Construction and standardization of an achievement test in chemistry practical for senior secondary students

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Abstract

Introduction: Active engagement in experimentation plays a pivotal role in fostering students' understanding, problem-solving abilities, and grasp of scientific principles. In the realm of chemistry, hands-on laboratory experience is indispensable for students at all educational levels to truly comprehend its intricacies. Laboratory work not only cultivates critical thinking skills but also enhances metacognition and experimental self-efficacy among students. Applying chemistry concepts to real-world scenarios necessitates students to possess profound knowledge, comprehension, and proficiency in conducting practical experiments. A thorough analysis of existing scholarly literature highlights the pressing need for an evaluative tool that can gauge students' overall comprehension in practical chemistry.

Method: To develop such a tool, an initial draft comprising 123 items was meticulously prepared and tested on 250 students. After undergoing a rigorous standardization process, 84 items were identified as suitable for inclusion in the final achievement test. Subsequently, Cronbach's alpha statistic value and split half reliability coefficient value were computed to be 0.98 and 0.96 respectively, indicating high internal consistency.

Result: A standardized achievement test to assess students' proficiency in chemistry practical, encompassing their knowledge, comprehension, practical application, and hands-on skills was prepared

Conclusion: The achievement test designed for chemistry practical is deemed highly appropriate for evaluating students' performance in chemistry experimentation, conceptual understanding, and practical applications.

Key words: Achievement test, standardization, chemistry practical, construction, senior secondary students, item analysis

Introduction

Numerous scholarly articles and research findings have consistently emphasized the importance of science laboratories in facilitating conceptual understanding. The laboratory environment is widely recognized as a unique space within the educational setting where students actively construct their own knowledge through hands-on experimentation [1,2.] Moreover, laboratories have been recognized as a valuable instructional medium for promoting creativity, critical thinking, and scientific aptitude. The objectives of chemistry practical encompass enhancing proficiency in scientific subject matter, developing scientific reasoning skills, and facilitating the comprehension of complex and ambiguous empirical work.

In addition to these goals, laboratory work offers various other advantages, including the acquisition of practical skills, fostering an appreciation for the essence of science, promoting a scientific attitude, and enhancing team-building abilities (USA Lab Report, published by the NRC, 1996).

Literature Review

The findings of the varied researchers concluded that practical work introduced in the curriculum has a great role in academics [2,3,4]. The demonstration of practical science plays an important role in inculcating differentiated learning skills [2]. If experiments are designed and conducted in an accurate & precise fashion, it enhances intellectual comprehension, invokes creativity and strategic awareness [5]. Practical experimentation is significant as it leads to the development of not only the ability to understand pre-established connotations but also the development of conceptual learning & knowledge that fosters social & vocational expertise. NEP (2020) emboldens Kolb's Cycle of Learning, a pedagogical approach that creates concrete experiences that have a practical application of knowledge and skills to real-world experiences.

Science experimentation is crucial for developing students' understanding, problem-solving abilities, and comprehension of science experiments. Practical work can inspire students to raise their interest in learning, offer them practice using that knowledge, and broaden their perspectives. Chemistry lab work in particular is a stepping stone in this path.

Chemistry as a subject, relies on learning by experimentation to provide complete understanding of the concepts. Practical knowledge is an essential element that propagates curiosity and a sense of self efficacy. Media supported learning has improved the practical skills of students [1].

Researchers have perceived the experimental aspect to be of significant help in enabling the students to dwell deeper into the subject knowledge and create their own hypothesis. To assess the knowledge gained by students and their ability to replicate the same in real life is generally measured by an achievement test.

Achievement test measures the present proficiency, mastery and understanding of a subject. It is the instrument used to gauge the depth of learning and achievement in the subject. Often, performance in chemistry appears to be one of the indicators of a student's professional success. To evaluate the knowledge and competence of

a student through the scheduled instructions, the practice of achievement testing is used [7]. The four general functions of an achievement test are summative, formative, diagnostic, and placement [8]. Students can benefit from an achievement test in chemistry because its major objective is to assess their understanding of the subject. The achievement test also places an emphasis on the final achievement of teaching and learning outcomes [9].

A well-designed achievement test must follow a standardized grading and scoring procedure to determine a student's level of comprehension of a subject[10]. Various assessment techniques are used to determine the knowledge and abilities of students. Achievement tests are an assessment tool to gather information about students' progress. Therefore, test quality should be properly coordinated with specified curriculum [11]. As a result, for creation of tests, several steps are followed [12]. The initial step for test developers should be to design the variable to be measured. The test is considered valid if the construct has been well stated and can convey concept [13]. Achievement tests help to make decisions about grading, monitoring, placement, promotions, and graduation [14].

An achievement test must be built using specific procedures, including test planning, item writing, item analysis, and item selection [15]. The analysis of the test items is essential for their improvement. Misleading test items can be removed via item analysis [10].

In any educational set up, the instrument used should be reliable and permissible, apart from being legitimate and dependable, according to some of the researchers. Assessment of a student's learning is required not only to award scores dependent on certain parameters but also to improve methods of teaching and imparting knowledge. Accuracy in assessment will direct teachers to improve their pedagogy. Reliable and valid tests which are devoid of any ambiguity are effective to carry out error-free assessment. Therefore, such types of tests need to effectively convey the right concepts and enrich the students with a creative mindset that inclines them to further learn and gather impartial knowledge [16].

Purpose of the Study

After reviewing the literature pertaining to achievement test, numerous studies done on multi grade students that belonged to preschool, primary school, junior school etc. and on subjects such as science, natural science, basic science, life science and biology [15,17,1819,20,21,22, 23, 24].

Few researches were conducted on university students also [6, 25, 26, 27, 28] in social science, health science, mathematics, social studies & English. These achievement tests were developed for the assessment of theoretical concepts. A dire need was felt to develop an achievement test on practical areas of science, especially in chemistry. This study attempts to assess the knowledge, understanding, application, and skills gained through chemistry laboratory experimentation.

Method

The process of creating a standardized achievement test involved several steps, including test planning, test construction, test administration, item analysis, and test standardization.

