect of chemistry. This might be due to the interactiveness and friendliness that the project method provides for the students. Students in the project group were better motivated to learn; this might be as a result of the discipline of having to and respect the opinion of others during discussion having discovered that knowledge does not belong to only a person. Webb (1982) had opined that the more interactions there among students the better their performance. The project-based learning encourages collaboration in some form, either through small groups, student-led presentations, or whole-class evaluations of project results (BIE, 2002). Project method of learning shares some overlapping characteristics with inquiry-based or experiential learning and appears to be an equivalent or slightly better model for producing gains

in academic achievement, although results vary with the quality of the project and the level of student engagement (Dohn and Wagne, 1999; BIE, 2002). However, it is not appropriate as a method for teaching certain basic skills such as reading or computation but it does provide an environment for the application of those skills. The Buck Institute review also states that project based learning enhances the quality of learning and leads to higher-level cognitive development through students' engagement with complex and novel problems, teaches students complex processes and procedures such as planning and communicating and supports authentic inquiry and autonomous learning for students. However, it is rigorous and requires time for both the teachers and students. Although, the idea of using project method in the classroom is not new, it is seldom use in Nigerian schools, there is a need to resuscitate it because of its numerous academic, social and emotional merits. We believe that if well organized and developed it could benefit both the students and the teachers alike. At its best, project method can help a teacher to create a high-performing classroom in which he and his students form a powerful learning community focused on achievement, self-mastery, and contribution to the community. It allows the teacher to focus on central ideas and salient issues in the curriculum, create engaging and challenging activities in the classroom, and support self -directed learning among the students (BIE, 2002). One criticism of the project method is that students by themselves were incapable of planning projects and activities - they needed the aid of a teacher who would ensure the continuous process of learning and growth (Dewey, 1938).

Furthermore, the LDM and IQM also yielded a significant difference when compared with the control group. The lecture method is the most widely used form of pre-

sentation and may be combined with other teaching methods to give added meaning and direction. For example, a demonstration is usually accompanied by a thorough explanation, which is essentially a lecture. The students in this study are conversant with LDM as their teachers often used it because of its adaptability to many different settings, including either small or large groups, which obtained in our school system here, and to practical demonstration which the teachers are used to due to insufficient materials in our laboratories. A major criticism of this method is its being teacher-centred allowing little or no participation from the students and without feedbacks. In the inquiry model, the science teacher will create a situation in the classroom in which students are asked to formulate their own ideas, state their opinion on an important issue, or to find things out for themselves. One proposed list of inquiry process in science education include: observing, measuring, predicting, inferring, using numbers, using space-time relationships, defining operationally, formulating hypotheses, interpreting data, controlling variables, experimenting and communicating. In teaching in school situations, very little actual time is spent by students doing inquiry activities and the predominant method of teaching in science is recitation, not inquiry. Holdzkom and Lutz (1985) reported that when inquiry models of teaching were implemented, they were very effective in enhancing student performance, attitudes and skill development. They reported that student achievement scores, attitudes, and process and analytic skills were either raised or greatly enhanced by participating in inquiry programs. While the inclusion of inquiry models of teaching in secondary science classrooms is desirable, the reluctance on the part of the science teachers to implement inquiry in the classroom are due to their lack of skills and strategies, lack of equipment and materials, and the claim that inquiry was only effective with bright students, and it caused too many problems with lower ability students. The ineffectiveness of the inquiry method in this study was due to lack of equipment and materials in the schools' laboratories, insufficient books in the library, low student response because they have not been exposed to this model of teaching and learning earlier and although, the teachers have the necessary skills, they have not been practicing the method all along. We also found that the level of response is very high with brilliant students while other just played along. In spite of these problems the evidence is that inquiry models of teaching are viable approaches to teaching, and should be part of the science teacher's repertoire as a fundamental part of science teaching.

Moreover, central to this study is the use of the laboratory. The laboratory in the science classroom has long been used to involve students in concrete experiences with objects and concepts, and in providing students with opportunities to engage in the process of investigation and inquiry (Tamir, 1976; Hofstein and Lunetta, 1982). They emphasized that laboratory activities when perfor-

med individually or in small groups is beneficial than large-group demonstrations, science museum visits or diffused field trips, discussions and audio-visual aided study (e.g. viewing filmed experiments). Abdullahi (1982) also stressed that laboratory was an integral part of science teaching. He pointed out that studies on methodology of science teaching had shown that students learned more when they are given opportunity to learn through "doing" than when they are allowed to observe.

## Conclusion

The main concern of chemistry teachers is the search for efficient and enjoyable ways of communicating chemistry concepts to students. The project method in this work produce significantly better performance in the Chemistry Achievement Test than the LDM and IQM, thus PRM is an effective mode of instruction for students in the secondary schools. However, a teaching method is seldom used by itself. In a typical lesson, an effective instructor normally uses more than one method.

The findings of this study has revealed that LDM, IQM and PRM can be used for teaching and learning processes depending on the topic but PRM is most effective because it affords the students the opportunity to study on their own. Thus while satisfying the attempt to improving the utilization of the regular school hours of the students; the provision of the sort of learning by "doing" is a technology that could be adequately employed in our classrooms. This study concludes that the use of project method of teaching should be embraced by all teachers. Corroboratively, Onwu (1980) was of the opinion that fundamental deficiency of the school system was its failure to motivate the youth of the country to want to learn, and chemistry should be made interesting to students, and one of the ways to motivate the learners better to want to learn is through the use of project method.

