



Is Test Item Arrangement a Factor in the Academic Achievement of Undergraduate Pharmacy Students in Chemistry?

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Authors' contributions

This work was carried out in collaboration among all authors. Authors BCEO, JJA and IHNN contributed to conception, design, acquisition, analysis or interpretation; drafted the manuscript; critically revised the manuscript; gave final approval and agreed to be accountable for all aspects of work ensuring integrity and accuracy. Authors PODU, OJA, FCU, CIO, BAU and JNE contributed to conception, design, acquisition, analysis or interpretation; critically revised the manuscript; and gave final approval. All authors read and approved the final manuscript.

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ABSTRACT

Aims: To determine the effect of test item arrangements in ascending, descending and no consistent order of difficulty in multiple choice tests on undergraduate pharmacy students' academic achievement in a chemistry course. The present study served as an attempt to relate the effect of test item arrangement on undergraduate pharmacy students' academic achievement in a chemistry course in Nigerian Universities.

Study Design: Quasi-experimental research design of pre-test posttest non-equivalent group design was adopted in carrying out this research.

Place and Duration of Study: This study was carried out in ten Nigerian Universities between August, 2020 to April, 2021.

Methodology: We sampled 200 participants (111 male, 89 females; age range 16 – 27 years)

undergraduate pharmacy students drawn from ten (10) Universities in Nigeria. Twenty undergraduate pharmacy students offering Basic Principle of Chemistry (Chem. 101) were randomly selected from each of the selected universities for the study.

Results: The mean scores when test items were arranged in ascending, descending, and no consistent orders of item difficulty were 44.38, 37.85 and 40.13 respectively. Their differential mean scores were 6.53, 2.28 and 4.26 in the same order. This implies that pharmacy students obtained higher scores when test items were arranged in ascending order of difficulty, followed by no consistent order and least in descending order of difficulty. The findings further revealed no significant arrangement by gender interaction effect on undergraduate pharmacy students' performance in the three tests.

Conclusion: This study will help pharmacy lecturers in determining the most appropriate test item order which will help the students obtain high scores in any pharmaceutical test. The researchers conducted a quasi-experimental study on the topic as part of their undergraduate curriculum to examine the best test item format that will enhance pharmacy students' academic achievement in a chemistry course.

Keywords: Pharmacy undergraduate students; test item arrangement; level of difficulty; academic achievement; chemistry course.

1. INTRODUCTION

Item arrangement is a major factor that may influence undergraduate pharmacy students' achievement in any examination. Arrangement of multiple-choice test items could be in ascending, descending and no consistent order of difficulty. Ascending order of difficulty arrangement means arranging the test items from simple to complex. Descending order of arrangement means arranging the test items from complex to simple while no consistent order of arrangement means arranging the test items in a random manner. Generally, it is not possible to say that a particular type of test item format is the best; the most important thing is the ability of the test format to measure learners' achievement with respect to recall or application of knowledge and by any other reliable means in the behavioural changes after instructions have been passed across [1]. Test item order is one of the factors influencing pharmacy students' learning outcome in higher institutions of learning.

A test is an instrument used to determine the level of qualities, traits, characteristics, attributes, etc. that a person, an object or a thing possess [2]. Test can also be defined as sets of questions designed to be answered and which adequately qualifies as valid and reliable information gathering instrument for effective measurement and evaluation of the examinees cognitive, affective and psychomotor traits [3]. There are two types of tests namely; the essay test and the objective test. Essay test refers to the tests in which the students are required to provide the answers to the questions. It gives every student

the freedom to select, organize, express and present his own ideas in writing. Objective tests on the other hand, are those tests that are objectively scored in that influence of the examiner's prejudice or bias or opinion on the student's scores is highly eliminated. Objective tests are dichotomously scored in that a student either passes or fails an item. There are different types of objective tests. The different types include completion, true/false, matching, rank-order and multiple-choice types.