1. Test Planning

The initial and most vital stage in developing an achievement test is the planning process. The researcher took into consideration various factors such as the intended audience, the content to be assessed, the timing, and the methodology of measurement while planning the test. This includes creating the test blueprint and making important decisions, such as the test's objectives, content, format, scoring method, measure of parameters, multiple types of options, duration, weighting of goals, time allocation, and marking procedures. The researcher examined existing Chemistry-related achievement tests and consulted laboratory manuals. The Chemistry practical syllabus of senior secondary classes as recommended by the Central Board of Secondary Education (C.B.S.E.) India was considered. Four types of questions were included in the test, namely multiple-choice, completion, true/false, and matching. The Achievement test features items that incorporate visual elements such as figures, diagrams, graphs, and tables. These items necessitate the application of advanced cognitive processes. Application-based items involve knowledge and concepts to solve real-world problems or situations. Few items test critical thinking skills which involve analyzing, evaluating, and synthesizing information. A template was then developed using the learning objectives outlined in Bloom's Taxonomy of Educational Objectives as a guide.

Test Objectives

Certain behavioral aspects that relied on knowledge, learning, experimental demonstration, and proficiency were judged through achievement tests. The table below presents the objectives in accordance with Bloom's Taxonomy and their weightages:

Table1: ***Weightage to the content as per bloom's taxonomy***

Objectives	No of questions	% Weightage
Knowledge	21	17.07
Understanding	20	16.26
Application	48	39.02
Skill	34	27.6
Total	123	100

Content of the test

An essential aspect of designing an achievement test is the content analysis. This step involved reviewing material from six units of the Chemistry Practical syllabus for senior secondary classes students' namely equilibrium, pH, melting and boiling point, volumetric analysis, crystallization, and salt analysis. Table 2 illustrates the weightage allocated to each unit.

Table 2: ***Topic Wise weightage of the content***

S. No.	Content	Weightage	Percentage
1	Equilibrium	10	8.13
2	pH	11	8.94
3	Melting & boiling point	14	11.38
4	Volumetric Analysis	16	13.00
5	Crystallization	12	9.75
6	Salt Analysis	60	48.78
Total		123	100

Blueprint of the Test

The blueprint stage of test preparation is crucial as it establishes the framework for the development of test items for the initial draft. In this stage, the researcher created a blueprint consisting of four types of questions and distributed them based on the cognitive abilities of the participants. Table 3 enumerates the 123 objective questions from the six units that comprise the blueprint.

Table:3 ***Achievement Test Framework (first draft)***

Objectives→	**Knowledge**	**Understanding**	**Application**	**Skill**	**Total**
Weightage→	**17.07%**	**16.26%**	**39.02 %**	**27.6%**	**100%**
Sub Content	**No of questions (Marks)**				
Equilibrium	2(2)	2(2)	4(4)	2(2)	10(10)
pH determination	3(3)	2(2)	4(4)	2(2)	11(11)
Melting point and boiling point determination	2(2)	6(6)	2(2)	4(4)	14(14)
Volumetric Analysis	3(3)	3(3)	6(6)	4(4)	16(16)
Crystallization	6(6)	1(1)	2(2)	3(3)	12(12)
Salt Analysis	5(5)	6(6)	30(30)	19(22)	60(63)
Total	21(21)	20(20)	48(48)	34(34)	123(126)

2. Test Construction

The process of creating test items involves three stages: Item-writing, expert review, and Item-editing. Initially, a rough draft was developed that included 123 questions addressing the teaching objectives of chemistry at the senior secondary level, specifically knowledge, comprehension, application, and skill. The distribution of questions across four objectives and six units of the curriculum is outlined in Table 4.

Table 4: ***Objective Wise Distribution of Items (123 questions)***

Objectives→	**Knowledge**	**Understanding**	**Application**	**Skill**	**Total**
Weightage→	**17.07%**	**16.26%**	**39.02 %**	**27.6%**	**100%**
Sub Content		**No of questions (Marks)**			
Equilibrium	2, 7	1, 8	3, 4, 9, 10	5, 6	10
pH determination	11, 12, 17	14, 16	13, 15, 20, 21	18, 19	11
Melting point and boiling point determination	22, 32	23, 24, 26, 27, 29, 30	31, 34	25, 28, 33, 35	14
Preparation of standard solution & titration	40, 42, 48	45, 47, 51	37, 38, 39, 43, 44, 50	36, 41, 46, 49	16
Crystallization	52, 54, 55, 56, 60, 62	63	58, 59	53, 57, 61	12
Salt Analysis	65, 91, 92, 96, 100	72, 75, 94, 99, 106, 123	64, 67, 68, 69, 70, 71, 73, 74, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 103, 105, 107, 112, 113, 114, 116	66, 93, 95, 97, 98, 101, 102, 104, 108, 109, 110, 111, 115, 117, 118, 119, 120, 121, 122	60
Total	21	20	48	34	123

The process of expert review entailed the thorough examination of each item by both the investigator and six experts to ensure the absence of ambiguous wording or vague terminology in the format of the test items. The experts provided valuable feedback which resulted in the removal of five items (items 37, 55, 65, 66, and 119) and the revision of several others. Through this process, a second draft comprising 118 items was created.

3. Test Administration

Preliminary Try Out

Items to be tested were finalized and afterwards they were administered to a group of 50 senior secondary students. Adequate instructions were provided to the students on how to attempt the test. Afterwards, students marked their

responses. The students were closely monitored to identify any areas of difficulty and language issues. The time spent by each student was recorded. Of the 118 items, 20 were found to be confusing and challenging by the students. These items (14, 21, 22, 52, 61, 67, 71, 74, 83, 86, 88, 89, 93, 95, 98, 100, 104, 106, 107, and 114) were subsequently removed from the draft. Considering the content and degree of difficulty, the third draft of the achievement test comprises 98 items.

Final try-out

For the final try out, 200 students of senior secondary level, from various educational institutions participated. After the examination papers were collected and assessed using a designated scoring key by the researcher. Correct responses were awarded one mark while incorrect responses received no points.

