

Factorial Validation of an Instrument for the Assessment of Practical Chemistry Skills Acquisition

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Abstract

This study developed and validated an instrument, for assessing secondary school students' practical chemistry skills acquisition in qualitative analysis. Three research questions guided the study. It was an instrumentation research design. An instrument known as Qualitative Analysis Observation Schedule (QAOS) was developed. It was first validated facially and then factorially by subjecting it to factor analysis to establish the construct validity at the end of which 35 items emerged as valid items. The instrument was then trial tested on 30 students used as a representative sample outside the study area. Cronbach's alpha reliability technique and kendall's coefficient of concordance (ω) were used to establish the internal consistency and inter-rater reliability coefficients of the instrument respectively. It was recommended that the instrument be adopted by examining bodies for use, as it has been found to be valid and reliable.

Keywords: Factorial validation, Instrument, Reliability, Practical chemistry skills Qualitative analysis

Introduction

Chemistry is an important science subject that occupies a prominent place in school science curriculum. It touches virtually on all aspects of life. It is one of the basic prerequisites for the study of all science based disciplines. Chemistry according to Njelita (2007, p.30) is a practical oriented subject which demands proper exhibition of science process skills acquisition and concept for effective interpretation of existing phenomena. It is an experimental science that demands a high standard of experimental work for its development and application (Bernett & O'Neala 1998).

Practical work in science require valid measuring instruments that can identify, assess and score skills acquisition Practical works, therefore, need to be properly assessed with valid and reliable instrument to ensure the acquisition of these skills. Sindu & Sharma (1998, p.35) opined that the importance of practical work in science demands attention to finding out valid, reliable and practicable assessment system that can test science process skills acquisition.

Chemistry practical skills are science process skills which include observation, classification, measurement, experimentation, manipulation, recording of data, communication, prediction, inference, formulation of models, controlling variables, formulation of hypothesis, making operational definition etc. Assessment of acquisition of these skills in Nigerian secondary schools in both internal and external examinations like West African Examination Council (WAEC) has always been done with the conventional paper and pencil test that cannot measure skills acquisition to any appreciable level of accuracy. This instrument assesses only the products and not the processes as it cannot identify, assess and score most of these skills and so cannot be said to be valid or reliable for assessing practical skills acquisition.

Besides, it has come to be realized over the past few years that the traditional techniques of assessment (like examinations involving paper and pencil tests) are very unreliable and are not really achieving the intended result (Reece & Walker, 2006, p.324) They only assess the end products and completely neglected the processes involved in achieving the products. This is apparently unacceptable since it is through the processes that the skills are inculcated and acquired. Assessment according to Ojokuku (2008, p.158) remains the most important and appropriate technique to be used in determining whether learning has taken place or not. Valid and reliable assessment instruments, therefore, becomes indispensable especially on skills acquisition.

The importance of a valid and reliable assessment instrument for assessing educational outcomes has been well recognized (Ayogu & Nworgu, 1999, p.217). The issue at stake is on the availability of valid and reliable assessment instrument that can identify, assess and score practical skills acquisition in practical work. Although several researchers (Esemonu & Onunkwo, 2004, Okeke, Akusioba & Okafor, 2004, Omoifo & Oloruntegbe, 1999) have tried to develop and validate instruments for assessing the acquisition of science process skills, their works were on integrated science mainly and not on chemistry, physics, biology, etc. Moreover the validity of the instruments cannot be said to be adequately guaranteed as most of them went for the casual face or content validation.

Validity and reliability are two very essential characteristics of educational tools for measurement. The usage and acceptability of any measuring instrument like test depends highly on its validity and reliability. Among the three main types of validity - content, construct and criterion related validity; it is only construct validity that can be used on skills acquisition in question. Abonyi (2005, p.45) refers to construct validity as the degree to which scores on a measure permit inference about underlying traits. This is the kind of validity that is ideal for any instrument that should measure skill acquisition.

Factor analysis is a means of determining the construct validity of an instrument. It operates by extracting as many significant factors from your data as possible based on the bivariate correlations between your measures (Avwokeni, 2007, p.157). It has the distinctive characteristics of reducing data. Factor analysis ends with a table that shows the weight or loading of the factors in each item (Factor matrix). These factor loadings represent the degree of correlation of each item to the factor and this determines the factorial validity of the item. A positive factor loading indicates that a variable is positively correlated with the underlying dimensions while a negative loading means that a negative correlation exists.

The objective of this study is to develop and factorially validate an instrument for assessing practical chemistry skills' acquisition in qualitative analysis aspects of practical chemistry. Specifically, the study intended to:

i. generate items for measuring practical chemistry skills acquisition in qualitative analysis aspect of practical chemistry.

ii. Establish the construct validity of the items by subjecting them to factor analysis.

iii. Establish the reliability of the instrument.

iv. Establish the inter-rater reliability coefficient of the instrument.