Test scores obtained by students in chemistry from their teacher made test or standardized test vary. Such variations are caused by several factors that include lack of laboratory and infrastructural facilities, inadequacy of teaching staff, teachers' attitude to practical, attitude to science, etc., [4]. Other variables like improper arrangement of test items, improper pattern of test item key placement, ambiguity of items, misleading languages in test item, and difficulty level of the test may also contribute to variations in test scores [5]. Different opinions were held by different people pertaining to how items should be arranged within a test format. [5] suggested that items of the same format (true/false, matching choice) should be grouped together. [5] believed that grouping items of the same format together makes it possible to write a concise and clear sets direction that will apply throughout that part of the test. The different kinds of item also require different response set or approaches to the item on the part of the examinee. The examinee is better able to maintain an appropriate set or approach if the items of the same type are grouped together. [6] suggested

that items that deal with the same instructional objective should be grouped together within each item format. The author claimed that this arrangement can help the lecturers ascertain which learning activities appear to be most readily understood and those that are in between.

In recent times, multiple-choice examinations were believed to be developed by arranging items from the easier ones to the harder ones as stated by [7]. This is based on the fact that students' performance will be enhanced whereas, test anxiety will be decreased. More so, it is believed that this type of test can help an average student make attempts in answering some test items as stated by [8]. In the words of [7], the order of arrangement of test items has been under consideration in terms of its difficulty. However, studies have shown that no significant difference exist in students' performance with respect to their level of difficulty [7]. [4] in a study of the organization of items on standardized test, found out that students attempt more items and therefore obtain higher scores when items are arranged in spiral-omnibus rather than in separate subsets according to content. [7] suggested that items should be ordered according to statistical difficulty. [9] supported the idea that tests of the same type should be arranged together and that easier ones come before the more difficult ones.

Arrangement of test items depends on the type of items used, the learning outcome measured, the difficulty of the items and the subject matter [10]. However, the author made a recommendation that items should be arrange in ascending order of difficulty once they are found to measure similar outcomes. As reported by [11] in a study on the influence of items arrangement in multiple choice objective tests, student's academic achievement in physics founds out that the students' performance was best when test items were arranged in ascending order of difficulty, followed by no consistent order of difficulty, and least when the test items were arranged in descending order of difficulty. More so, [12] reported in their study on the effect of item arrangements and performance in mathematics among students that test item arrangements in ascending order of difficulty significantly and positively influence students' performance in mathematics. It was equally revealed that most students failed because the test items were arranged from a more difficult to simpler ones. [13] carried out a study on the

impact of item positions in multiple choice test on students' performance at the Basic Education Certificate Examination (BECE) level, it was reported that the performance of students were significantly better when test items are arranged from the easier ones to the difficult one, but on the contrary, [14] in their study on test anxiety work and [15] in a study on the effect of change in item sequence on students' performance in multiple choice test reported no significant difference in the scores of the students with respect to different orderings of test items. Likewise, [16,17,18,19] in their various studies on items arrangement agreed that items arranged from simple to complex will yield positive achievement.

[20] carried out a study on differential performance of boys and girls using open ended and multiple-choice items on the 1988 and 1991 International Assessment of Educational Progress (IAEP) Mathematics test and found that in the 1988 assessment, the influence of gender on multiple-choice test was higher compared to open-ended items. However, the 1991 IAEP assessment produced results that are different, it showed that gender influence appeared to be higher when open ended test items were used compared to multiple items. These inconsistencies in the results gotten tend to disagree with the opinion that females appear to perform relatively better than the males in an open-ended test item, thus, it was opined that format of the items alone cannot determine gender difference in mathematics performance. More so, it was shown from the result of the study the inconsistencies in the pattern of test items with respect to gender and item format were related to items difficulty level, regardless of item format. [21] investigated the effect of question sequencing on examination performance. No evidence was found to support the contention that question sequencing affected examination performance or dropout behaviour from the class. Significant differences were observed, however, in student attitudes toward the course, instructor, and field of accounting. [22] carried out a study on the extent to which the kind of grading scheme used on students could influence how they learn and their reactions to assessment techniques such as the Immediate Feedback Assessment Technique (IFAT) using an answer form in order to generate immediate feedback on multiple-choice questions. The study made use of 141 undergraduate students who participate in a general-knowledge multiple-choice test involving low, medium and high

difficulty level. The IFAT was employed in the study using a grading scheme of number-correct (NC), partial-credit (PC), or correction-for-guessing (CG). After a week of administering the IFAT, another administration of the test was done using a conventional response form with an NC scheme. It was observed that when the NC and PC schemes were adapted for the first test, the number of correct answers increased by over 30% on the second test. Nevertheless, the increment was just a fraction as large as the CG scheme. This implies that in a way, it interferes with the IFAT's learning benefits. From the responses gotten using the questionnaire items, no strong information was found with respect to the origin of this difference. Thus, the participants who received both treatment conditions demonstrated positive attitudes toward the IFAT.