4. Item Analysis

Item analysis was done after test items had been scored. It was done to evaluate the efficacy of various items by item analysis. Item analysis is a statistical science that enables researcher to accept or reject test items based on the value of difficulty and discrimination power of the items. This serves the purpose of getting the test's most appropriate items. The steps in this process are as follows: orderly arrangement of the response sheets in descending order, calculation of difficulty value (DV) and discrimination power (DP) and finally rejection of items based on the values of DV and DP.

Difficulty Value

The percentage of students who successfully answered each question indicates the item's complexity. The value can be anywhere between 0% and 100%. The higher the value, the simpler the item is. A very easy item has a p value of 0.90 or higher, while a tough item has a DV value of 0.20 or lower. 0.5 difficulty value is ideal to create a distinction between high and low achievers. In general, moderately challenging products should be chosen over extremely easy or extremely difficult ones. The difficulty value is represented by P and the calculation of difficulty value is:

$P= (Ru + Rl)/ T$

Where: P= Difficulty Value; Ru = Number of students who answered correctly in upper group; RL= Number of students who answered correctly in lower group; T= Total number of students

The difficulty indices were evaluated based on the points as shown in the following table:

Table 5: ***Relation between marks range and difficulty level***

Range	***Difficulty Level***
20 & below	Very Difficult
21- 40	Difficult
41- 60	Average
61 - 80	Easy
81 & above	Very Easy

The P value of an item indicates accurate evidence of how easy or difficult the item was for the respondent. It is documented that in a multiple-choice test consisting of four or more alternatives, the items lying in the range of 0.20 to 0.80 should be selected (Nunnally, 1972). All items found too easy or too difficult were excluded.

Discrimination Power

High and low scorers can be distinguished by the value of the Discrimination index. Out of all the students under consideration, the top 27% are categorized as high scorers and the bottom 27% are categorized as low scorers. An item is retained in the achievement test if it is able to distinguish between high and low scorers. Calculation of the Discrimination index is as follows:

D I = (Ru - RL) / T/2,

Where: D I = Discrimination Index; Ru = Number of students who answered correctly in upper group; RL= Number of students who answered correctly in lower group; T= Total number of students

The selection of items in achievement tests were formalized based on Ebel's (1979) parameters and guidelines for categorizing discrimination power.

Ebel's Parameters on Discrimination power (1979) are as follows:

- If the value of Discriminating Power is 0.40 and above, the item is quite satisfactory.
- If it is between 0.30-0.39, less or no revision is required in the item.
- If it is between 0.20-0.29 item is marginal and need revision
- If it is less than 0.19, The item should be eliminated or completely revised.

As per Ebel's parameters, 98 selected items are mentioned in the following table along with their Difficulty Value & Discriminating Power.

Table 6: ***Item Decision table***

S. No.	Difficulty Value	Discriminating Index	Item Decision	S. No.	Difficulty Value	Discriminating Index	Item Decision	S. No.	Difficulty Value	Discriminating Index	Item Decision
1	0.91	-0.19	Rejected	**17**	0.49	0.98	Selected	**33**	0.51	0.98	Selected
2	0.50	-0.11	Rejected	**18**	0.52	0.96	Selected	**34**	0.51	0.98	Selected
3	0.88	-0.17	Rejected	**19**	0.38	0.31	Rejected	**35**	0.51	0.98	Selected
4	0.56	0.48	Selected	**20**	0.50	0.96	Selected	**36**	0.51	0.98	Selected
5	0.57	0.48	Selected	**21**	0.51	0.98	Selected	**37**	0.51	0.98	Selected
6	0.56	0.48	Selected	**22**	0.49	0.98	Selected	**38**	0.84	0.31	Rejected
7	0.90	-0.20	Rejected	**23**	0.34	0.28	Rejected	**39**	0.84	0.31	Rejected
8	0.56	0.48	Selected	**24**	0.50	0.96	Selected	**40**	0.51	0.98	Selected
9	0.55	0.46	Selected	**25**	0.44	0.39	Selected	**41**	0.62	0.31	Rejected
10	0.56	0.48	Selected	**26**	0.51	0.98	Selected	**42**	0.50	1.00	Selected
11	0.56	0.50	Selected	**27**	0.50	1.00	Selected	**43**	0.50	1.00	Selected
12	0.56	0.50	Selected	**28**	0.51	0.98	Selected	**44**	0.50	1.00	Selected
13	0.50	-0.07	Rejected	**29**	0.50	1.00	Selected	**45**	0.51	0.98	Selected
14	0.50	0.96	Selected	**30**	0.50	1.00	Selected	**46**	0.34	0.28	Rejected
15	0.50	1.00	Selected	**31**	0.50	1.00	Selected	**47**	0.50	1.00	Selected
16	0.50	1.00	Selected	**32**	0.50	1.00	Selected	**48**	0.44	0.39	Selected

	Difficulty Value	Discriminating Index	Item Decision	S. No.	Difficulty Value	Discriminating Index	Item Decision	S. No.	Difficulty Value	Discriminating Index	Item Decision
49	0.51	0.98	Selected	**65**	0.83	0.33	Rejected	**82**	0.62	0.61	Selected
50	0.44	0.39	Selected	**66**	0.50	1.00	Selected	**83**	0.5	1	Selected
51	0.50	0.96	Selected	**67**	0.50	1.00	Selected	**84**	0.5	1	Selected
52	0.62	0.61	Selected	**68**	0.50	1.00	Selected	**85**	0.5	1	Selected
53	0.44	0.39	Selected	**69**	0.50	1.00	Selected	**86**	0.51	0.98	Selected
54	0.49	0.98	Selected	**70**	0.51	0.98	Selected	**87**	0.51	0.98	Selected
55	0.50	0.96	Selected	**71**	0.51	0.98	Selected	**88**	0.51	0.98	Selected
56	0.49	0.98	Selected	**72**	0.44	0.39	Selected	**89**	0.51	0.98	Selected
57	0.84	0.31	Rejected	**73**	0.50	1.00	Selected	**90**	0.5	1	Selected
58	0.84	0.31	Rejected	**74**	0.50	1.00	Selected	**91**	0.5	1	Selected
59	0.51	0.98	Selected	**75**	0.50	1.00	Selected	**92**	0.5	1	Selected
60	0.50	1.00	Selected	**76**	0.51	0.98	Selected	**93**	0.5	1	Selected
61	0.51	0.98	Selected	**77**	0.51	0.98	Selected	**94**	0.62	0.61	Selected
62	0.51	0.98	Selected	**78**	0.51	0.98	Selected	**95**	0.62	0.61	Selected
63	0.50	1.00	Selected	**79**	0.62	0.61	Selected	**96**	0.62	0.61	Selected
64	0.50	1.00	Selected	**80**	0.62	0.61	Selected	**97**	0.62	0.61	Selected
				81	0.62	0.61	Selected	**98**	0.56	0.48	Selected

Achievement Test (Final Draft)

The concluding draft was formulated based on item analysis. After choosing the items for the end draft, the researcher reassembled them into the four categories established by Blooms: knowledge, understanding, application, and skill. There are 84 elements in the achievement test's final draft.