Research Questions

i. What is the construct validity of the qualitative analysis observation schedule items?

ii. What is the internal consistency reliability coefficient of the items?

iii. What is the inter-rater reliability coefficient of the items?

Development of the instrument

The instrument was development through the following processes:-

i. Identification and selection of practical chemistry skills through review of literature, consultation of chemistry curriculum and interview of some chemistry teachers;

ii. Writing of statement of activities portraying the skills acquired to be carried out by the students;

iii. Attachment of a four-point likert type rating scale to the statements to guide the rating of students' performances.

A total of forty-two (42) items were generated as qualitative analysis observation schedule (QAOS) – the instrument. The (QAOS) is a 42-item, 4-point Likert type scale of very good, good, fair and poor distributed unevenly among ten skills that were taken into consideration during the development and these included observation, classification, recording, measurement, controlling variables, experimenting, communication, inference, interpretation of data and prediction. The item statements are meant to measure the students' ability to carry out the activities as a sign of acquisition of these skills. A rating guide developed by the researcher was used in measuring the students' level of performance on the activities.

Validation of the Instrument (QAOS)

The instrument and the rating guide were validated facially by three experts in science education, measurement and validation and 2 experienced chemistry teachers. Their suggestions were used in modifying the instrument and the rating guide. The instrument was then subjected to factor analysis of the varimax rotation type using Statistical Package for Social Sciences (SPSS) version 6.0 computer software. Strong factors were sieved out from weak ones by assigning factor loadings to each item in each of the nine clusters found at the end of the factor analysis. Valid (strong) items were selected using Meredith's (1969) bench mark of 0.35 and above.

Table 1: Summary of Factor Analysis of Qualitative Analysis Items and the Factor Loadings

Skills	No of Items Selected	Item Loading	Impure Items	Complex Items	Total Number of Items Selected	Total Number of Items not selected
Observation	1.	0.82843	-	2	8	1
	3.	0.83945	-	-	-	-
	4.	0.96441	-	-	-	-
	5.	0.86386	-	-	-	-
	6.	0.37278	-	-	-	-
	7.	0.91457	-	-	-	-
	8.	0.36644	-	-	-	-
	9.	0.51262	-	-	-	-
Classification	10.	0.56002	-	-	3	-
	11.	0.88948	-	-	-	-
	12.	0.83213	-	-	-	-
Recording	13.	0.96620	-	-	4	-
	14.	0.83751	-	-	-	-
	15.	0.61153	-	-	-	-
	16.	0.47217	-	-	-	-
Measurement	17.	0.37783	-	-	-	-
	19.	0.75933	-	18	2	-
Controlling variables	20.	0.64360	-	-	3	1
	21.	0.87574	-	-	-	-
	22.	0.54183	-	-	-	-
Experimenting/ Manipulating	23.	0.40096	26	-	4	1
	24.	0.45603	-	-	-	-
	25.	0.67899	-	-	-	-
	27.	0.51899	-	-	-	-
Communication	28.	0.72903	-	29	3	2
	30.	0.95475	-	31	-	-
	32.	0.52903	-	-	-	-
Inference	33.	0.78846	-	-	-	-
	34.	0.48414	-	36	3	1
Interpretation of Data	35.	0.59658	-	-	-	-
	37.	0.95963	-	-	-	-
	39.	0.60723	-	38	2	1
Prediction	40.	0.47358	-	-	-	-
	41.	0.58230	-	-	3	-
	42.	0.85258	-	-	-	-
Total	35		1	6	35	7

Table 1 showed the summary of factor analysis of qualitative analysis items from the factor matrix not shown here. It can be seen that ten skills were extracted and each skill has some items loaded on it. The skills as shown above include observation, classification, recording, measurement, controlling variable, experimenting, communication, inference, interpretation of data, and prediction. For understanding of the summary of the factor analysis of qualitative analysis items and the factor loadings, it is important to note that Meredith (1969) bench mark of 0.35 and above was used in selecting the items. Based on this, items without factor loading up to 0.35 were considered factorially impure and not selected, while items with factor loading of 0.35 or more on more than one factor is considered factorially complex and thus not selected too. Based on this criterion, 35 items as shown in Table 1 were selected from 42 items that went for factor analysis while 7 items were rejected on the basis of being either factorially impure or factorially complex. These are considered valid items.

Trial –testing of the Instrument

The instrument was trial tested on representation samples of 30 students outside area of study. Three trained chemistry teachers were used to observe and rate the students while the activities were going on using the instrument and the rating guide. Scores of each student were summed up and used in determining the reliability of the instrument.