The reviewed literature showed an inconclusive trend in the area of item arrangement styles and academic achievement. Some researchers found out that items should be arranged according to content for higher academic achievement while others reported that items should be arranged according to their difficulty level for higher academic achievement on the part of students. Based on the inconsistency noted, there is need to find out whether item arrangement style is a factor in the academic achievement of undergraduate pharmacy students in Nigerian Universities. Undergraduate pharmacy students most times obtain poor achievement in some of the test taken daily. Many factors have been identified to be responsible for this poor achievement. These factors include lack of laboratory facilities, inadequacy of academic staff, academic staff attitude to practical, and item arrangement among others. Item arrangement in test is considered by the researchers as a factor that may also affect undergraduate pharmacy students' achievement in a chemistry course. For this reason, this study aimed at finding out the effects of item arrangements on undergraduate pharmacy students' academic achievement in Nigerian Universities. The following questions were addressed;

1. What are the differential mean scores of the undergraduate pharmacy students' when test items were arranged in

ascending, descending and no consistent order of difficulty?

2. Does item arrangement influence the variance of test scores in chemistry course?

2. MATERIALS AND METHODS

The study examined the effect of item arrangements in multiple choice tests on undergraduate pharmacy students' academic achievement in a chemistry course in ten Universities in Nigeria. We employed quasi-experimental research design in carrying out this research work. This is an experimental design which incorporates two or more independent variables in a single experiment and the effect of each independent variable is measured using different group of participants [23]. The design was considered appropriate for this study because it is used in a situation where the independent variable can be manipulated. Furthermore, the extraneous and intervening variables cannot be controlled in this research work.

2.1 Participants

Two hundred (n = 200) undergraduate pharmacy students drawn from ten (10) Universities in Nigeria participated in the study. Twenty undergraduate pharmacy students offering Chem. 101 were randomly selected from each of the selected universities for the study. The study participants were recruited online through social media platforms (WhatsApp and Telegram) of the undergraduate pharmacy students of the universities. Participation in the program was made voluntary and the participants were asked to indicate their interest in participating in the study. The participants were screened based on eligibility criteria made up of:

Must be an undergraduate pharmacy student of the university in Nigeria
Must be active in WhatsApp and Telegram platform.
The intervention was delivered online hence the use of WhatsApp and Telegram platforms.
Table 1 displays demographic characteristics of the participant students such as the universities they attend, age and gender.

Table 1. Demographic Information of Participants according to the university, Age and Gender

Study Centers	N	Age	Gender	
			Male	Female
University of Nigeria, Nsukka	20	18-25	10	10
University of Port-Harcourt	20	16-25	9	11
University of Lagos	20	18-27	11	9
Ahmadu Bello University	20	17-24	8	12
Obafemi Awolowo University	20	16-27	15	5
University of Ibadan	20	17-25	17	3
University of Abuja	20	16-25	14	6
Nnamdi Azikiwe University	20	18-27	8	12
Federal University Otuoke	20	18-25	12	8
Federal University Kashere	20	16-24	7	13
Total	200		111	89

Table 2. Test Blue Print

No. of Weeks	Content Area	Knowledge 20%	Compreh 20%	Application 25%	Analysis 25%	Synthesis 5%	Eval 5%	Total 100%
2	Particulate nature of matter	1	-	1	1	1	1	5
1.5	Atomic structure	1	1	1	1	-	-	4
1.5	Chemical combination	1	1	1	1	-	-	4
3	Kinetic theory of matter	1	2	2	2	-	-	7
8	Total	4	4	5	5	1	1	20