Table 7: ***Achievement Test Framework (final draft)***

S. No.	Sub Content	Knowledge	Understanding	Application	Skill	Total
Weightage		**16.4 %**	**23.5 %**	**35.2 %**	**24.7 %**	**100%**
1	**Equilibrium**	-	8	4, 9, 10	5, 6	6
2	**pH determination**	11, 12, 17	14, 16	15, 20	18	8
3	**Melting point and boiling point determination**	29	21, 24, 26	27, 28, 30, 31, 32	22,25	11
4	**Preparation of standard solution & titration**	36, 44	43, 47	34, 35, 37, 40,	33, 42, 45	11
5	**Crystallization**	48, 49, 50, 54	56	52, 53	51, 55	9
6	**Salt Analysis**	80, 82, 84, 85	62, 74, 75, 76, 77, 78,86, 87, 89, 90, 91	59, 60, 61, 63, 64, 66, 67, 68, 69, 70, 71, 72, 73,	79, 81, 83, 88, 92, 93, 94, 95, 96, 97, 98	
Total		14	20	29	21	84

Table 8: ***Types of Objective Test Items in Final Draft of Achievement Test***

S. No.	Types of Questions	No. of Questions	Marks
1	**Multiple Choice**	**55**	**55**
2	**Complete the sentence**	**14**	**14**
3	**True False**	**14**	**14**
4	**Match the columns**	**1**	**1**

5. Test Standardization

The final draft retained 84 items of the Achievement test that facilitated standardization by the researcher. To carry out the standardization process, reliability and validity of the test was established.

Test Reliability

Reliability is one of the most significant features of any test and measuring instrument. Researcher used the Split-half method to establish the reliability of the test. Split-half is the method of splitting the test in two halves and finding the correlation. The responses of 200 students were used for the calculation. The scores of two halves were correlated and reliability of the test was calculated (Pearson Coefficient). The reliability coefficient of full test was measured as rtt by the following formula:

rtt= 2r/1+r.

The reliability coefficient for the full test was 0.96. Also, the reliability coefficient value for full test by Cronbach's Alpha statistic was .98. It concluded that the test has a high degree of reliability.

Test Validity

Validity means that the findings reflect what was intended to be measured. The reference of validity can be used to interpret the relevance of evidence of data and theory. Thus, absolute validity of the test cannot be established. However, the validity of scores are relevant for some uses or interpretations and not for others [29].

Validity of the Test was done while preparing the blueprint and item writing of the test. The views of experts in this field were noted and indispensable modifications were made in the achievement test as per their recommendations. Face validity and content validity of the test was assured by awarding adequate weightage to content and objectives. The content Validity Ratio (CVR) of all selected items came out to be 0.99 and CVR for rejected items was less than 0.42.

Scoring Norms of Achievement Test

In table no. 9, norms grades were assigned based on percentage marks, Raw score and Z score:

Table 9: Calculation of Scoring Norms

Grade	**Marks %**	**Raw Score**	**Z score**
Excellent	90 % & above	76 & above	1.04 & above
A	75% & less than 90%	63 & less than 76	0.60 & less than 1.04
B	60 % & less than 75%	50 & less than 63	0.16 & less than 0.60
C	50% & less than 60%	42 & less than 50	-0.12 & less than 0.16
D	33% & less than 50%	28 & less than 42	-0.59 & less than -0.12
F	Below 33%	Below 28	Less than -0.59

Conclusion

The purpose of this research was to create a reliable and valid Chemistry practical achievement test. The standardization process involved 250 students from different schools who participated in various stages of tryouts. To develop the

achievement tool, a comprehensive and evidence-based literature review was conducted, resulting in the creation of 123 items. Following the administration of the test and item analysis, 84 items were selected for retention in the achievement test. The content validity of the test was assessed by six distinguished subject experts, and the input of a language expert was also considered.

To determine reliability, the Split-half method was employed, resulting in a reliability coefficient of 0.96. As a result of this study, an achievement test in Chemistry was developed that exhibits a high level of reliability and validity. It is essential for teachers to assess the progress of their students in Chemistry practical, and this achievement test can serve as an effective means of evaluation once students have completed the senior secondary level curriculum.

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Appendix A- Tool: Achievement Test
Appendix B: Answer Key