## Recommendation

In view of the results of these findings and conclusions reached in this study, the following recommendations are hereby offered:

- 1). Teachers occasionally should give students topics to go and make inquiry about it, so that before the teacher teaches a new concept, students will be able to explain in their own terms what they know about the new concepts. That is, student's explanation will be regarded as hypothesis to be discussed and tested, if the teacher can create an atmosphere in the classroom of a kind in which the students can express themselves without bordering about making mistakes, their hypotheses can be used to illustrate their concepts.
- 2). Governments should be implored to give enough grants to equip laboratories with chemicals and apparatus, and also to provide useful materials and appropriate teach-

hing aids. For example in the case of inquiry, this can not be effectively carried out in schools where the libraries are not well stocked and also where there are no personal computers. Teachers' conditions of service should also be improved for maximum efficiency.

3). Government should introduce the concept of professionalism to give room for proper and relevant retraining to science teachers. Chemistry teachers should be given on-the-job training opportunities such as short-term courses, seminars, and workshop to enable the teachers to update their knowledge; this will help them to constantly keep abreast with the ever-changing scientific knowledge and various modern methods of teaching science.

4). Students in the senior secondary school should be given a project topic to work in the form of term paper which should be guided by teachers and submitted at the end of the last term in the final year.

## APPENDIX

### Chemistry Achievement Test

Below are questions on separation of mixtures: Fill the data (Name, Class, Age etc) and answer the questions that follow.

#### PART A: Personal Data

Name of School \_\_\_\_\_  
Name of students \_\_\_\_\_  
Age: ----- Class-----  
Sex-----

#### PART B: Answer all the questions in this section

(1) A mixture is -----

A. a substance that contains two or more elements or compounds each of which retain its characteristics properties (chemical identities) and can be separated by physical process.

B. naturally bonded together

C. one that occurs in the periodic table

D. a substance that contains two or more elements and can be separated by chemical technique.

2. Which of the following is not a separating technique?

A radiation

B decantation C

distillation

D chromatography

3. A mixture of water and mud can be separated by:

A chromatography

B filtration

C hand picking D

distillation

4. The different method colours of the green substance in leaves can be separated by:

A filtration

B fractional distillation

C ascending paper chromatography D

gas chromatography

5. The mixture of sulphur and iron fillings can be separated by:

A decantation B

distillation C

evaporation

D magnetization.

6. Fractional distillation is used to separate

A an insoluble substance from a soluble volatile substance

B liquids with different boiling points

C substances which are adsorbed differently and different in their solubility are in a solvent.

D gas, liquid, or solid impurities from a mixture.

7. A mixture of oil and water can be separated by:

A Sublimation

B evaporation to dryness

C using a separating funnels

D fractional crystallization.

8. The following are examples of mixtures except:

A suspension

B solution

C air

D oxygen.

9. Sieving is one of the separating technique in:

A mining industry

B petroleum industry C

sugar industry

D salt industry

10. ----- method is used in salt making industries,

A decantation

B evaporation

C chromatography

D magnetization.

11. Distillation method is used in making -----

A salt

B sugar

C gin and distilled water

D substances.

12. ----- is used in sugar and drug manufacture

A suspension

- B magnetization.
- C crystallization.
- D evaporation

13. An example of substance that undergo sublimation is -----

- A Iodine
- B water
- C NaCl
- D NH<sub>3</sub>

14 A mixture of iron dust and zinc dust can be separated by:

- A Sieving
- B magnetization.
- C filtration
- D sublimation.

15. In a mixture of petrol and water, two separate layers are formed because-----

- A water is less dense than petrol
- B of the presence of hydrogen bond
- C petrol is less dense than water
- D petrol and water were not mixed thoroughly.

16. When Yellow and Blue are mixed, the colour obtained is

- A red
- B green
- C purple
- D yellow

17. Chromatography is used in separating one of the following types of mixtures

- A miscible
- B insoluble
- C suspension
- D chemicals

18. Which of the following items listed below is NOT needed in paper Chromatography?

- A container
- B solvent
- C water
- D paper

19 In paper Chromatography, the spot of mixture is made on the paper which is then placed in a -----

- A solvent B
- solution C
- solute D
- salt

20. Fractional distillation is used for separating mixtures of substance with different -----

- A densities
- B boiling points

- C specific gravities
- D temperatures.

21. In paper Chromatography, the strip of the paper must not touch the liquid in the container so as to -----

- A make the paper become wet B
- dissolves the mixture
- C protect the paper
- D provides support for the container.

22. Crystallization apart from being used for separating mixtures can also used one of the following

- A Purification B
- reduction C
- dissolution D
- oxidation

23. The principles of paper Chromatography is based mainly on different rates of movement o substance over A wet surface

- B an adsorbent surface C
- a smooth surface
- D a hard surface.

24 In Chromatography the substances are -----

- A destroyed
- B made
- C not changed chemically
- D separated chemically.

25 Which of the following is NOT a reason for the wide use of Chromatography in industry?

- A it is the easiest method of separation of mixtures
- B it needs a very small quantity of the given mixture
- C its paper can be stored and used for the future
- D it can be used for separation of any type of mixture.

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