2.2 Research Instrument

The instrument used in collecting data for this study was Chemistry Achievement Test (CAT). This is a twenty-item, 4-option multiple choice test based on four topics for the first semester undergraduate pharmacy chemistry course (Chem 101 - Basic Principles of Chemistry). The topics include particulate Nature of matter, Atomic Structure, Chemical Combination and Kinetic Theory of Matter. Based on the table of specification shown in Table 2, initial pool of 30 items was constructed by the researchers for face validation and ten items were dropped based on expert's advice. The number of items in each topic was based on the number of weeks each topic lasted. The data collected were used for item analysis of the CAT. Three versions of the test were assembled. The acceptable range for difficulty index (D) is 0.30 to 0.70 while the acceptance ranges for discrimination index (R) is 0.20 to 1.00. The higher the value of D, the easier the item while the lower the value of D, the more difficult the item. The three versions of the test items are; ascending order of difficulty, descending order of difficulty and no consistent order of difficulty (Appendix A).

2.3 Instrument Validation and Reliability

A well-designed table of specification was used in constructing CAT items. This ensured content validity of the instrument. Copies of the initial draft of the CAT with the table of specification were given to experts for face validation. These experts were to assess the items of clarity of words and plausibility of the distracters. Some of the items were either modified or dropped following the advice and assessment of these experts. The final version of CAT was administered to 20 undergraduate pharmacy students of different university outside the main study area. The students' scores were analyzed using Kuder-Richardson formula 20 ($K-R_{20}$) techniques. The coefficient of internal consistency of CAT was computed to be 0.89 and this signifies a high degree of intra-item coherence.

2.4 Data Analysis

The analysis of the data collected was done using mean and standard deviation to answer the research questions while ANOVA statistics was used to test the hypothesis at 0.05 alpha level of significance using SPSS version 23.

3. RESULTS

The result on Table 3 shows that the mean scores when test items were arranged in ascending, descending, and no consistent orders of item difficulty were 44.38, 37.85 and 40.13 respectively. Their differential mean scores were 6.53, 2.28 and 4.26 in the same order. This implies that pharmacy students obtained higher scores when test items were arranged in ascending order of difficulty, followed by no consistent order and least in descending order of difficulty.

Table 4 shows that the variance of the students' achievement in ascending, descending and no consistent orders of item difficulty were 287.48, 251.88, and 289.11, respectively. This means that no consistent order that has the highest variance is highly discriminating, followed by ascending order and then descending order of difficulty.

Table 5 shows that the value of F-calculated (0.37) is less than the critical value (3.15) at 0.05 alpha level, degrees of freedom 2 and 78. This means that the students' mean achievement scores when multiple choice test items were arranged according to ascending, descending and no consistent order of difficulty did not differ significantly. The Table also shows that the value of F-calculated (0.11) is less than critical value (4.00) at 0.05 alpha level, degrees of freedom 1 and 78. Null hypothesis is therefore not rejected. This means that gender is not a significant factor on the academic achievement of the students based on the different test arrangement. Table 5 further shows that value of F-calculated (0.02) is less than the critical F-value (3.15) at 0.05 alpha level. Degree of freedom 3 and 78. This implies that the interaction effect between arrangement order and gender on the performance of the students in the three tests was not significant.

Table 3. Mean and differential mean of pharmacy students' achievement based on the different test item arrangement

IAO	Mean	Differential Mean		
		AO	DO	NCO
Ascending	44.38	-	6.53	4.25
Descending	37.85	6.53	-	2.28
No consistent	40.13	4.25	2.28	-

Note. IAO = Item arrangement order; AO = Ascending order; DO = Descending order; NCO = No consistent order

Table 4. Mean scores of male and female pharmacy students and Variances of achievement based on the different test item arrangement

Item Arrangement	Male(\bar{X})	Female(\bar{X})	SD	Variance
Ascending	44.90	43.85	16.96	287.48
Descending	39.10	36.60	15.87	251.88
No consistent	40.45	39.80	17.00	289.11

Note. SD = Standard deviation

Table 5. Summary of analysis of variance for male and female pharmacy students' achievement based on the different test item arrangement