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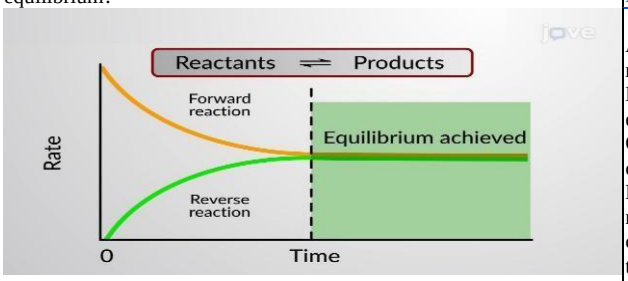
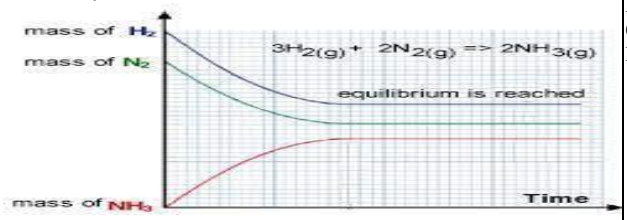
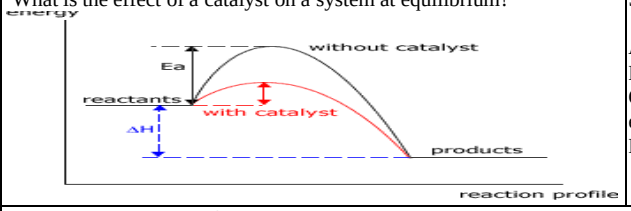
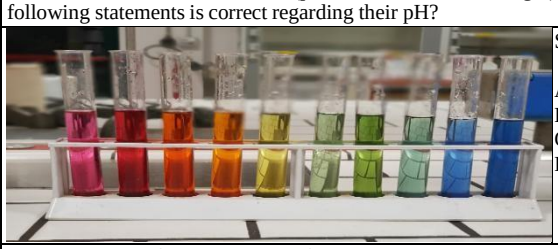
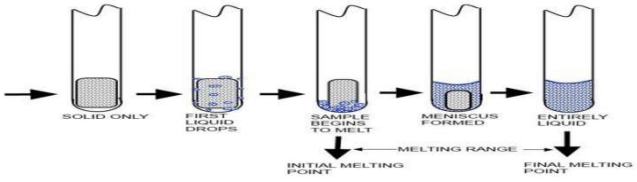
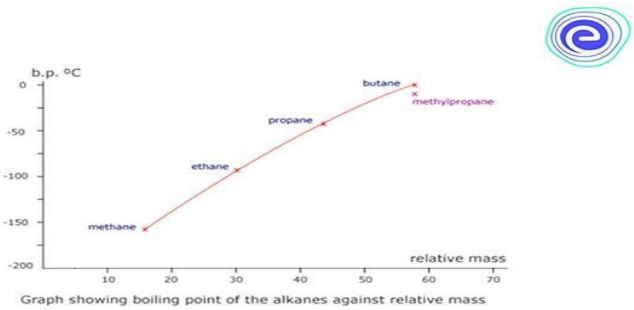
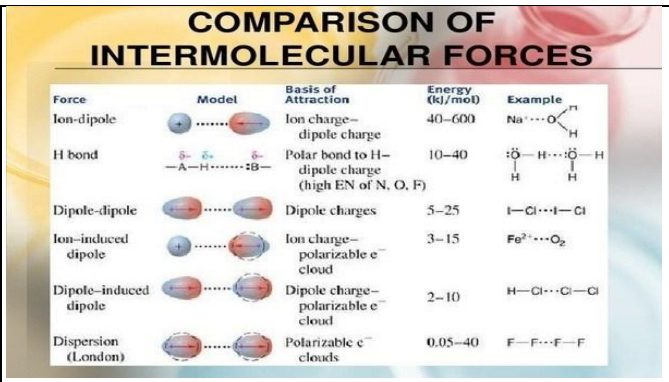
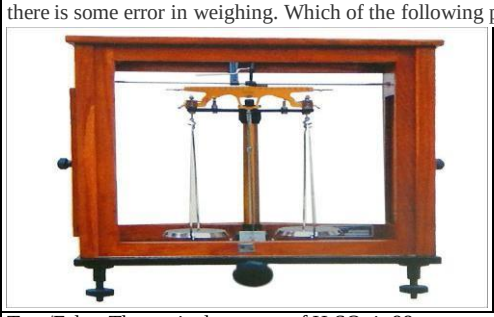
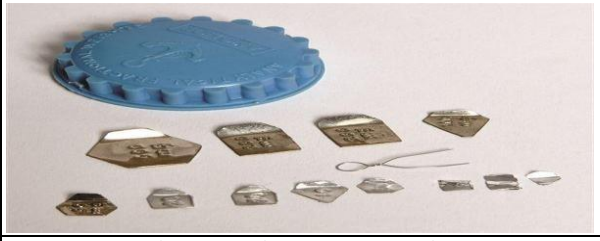
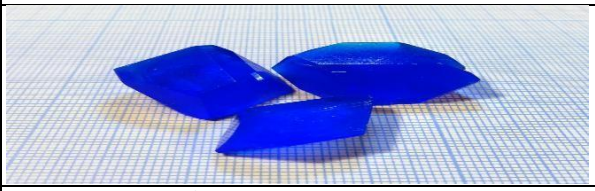
APPENDIX A
Achievement Test

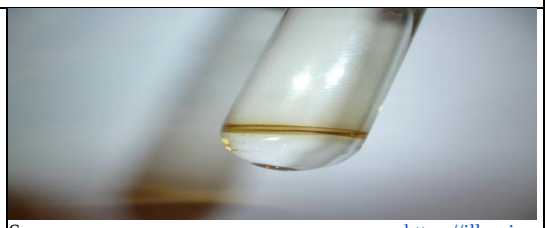
S. No.	Experiment
I	**Equilibrium**
1.	Analyze the shift in equilibrium between ferric ions and thiocyanate ions by increasing/decreasing the concentration of either of the ions. True/False: For an exothermic reaction, increasing the temperature will shift the reaction towards the forward direction.
0.	Two chemicals are mixed together in a test tube in order to set the equilibrium. The colour obtained in the test tube is compared with the reference test tube. What is the role of reference test tube? A. It is used to compare the intensity of colour observed in the other test tubes giving an idea about the direction of equilibrium. B. To match the colour observed in the other test tubes to the reference test tube. C. It has no role in the experiment. D. To dilute the sample size.

0.	What is the colour of $[Co(H_2O)_6]^{+2}$ ions and $[CoCl_4]^{-2}$ ions respectively: 	Source: https://thumbs.dreamstime.com/z/test-tube-rainbow-9460182.jpg A. Pink and Blue B. Blue and Pink. C. Red and Yellow. D. Yellow and Red.
0.	Which one of the following is CORRECT regarding chemical equilibrium? 	Source: https://www.jove.com/science-education-library/116/chemical-equilibrium A. Equilibrium is achieved only when pressure of the reaction is decreased. B. Equilibrium is achieved when forward reaction rate equals reverse reaction rate. C. Equilibrium constant depends on the initial concentration of the reactant. D. Equilibrium is achieved only when temperature of the reaction is increased. It is used to compare the intensity of colour observed in the other test tubes giving an idea about the direction of equilibrium.
0.	The reaction $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$ [$\Delta H = -92.22$ KJ/mol] is at equilibrium. How will the system respond if the temperature is increased? 	Source: https://tinyurl.com/56mwdfkw A. The reaction becomes endothermic. B. The equilibrium will shift to the right. C. No change in the equilibrium position of the reaction. D. The equilibrium will shift to left.
0.	What is the effect of a catalyst on a system at equilibrium? 	Source: https://www.ibchem.com/IB16/07.26.htm A. The rate of reaction decreases. B. The enthalpy of reaction first increases then decreases. C. Increase the rate of reaction by making a new low energy pathway. D. The potential energy of the product decreases.
II	**To determine the pH of the given sample using pH paper /Universal indicator**	
7.	What is the nature of the blood in the human body? A. Strongly basic B. Slightly acidic C. Strongly acidic D. Slightly basic	
8.	True/False: pH is defined as the negative logarithm of hydronium ion concentration in moles per litre.	
9.	Shalini & Shivam performed different activities to determine the nature of a solution. Shalini checked the pH of the solution and got its value 4.5. Shivam dipped the litmus paper in the solution. What is his observation about the change of colour of litmus paper & nature of solution? 	Source: https://tinyurl.com/3zja2w9f A. Solution turns blue litmus paper red and is acidic. B. Solution turns blue litmus paper red and is basic. C. Solution turns red litmus paper blue and is acidic. D. Solution turns red litmus paper blue and is basic
10.	Complete the following sentence- When water is added to a weak acid then concentration of hydronium ion ..... and the pH of the solution..... 	Source: https://www.thoughtco.com/add-sulfuric-acid-to-water-606099 A. Increases, Decreases B. Decreases, Increases C. Decreases, Decreases D. Increases, Increases

11.	Complete the following sentence- The relationship between pH and pOH of an aqueous solution is.....
12.	What is the effect of a rise in temperature on the pH of pure water? A. pH value increases. B. pH value decreases. C. pH value remains same. D. pH value first increases then decreases.
13.	What is the nature of lemon juice and oranges? A. Slightly basic B. Acidic C. Neutral D. Amphoteric
14.	Look at the color of the solutions (pink to blue from left to right) placed in the test tube in the picture and mention which of the following statements is correct regarding their pH?  Source: https://en.wikipedia.org/wiki/PH A. pH increases from left to right. B. pH decreases from left to right. C. Acidity increases from left to right. D. Basicity decreases from left to right
III	**Determination of melting point of an organic compound**
15.	Which of the following is known as the temperature at which a substance in solid state changes to liquid state at normal atmospheric pressure? A. Melting point. B. Boiling point. C. Freezing point. D. Triple point.
16.	A solution is kept in a liquid bath for heating. The instructor is continuously stirring the solution. Fill in the blanks using suitable option (Increase, decrease, make uniform)- The liquid bath is stirred continuously in order to..... the temperature throughout.
17.	True/False: Melting point determination of a substance gives an idea about the purity of the substance.
18.	Observe the steps of melting given below and indicate the nature of the substance.  Source: https://chembam.com/definitions/melting-point/ A. Crystalline B. Amorphous C. Liquid D. Gas
IV	**Determination of the boiling point of an organic compound**
19.	Complete the sentence using suitable option (Increase, decrease)- On increasing the pressure outside, the boiling point of liquid.....
20.	True/False: At higher altitude, the boiling point of liquid increases.
21.	When some non-volatile liquid is added to a liquid, the boiling point of the liquid will- A. Increase. B. Decrease. C. Increase then decrease. D. Remain the same.
22.	What is the boiling point of pure water at sea level? A. 99 °C B. 103.7 °C C. 273 °C D. 100 °C
23.	Observe the graph plotted between molecular weight and the boiling point of alkanes and choose the most correct option.  Graph showing boiling point of the alkanes against relative mass Source: https://www.embibe.com/exams/alkanes/ A. It increases with an increase in molecular weight. B. It increases with decrease in molecular weight. C. It decreases with an increase in molecular weight. D. Its molecular weight does not affect the boiling point.
24.	Why is food cooked more quickly in a pressure cooker? A. Water boils at lower temperature. B. Water boils at higher temperature C. Vapour pressure is lowered. D. Presence of food elevates boiling temperature
25.	Observe the given table carefully and mention which of the following compounds has the lowest boiling point.

	 Source: https://tinyurl.com/42d64m7v A. H_2O B. ICl C. HCl D. F_2
V	**Preparation of standard solution of Sodium carbonate.**
26.	Shivam wanted to prepare M/20 sodium carbonate solution for acid base titration. He weighed 10.6 g of sodium carbonate in the two-pan balance available in his school lab. After performing titration, he did not get an accurate result. His teacher told him that there is some error in weighing. Which of the following points he missed-  Source: https://www.indiamart.com/proddetail/chemical-balance-2243507355.html A. He cleaned the pans of the balance with a hairbrush. B. He leveled the balance by adjusting the leveling screw. C. He placed weights and fractional weights with wet hands. D. He took a clean and dry watch glass & kept an appropriate amount of salt in it.
27.	True/False: The equivalent mass of H_2SO_4 is 98u.
28.	What is the molarity of the solution obtained by diluting 13.9 ml of 18 M H_2SO_4 to 100 ml? A. 0.25 M B. 1.8 M C. 18 M D. 2.5 M
29.	Which one of the following is the Normality equation? A. $N_1N_2 = V_1V_2$ B. $N_1+V_1 = N_2+V_2$ C. $N_1/V_2 = N_2/V_1$ D. $N_1V_2 = N_2V_1$
30.	Shalini wanted to weigh a substance with the help of a two-pan balance. She found that the imprint on fractional weights had faded. Can you help her to identify the fractional weights?  Source: https://th.bing.com/th/id/OIP.CRjUDnX1kliUijgIDhSDWwHaHd?pid=ImgDet&rs=1 She may identify them by A. shape B. size C. color D. thickness
VI	**Determination of strength of a given solution of hydrochloric acid by titrating it against standard sodium carbonate solution.**
31.	What is the indicator used in strong base-weak acid titration? A. Potassium permanganate B. Phenolphthalein C. Methyl yellow D. Methyl orange
32.	True/False: Last drop of the solution should not be blown out of the jet end of the pipette because pipette is calibrated using this liquid into account. Source: https://tinyurl.com/yc32dwzs 
33.	What is an indicator? A. It is a chemical substance which changes colour at the end point. B. Solution of known concentration to determine the concentration of unknown solution. C. A solution of unknown concentration whose strength is to be determined. D. An indicator is a catalyst.
34.	True/False: The number of replaceable hydrogen atoms in a molecule of the acid is known as the basicity of an acid.
35.	Which meniscus is customary to read in case of colourless and transparent solutions?