Source of variation	SS	Df	MS	F-Cal	F-Tab
Arrangement	14908.88	2	7454.44	0.37	3.15
Gender	2151.22	1	2151.22	0.11	4.00
Interaction	797.25	2	398.63	0.02	3.15
Error	1590636.55	78	20392.78	-	-
Total	1608493.90	81	-	-	-

4. DISCUSSION

The result of this study revealed that the performance of undergraduate pharmacy students was high when the test items are arranged in ascending order of difficulty. This implies that the scores of undergraduate pharmacy students in chemistry test are higher when the test items are arranged in ascending order compared to their scores when the items are arranged in descending order as well as when the order of the difficulty level is not consistent. This finding is in line with the reports of [12] where it was found that a significant positive influence exists in the performance of students in mathematics with respect to test item arrangement in ascending order of difficulty. This implies that students will always perform better academically especially if they are presented with task from simple to complex. The result of this finding however also agrees with that reported by [13] who noted that students perform significantly better as shown by their mean score when questions are arranged from easy – to-hard format. Similarly, the findings of [16], [17] and [18] reported that test item arrangement based on simple to-complex aids students' understanding and consequential better performance than when they are presented on random basis. [19] also submitted that ascending order of difficulty aids students' performance.

The findings further revealed that undergraduate pharmacy students had the lowest scores on all the three examinations in the descending order of difficulty version; however, the differences were not significant. The result of this study is consistent with the report of [12] who found out that majority of students failed because of the arrangement of the test items from hard to simple ones. It likely arises because students do not like tedious tasks. This, of course coincides with the psychological theory of job performance which notes that humans naturally do not like tedious jobs and they will do everything possible in order to avoid such except in inevitable circumstances like test situations like this. This finding disagreed with the findings of other studies carried out using different courses where it was reported that the difference in the performance of students were not significant using test item order based on difficulty level [22]; [21]; [24]; [25]. It also contradicts the report of [14] who argued that test item arrangement of any format does not have any effect on students' performance in mathematics.

Result obtained after analyzing the data relating to the effects of item arrangement as presented in Table 5 showed that the order of test item arrangement does not significantly influence students' academic achievements. This finding is in agreement with the view of [15] who reported that there was no significant difference in the students' test scores using different orderings in multiple choice test. This finding disagrees with the report of [13], according to the authors, a reasonable difference in students' performance can be obtained if there is a change in the format of test items. In line with the finding of this study, it is possible to attribute students' poor performance to the methods or arrangement of test items based on the difficulty level.

The findings also showed that gender of students does not significantly affect their academic achievement based on the different test arrangements. This finding is consistent with previous studies where it was found that no main effect with respect to gender was found in other subject areas [7]; [26] and [27]. The findings disagree with the findings of [28] who reported a significant gender difference in both multiple choice and essay test in favor of the male students. Also, this study is in disagreement with the study of [20]. This is because, the authors reported gender a significant difference in the mean achievement scores of male and female in multiple choice test item format. The result however, agrees with the report of [29] who reported that the mean achievement scores of male and female in multiple choice test item formats was not significant.

5. CONCLUSION

From the findings, the difference in the mean achievement scores of the undergraduate pharmacy students when test items were arranged in ascending, descending and no consistent orders of difficulty was not significant. This shows that the achievement of the undergraduate pharmacy students is not dependent on the arrangement of test items. Similarly, the difference in the mean achievement scores of undergraduate pharmacy male and female students when test items were arranged in ascending, descending and no consistent orders of difficulty was also found not be significant. This indicates that gender is not a significant factor on the academic achievement of the pharmacy students based on the different test arrangements. In the same vein, there was no significant arrangement by gender interaction

effect on the performances of the students in the three tests. The result of this study would help instructors in determining the most appropriate test item arrangement order which will help the students obtain high scores in any test. The result of this study would be useful to higher institutions of learning and other professional test constructors in determining the best test item arrangement for higher academic achievement.

The findings of this research work have implications for higher institutions and students. Test items should be arranged using different orders of difficulty either ascending, descending or no consistent order. The different test arrangements will help the instructors prevent cheating among the students during tests and examinations. For examination bodies, the arrangement of test items differently will enable them reduce and check examination malpractice.