		Source: http://soft-matter.seas.harvard.edu/index.php/Drops,_menisci,_and_lenses A. Upper meniscus. B. As per choice. C. Lower meniscus. D. None of the above.
36.	What is the pH of the solution obtained by the reaction between equivalent amount of a strong acid and a strong base? A. 14 B. <7 C. >7 D. 7	
37.	What is the difference between endpoint and equivalence point in an acid base titration? A. end point and equivalence point are same B. end point is achieved before the equivalence point. C. end point is the visible change and equivalence point is the actual completion of reaction. D. end point is the actual completion of reaction and equivalence point is the visible change.	
VII	**Crystallization of impure sample of benzoic acid**	
38.	Complete the sentence- The most important characteristic of a crystal is	
39.	Identify the shape of Benzoic acid crystals?	
		Source: https://en.wikipedia.org/wiki/Benzoic_acid A. Tetrahedral B. Octahedral C. Needle shaped. D. Monoclinic
40.	What is Mother Liquor? A. Definite number of water molecules present with one formula unit of the compound. B. Liquid left behind after the separation of crystals from a saturated solution. C. Liquid, used to prepare a saturated solution of the solute. D. It is the hot saturated solution	
41.	If the crystals obtained are very small after the process of crystallization, what does it indicate? A. Solution has been concentrated more than that required for the crystallization stage. B. Solution has been concentrated less than that required for the crystallization stage. C. Reaction is in equilibrium. D. Reaction is irreversible.	
VIII	**Crystallization of impure sample of Copper Sulphate**	
42.	What is the crystal structure of blue vitriol?	
		Source: https://tinyurl.com/3xxkzbnw A. Monoclinic. B. Triclinic. C. Cubic. D. Octahedral.
43.	What is an example of crystalline solid? A. Quartz. B. Fused silica. C. Glass. D. Plastic.	
44.	What is the chemical formula of blue vitriol? A. $CuSO_4$ B. $CuSO_4.5H_2O$ C. $FeSO_4.5H_2O$ D. $FeSO_4.7H_2O$	
45.	What is the role of seeding in crystallization? A. It helps in the purification of crystals. B. It helps the crystals to achieve the desired shape and size. C. It does not have any important role. D. It helps in quick separation of crystals from saturated solution.	
IX	**Determination of sulphide anion in a given salt**	
46.	True/False: The sulphide salts smell like that of rotten eggs.	
47.	Which of the following gases can turn the lead acetate paper black?	

48.		Source: https://tinyurl.com/598ajd2v A. H_2S B. NH_3 C. NO_2 D. SO_2
49.	Name a gas which turns lime water milky other than CO_2 A. H_2S B. NH_3 C. NO_2 D. SO_2	
50.	Complete the sentence- When sodium sulphide reacts with sodium nitroprusside, It forms a violet complex $Na_4[Fe(CN)_5NOS]$. The charge on the anion is	 Source: https://tinyurl.com/yckmjhw3
X	**Determination of nitrate anion in a given salt**	
51.	Complete the sentence- When freshly prepared $FeSO_4$ solution is added to nitrate salt aqueous solution and afterwards..... is poured slowly along the sides of the test tube, a brown ring is formed as shown in the pic.	 Source: https://illumina-chemie.de/viewtopic.php?t=4407&start=30
52	True/False: Dark Red colouration is observed in the confirmatory test of nitrate ion in the salt when diphenylamine is added to it.	
XI	**Determination of chloride anion in a given salt**	
	The colour of the fumes observed when concentrated sulphuric acid is added to a chloride salt? A. Red B. Brown C. Black D. Colourless	
53.	Complete the sentence- The colour of the final precipitate observed in the chromyl chloride confirmatory test of chloride ion is.....	
54.	Which of the following gases evolves when concentrated sulphuric acid is added to a chloride salt? A. H_2S B. NH_3 C. HCl D. SO_2	
55.	True/False: When sodium hydroxide is added to silver chloride precipitate, a completely soluble complex is formed	
XII	**Determination of bromide anion in a given salt**	
56.	What is the colour of the fumes observed when concentrated sulphuric acid is added to a bromide salt? A. Red B. Reddish Brown C. Black D. White	
57.	Which of the following gas evolves when a bromide salt is acidified with dil. HCl acid for chlorine water test? A. H_2S B. HBr C. HCl D. Br_2	
58.	Complete the sentence- The colour imparted to the carbon disulphide layer in chlorine water test for the bromide ion is.....	
59	True/False: When ammonium hydroxide is added to light yellow silver bromide precipitate, a partially soluble complex is formed.	
XIII	**Determination of sulphate anion in a given salt**	
60.	The colour of the precipitate observed in Barium Chloride test of Sulphate salt is A. Red B. Reddish Brown C. Black D. White	
61.	True/False: The precipitate observed in the Barium Chloride test of Sulphate salt is soluble in dil. HCl.	
62.	Few drops of lead acetate solution is added to the sulphate aqueous solution. A white ppt is observed. What is the chemical name of the white ppt?	
		Source: https://www.sciencephoto.com/media/4683/view/barium-sulphate-precipitation A. Lead sulphate B. Barium sulphate C. Sodium sulphate D. Sodium acetate
XIV	**Determination of phosphate anion in a given salt**	
63.	Complete the sentence- The colour of precipitate observed in confirmatory test of phosphate salt with conc. HNO_3 and ammonium molybdate is	

XV	**Determination of ammonium cation in a given salt**
64.	Name a cation which is not obtained from a metal. A. Pb^{2+} B. Mg^{2+} C. NH_4^+ D. As^{3+}
65.	Complete the sentence- The gas evolved when sodium hydroxide is added to an ammonium salt is .....
66.	Which one of the following reagents is used to test the presence of ammonium ion in a given salt? A. Nessler's reagent B. Ammonium thiocyanate C. Potassium ferrocyanide D. Dimethyl glyoxime
67.	Complete the sentence- When sodium hydroxide is added to an ammonium salt, a gas is evolved. To confirm its presence, a rod dipped in HCl is brought near the mouth of the test tubes which evolves .....colour fumes.
XVI	**Determination of lead cation in a given salt**
68.	Which one of the following belongs to Group I & 2 cation? A. Pb^{2+} B. Mg^{2+} C. NH_4^+ D. Co^{2+}
69.	What is the name of the product obtained by the reaction of lead ion with potassium iodide solution?
	 Source: https://tinyurl.com/4nf68abm A. Lead chromate B. Lead dichromate C. Lead oxide D. Lead iodide
70	Complete the sentence- Group reagent for group I cations is .....
XVII	**Determination of iron cation in a given salt**
71.	Complete the sentence- Group reagent for group III is .....
72.	True/False: Ammonium sulphate can be used instead of ammonium chloride for the precipitation of Iron cation.
73.	What is the colour of the salt containing Fe^{+3} ions? A. White B. Green C. Yellow D. Brown
74.	Iron salt aqueous solution is added with NH_4Cl, heated, cooled and dropped the liquid ammonia solution in excess. A reddish-brown precipitate is obtained. When potassium sulphocyanide is added to the ppt, which coloration confirms the presence of Iron? A. Prussian blue B. Green C. Blood Red D. Brown
75.	What is the colour of the salt containing Fe^{+2} ions? A. White B. Green C. Yellow D. Brown
XVIII	**Determination of nickel in a given salt**
76.	Nickel ion gets precipitated with hydrogen sulphide gas in the presence of acidic medium only. A. True B. False
77.	What is the colour of the salt containing Ni^{+2} ions? A. Buff White B. Bluish Green C. Crimson Red D. Dark Brown
78.	When H_2S gas is passed through the ammoniacal solution of group IV cations, which colour precipitate indicates the presence of nickel cation? A. Dull White B. Bluish Green C. Black D. Flesh colour
79.	Complete the sentence- The colour of the Nickel DMG complex obtained during the confirmatory analysis of Nickel is .....
80.	When H_2S gas is passed through the ammoniacal solution of group IV cations, which cation gives the same colour precipitate as that of nickel cation? A. Co^{+2} B. Zn^{+2} C. As^{+2} D. Mn^{+2}
XIX	**Determination of barium, strontium & calcium cation by flame test in a given salt**
81.	Ca^{2+} ion gives..... color when inserted in blue flame. A. Pink-violet B. Golden yellow C. Brick-red D. Crimson red
82.	Shalini and shivam performed flame test to identify barium ion. Shalini got the beautiful apple green flame but shivam did not. What could be the reason?
	 Source: https://www.sciencephoto.com/media/5158/view/barium-flame-test A. Shivam performed the test with a Pt wire. B. Shivam inserted Pt wire in a luminous flame. C. Shivam inserted Pt wire in non-luminous flame D. Shivam prepared the paste of the salt in Conc. HCl
83.	Strontium salt is mixed with conc. HCl and when inserted in outer flame via Pt wire gives crimson red color. Why is it advised to make a paste in conc. HCl?

		Source: https://tinyurl.com/2p8dwe3e A. Conc. HCl is an oxidizing agent. B. Conc. HCl is reducing agent. C. Conc. HCl converts salt into chloride which is volatile in non-luminous flame. D. Conc. HCl converts salt into chloride which is non-volatile in non- luminous flame.
84.	Rows have cations and columns have their group reagent. Match the columns with the rows and tick the most appropriate option. Rows Columns 1.Aluminium ion a Hydrogen Sulphide gas 2.Nickel ion b Ammonium carbonate solution 3.Barium c Sodium hydroxide solution 4.Ammonium d Ammonium hydroxide solution **Options** A. 1-d, 2-c, 3-b, 4-a B. 1-b, 2-c, 3-d, 4-a C. 1-d, 2-a, 3-b, 4-c D. 1-c, 2-d, 3-a, 2-b	

Appendix B

ANSWER KEY

Q1- FALSE, Q2- A, Q3 -A, Q4- B, Q5 -C, Q6- C, Q7 -D, Q8- TRUE, Q9- A, Q10- A, Q11- pH + pOH= 14, Q12-B, Q13- B, Q14- A, Q15- A, Q16- UNIFORM, Q17- TRUE, Q18-B, Q19- increases, Q20- FALSE, Q21- A, Q22- D, Q23- A, Q24- B, Q25- D, Q26- C, Q27- FALSE, Q28-D, Q29- C, Q30- A, Q31- B, Q32- TRUE, Q33- A, Q34- TRUE, Q35- C, Q36- D, Q37- C, Q38- GEOMETRY/ SHAPE, Q39- C, Q40-B , Q41-A, Q42- B, Q43-A, Q44- B, Q45-D, Q46- TRUE, Q47-A , Q48-D, Q49- 4- , Q50- CONC. Sulphuric Acid, Q51-FALSE, Q52-D, Q53-YELLOW, Q54- C, Q55- TRUE, Q56- B, Q57- D, Q58- PALE YELLOW, Q59- TRUE, Q60- D, Q61- FALSE, Q62- A, Q63-CANARY YELLOW , Q64- C, Q65- AMMONIA , Q66-A, Q67- WHITE FUMES, Q68- A, Q69-A, Q70- DIL HCl , Q71- AMMONIUM HYDROXIDE, Q72- FALSE, Q73- C, Q74- C, Q75- C, Q76- FALSE, Q77-B, Q78- C, Q79- ROSE RED, Q80- A, Q81- C, Q82- B, Q83- C, Q84- C.