The use of multiple-choice tests only for this research work might be a source of limitation to this research work. Other types of objective test such as matching, true/false, arrangement, completion should have been involved by the researchers to check the problem of guess work on the part of the students.

CONSENT AND ETHICAL APPROVAL

The ethics committee at the institutions where the research was conducted granted ethical approval. The informed consent forms were properly filled and signed by the lecturers.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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APPENDIX 'A'

Final Version of Chemistry Achievement Test (CAT)

Test Items in Ascending Order of Difficulty

TIME: 20 MINUTES

Name:

School:

Class:

Sex: Male Female

INSTRUCTION: Read the following questions carefully and choose the option that best answers each question, then encircle the letter before you choose option.

1. These are basic particles which matter could be made up of except
 - (a) Molecules
 - (b) Ions
 - (c) Salt
 - (d) Atoms
2. The major difference between SO_3 and SO_3^{2-} is that
 - (a) SO_3 is a molecule while SO_3^{2-} is an atom
 - (b) SO_3 is a molecule while SO_3^{2-} is a radical
 - (c) SO_3 is a radical while SO_3^{2-} is a molecule
 - (d) SO_3 is a radical SO_3^{2-} while is an atom.
3. An element Q has mass number Y and atomic number Z; how many neutrons are there in an atom of Q?
 - a) Y
 - b) Z
 - c) Y-Z
 - d) Z-Y
4. Electrovalent compounds have the following properties except
 - (a) They have high melting and boiling point
 - (b) They are readily soluble in water
 - (c) They are poor conductors of electricity
 - (d) They are mainly solids at room temperature.
5. Which of these does not support the phenomenon of kinetic theory?
 - (a) Tyndall effect
 - (b) Linear expansivity
 - (c) Brownian motion
 - (d) Diffusion
6. The scientist who discovered the zig-zag, movement of gas molecules is
 - a) Brownian
 - b) Dalton
 - c) Newton
 - d) Graham

7. In the formation of a double covalent bond, each of the participating atoms contributes
- 4 electrons
 - 2 electrons
 - 1 electron
 - 3 electrons
8. The unit of measurement of molar mass is
- Grams
 - Moles
 - Gram per dm^3
 - Gram per mole
9. A molecule of hydrogen is
- diatomic
 - ionic
 - triatomic
 - monoatomic
10. Modern standard element with which chemist define relative atomic mass is
- ^{12}C
 - ^{13}C
 - ^3H
 - ^{14}C
11. An atom is electrically neutral if the number of
- Protons is equal to the number of electrons
 - Protons is equal to the number of neutrons
 - Neutrons is equal to the atomic number
 - Electrons is equal to the number of neutrons
12. The phenomenon observed when dust particles collide . randomly is a beam of sunlight is known as
- Tyndall effect
 - Diffusion
 - Osmosis
 - Brownian movement
13. The escape of molecules with more than average kinetic energy of molecule is called
- Efflorescence
 - Evaporation
 - Boiling
 - Melting
14. In the periodic table, elements are arranged according to their
- Atomic masses
 - Atomic numbers
 - Electronegativities
 - Mass numbers

15. Bonds between a highly electronegative atom and hydrogen from another molecule is called
- (a) Hydrogen bond
 - (b) intermolecular forces
 - (c) van der Waal force
 - (d) metallic bond
16. The electron for bonding is electrovalent combination in known as:
- (a) Valence electrons
 - (b) Shared electron
 - (c) Lone electrons
 - (d) Outermost electrons
17. The major reason why elements combine is that they want to
- (a) Become a non-metal
 - (b) Become a metal
 - (c) Become a noble gas
 - (e) Attain the nearest noble gas structure
18. Which of the three states of matter has no fixed shape, no fixed volume and least dense?
- (a) Gas
 - (b) Liquid
 - (c) Solid
 - (d) Crystals
19. An atom with 17 protons, 17 electrons and 18 neutrons has a mass number of .
- (a) 17
 - (b) 34
 - (c) 35
 - (d) 52
20. When an atom gains an electron, it becomes
- (a) A cation
 - (b) Neutral
 - (c) Negatively charged
 - (d) Positively charged

APPENDIX 'B'

Final Version of Chemistry Achievement Test (CAT)

Test Items in Descending Order of Difficulty

TIME: 20 MINUTES

NAME:

SCHOOL:

CLASS:

SEX: male female

INSTRUCTION: Read the following questions carefully and choose the option that answers each question, and then encircle the letter before your chosen option.

1. When an atom gains an electron, it becomes
 - (a) A cation
 - (b) Neutral
 - (c) Negatively charged
 - (d) Positively charged

2. The major reason why elements combine is that they want to
 - (a) Become a non-metal
 - (b) Become a metal
 - (c) Become a noble gas
 - (d) Attain the nearest noble gas structure

1. Which of the three states of matter has no fixed shape, no fixed volume and least dense?
 - (a) Gas
 - (b) Liquid
 - (c) Solid
 - (d) Crystals

2. An atom with 17 protons, 17 electrons and 18 neutrons has a mass number of
 - (a) 17
 - (b) 34
 - (c) 35
 - (d) 52

5. Modern standard element with which chemists define relative atomic mass is
 - (a) ^{12}C
 - (b) ^{13}C
 - (c) ^3H
 - (d) ^{14}C

6. The electrons for bonding in electrovalent combination is known as
 - (a) Valence electrons
 - (b) Shared electrons
 - (c) Lone electrons
 - (d) Outermost electrons

7. In the periodic table, elements are arranged according to their
 - (a) Atomic masses
 - (b) Atomic numbers
 - (c) Electronegativities
 - (d) Mass numbers

8. Bonds between a highly electronegative atom and hydrogen from another molecule is called
 - (a) Hydrogen bond
 - (b) Intermolecular forces

- (c) Vander Waal force
 - (d) Metallic bond
9. An atom is electrically neutral if the number of
- (a) Protons is equal to the number of electrons
 - (b) Protons is equal to the number of neutrons
 - (c) Neutrons is equal to the atomic number
 - (d) Electrons is equal to the number of protons
10. A molecule of hydrogen is
- (a) Diatomic
 - (b) Ionic
 - (c) Triatomic
 - (d) Monoatomic
11. The phenomenon observed when dust particles collide randomly in a beam of sunlight is known as
- (a) Tyndall effect
 - (b) Diffusion
 - (c) Osmosis
 - (d) Brownian movement
12. The unit of measurement of molar mass is
- (a) Grams
 - (b) Moles
 - (c) Gram per dm^3
 - (d) Gram per mole
13. The escape of molecules with more than average kinetic energy of the molecule is called
- (a) Efflorescence
 - (b) evaporation
 - (c) boiling Melting
14. Electrovalent compounds have the following properties except
- (a) They have high melting and boiling point
 - (b) They are readily soluble in water
 - (c) They are poor conductors of electricity
 - (d) They are mainly solids at room temperature
15. The scientist who discovered the zig-zag movement of gas movement of gas molecules is
- (a) Brownian
 - (b) Dalton
 - (c) Newton
 - (d) Graham
16. Which of these does not support the phenomenon of kinetic theory?
- (b) Tyndall effect
 - (c) Linear expansivity
 - (d) Brownian motion

- (e) Diffusion
17. The major difference between SO_3 and SO_3^{2-} is that
- (a) SO_3 is a molecule while SO_3^{2-} is an atom
 - (b) SO_3 is a radical while SO_3^{2-} is a molecule
 - (c) SO_3 is a molecule while SO_3^{2-} is a radical
 - (d) SO_3 is a radical while SO_3^{2-} is an atom
18. In the information of a double covalent bond, each of the participating atoms contributes
- (a) 4 electrons
 - (b) 1 electron
 - (c) 2 electrons
 - (d) 3 electrons
19. An element has mass number Y and atomic number Z. How many neutrons are there in an atom of Q?
- (a) Y
 - (b) Z
 - (c) Y-Z
 - (d) Z-Y
20. These are basic particles which matter could be made up of except
- (a) molecules
 - (b) ion
 - (c) salt
 - (d) atoms

APPENDIX 'C'

Final Version of Chemistry Achievement Test (CAT)

Test Items in no Consistent Order of Difficulty

TIME: 20 MINUTES

NAME:

SCHOOL:

CLASS:

SEX: Male Female

INSTRUCTION: Read the following questions carefully and choose the option that answers each question, and then encircle the letter before your chosen option.

1. Which of the three states of matter has no fixed shape, no fixed volume and least dense?
- (a) Gas
 - (b) Liquid
 - (c) Solid
 - (d) Crystals

2. When a solid substance changes directly to a gas on heating without passing through the liquid state, the substance is said to have undergone .
 - (a) Crystallization
 - (b) Sublimation
 - (c) Evaporation
 - (e) Melting
3. The major difference between SO_3 and SO_3^{2-} is that
 - (a) SO_3 is a molecule while SO_3^{2-} is an atom
 - (b) SO_3 is a radical while SO_3^{2-} is a molecule
 - (c) SO_3 is a molecule while SO_3^{2-} is a radical
 - (d) SO_3 is a radical while SO_3^{2-} is an atom
4. The electrons for bonding in electrovalent combination is known as
 - (a) Valence electrons
 - (b) Shared electrons
 - (c) Lone electrons
 - (d) Outermost electrons
5. Modern standard element with which chemists define relative atomic mass is
 - (a) ^{12}C
 - (b) ^{13}C
 - (c) ^3H
 - (d) ^1H
6. An element Q has mass number Y and atomic number Z. How many neutrons are there in an atom of Q?
 - a Y
 - b Z
 - c Y-Z
 - d Z-Y
7. The percentage by mass of oxygen in water, 1-120 is (H = 1, O = 16)
 - (a) 98%
 - (b) 11%
 - (c) 88%
 - (d) 81%
8. Water exists as a solid, liquid and gas respectively because
 - (a) Water is colourless
 - (b) Water is electrovalent
 - (c) Water in any state possesses a certain degree of motion in the molecules
 - (d) Water is molecular

9. The unit of measurement of molar mass is,
- (a) Grams
 - (b) Moles
 - (c) Gram per dm^3
 - (d) Gram per mole
10. The major reason why elements combine is that they want to
- (a) Become a non-metal
 - (b) Become a metal
 - (c) Become a noble gas
 - (d) Attain the nearest noble gas structure
11. Which of these does not support the phenomenon of kinetic theory?
- (a) Tyndall effect
 - (b) Linear expansivity
 - (c) Brownian Motion
 - (d) Diffusion
12. One of the following is NOT a property of electrovalent compounds
- a) They have high boiling and melting point
 - b) They are readily soluble in water
 - c) They are poor conductors of electricity
 - d) They are mainly solids at room temperature
13. An atom with 17 protons, 17 electrons and 18 neutrons has a mass number of
- (a) 17
 - (b) 34
 - (c) 35
 - (d) 52
14. The scientist who discovered the zig-zag movement of gas molecule is
- (a) Brownian
 - (b) Dalton
 - (c) Newton
 - (d) Graham
15. Which of these is the same in isotopes of an element?
- (a) Mass number
 - (b) number of neutrons
 - (c) Number of protons and Neutrons
 - (d) Number of Protons
16. The escape of molecules with more than average kinetic energy of the molecule is called
- (a) Efflorescence
 - (b) Evaporation
 - (c) Boiling
 - (d) Melting

17. Elements are arranged in the periodic table based on their
- (a) Atomic masses
 - (b) Atomic numbers
 - (c) Electro negativities
 - (d) Mass numbers
18. When atoms gain electrons, they become
- (a) Cations
 - (b) Neutral
 - (c) Negatively charged
 - (d) Positively charged
19. When dust particles collide randomly under a beam of sunlight, the phenomenon is referred to
- (a) Tyndall effect
 - (b) Diffusion
 - (c) Osmosis
 - (d) Brownian movement
20. An atom is electrically neutral if the number of
- (a) Protons is equal to the number of electrons
 - (b) Protons is equal to the number of neutrons
 - (c) Neutrons is equal to the atomic number
 - (d) Electrons is equal to the number of neutrons

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