Reliability of the Instrument

For the establishment of both internal consistency and inter-rater reliability coefficients, SPSS version 6.0 computer software was used. Cronbach's alpha reliability technique was used to determine the internal consistency reliability coefficients of the items (instrument) while Kendall's coefficient of concordance (ω) was used to establish the inter-rater reliability coefficient of the items.

Table 2: Summary of Internal Consistency Reliability Coefficients of Qualitative Analysis Items

Factors (Skills)	No of Items Loaded	Internal Consistency Reliability Coefficient
Observation	8	0.6861
Classification	3	0.7046
Recording	4	0.8789
Measurement	2	0.5571
Controlling Variables	3	0.6475
Experimenting/Manipulating	4	0.6481
Communication	3	0.9552
Inference	3	0.5312
Interpretation of Data	2	0.9700
Prediction	3	0.8147
Overall	35	0.9237

From table two above, the summary of the internal consistency reliability coefficient of the qualitative analysis items using Cronbach alpha reliability technique ranges from 0.5312 to 0.9552. The overall internal consistency reliability coefficient is 0.9237. This is high, indicating that the instrument is reliable. The instrument is, therefore, valid and reliable for identifying, assessing and scoring practical chemistry skills acquisition.

Table 3: Summary of inter-rater reliability coefficient of qualitative analysis items of QAOS (Coefficient of concordance)

S/No	Factors/ Clusters	Items	Coefficient of Concordance
1	Observation	1,3,4,5,7,8,9	0.818
2	Classification	10,11,12	0.818
3	Recording	13,14,15,16	0.933
4	Measurement	17,19	0.934
5	Controlling variables	20,21,22	0.939
6	Experimenting/Manipulating	23,24,25,27	0.817
7	Communication	28,30,32	0.979
8	Inferences	33,34,35	0.778
9	Interpretation	37,39	0.750
10	Prediction	40,41,42	0.933
	Overall		0.718

Table 3 shows the summary of the inter rater reliability coefficients of the qualitative analysis items. These range from 0.750 – 0.979 with an overall reliability index of 0.718 for the entire items.

This is high indicating that there is agreement among the raters and so it has scorer reliability.

Discussion

From the summary of the factor analysis, it is shown that all the skills of QAOS are valid. This is in agreement with Meredith (1969) who submitted that an item should have a factor loading of 0.35 and above for it to have construct validity. All the items under the 10 skills have factor loading of 0.35 and above and so they have construct validity. It, therefore, means that QAOS items adequately represent various skills of QAOS in respect of skills acquisition in practical chemistry. This implies that skills acquired by students in practical chemistry can be identified, assessed and scored against the traditional paper and pencil technique of assessment.

The high reliability index coefficient is a confirmation of high inter-item consistency which is dependable and reliable. This implies that QAOS can reliably and dependably measure skills acquisition in practical chemistry to high level of accuracy. This is in agreement with Omoifo & Oloruntegbe (1999, p. 46) who submitted that several science process skills are better assessed with on the spot assessment technique combined with the traditional paper and pencil tests.

Recommendation

Based on the findings of the study, the researcher recommends that chemistry teachers and examining bodies like WAEC and NECO should adopt this instrument in addition to the traditional paper and pencil assessment technique in assessing students in qualitative analysis aspect of practical chemistry. On another angle, for effective use of the instrument, chemistry teachers should be organized for training/workshop on how to use the instrument in assessing practical chemistry skills acquisition.

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Appendix A:
Qualitative Analysis Observation Schedule Items (QAOS)

S/No	Practical activities	Scale			
	Observation skill	**4**	**3**	**2**	**1**
1	Detecting effervescence or evolution of gas when a solution is added to a solid or when a solid is heated				
2	Recognizing the colour of the precipitate formed during chemical reactions				
3	Detecting the colour of the gases evolved from chemical reactions				
4	Detecting the odour of gases evolved from chemical reaction				
5	Recognizing the effects of solutions on colour of litmus papers				
6	Recognizing the effects gases evolved on colour of litmus paper				
7	Detecting the effect of adding reagents to samples in dropwise and in excess				
8	Recognizing the effect of gases evolved on limewater				
	Classification Skill	**4**	**3**	**2**	**1**
9	Separating mixtures into residues and filtrate by filtration process				
10	Grouping gases according to their odour like odourless for CO_2 gas, choking and irritating for NH_3 gas, rotten egg smell for SO_2 gas, irritating for NO_2 gas etc				
11	Grouping solution as acidic, alkaline or neutral following their action on red or blue litmus paper				
	Recording/Reporting Skill	**4**	**3**	**2**	**1**
12	Tabulating activities for identification of salt into test, observation and inferences				
13	Writing down concisely the test carried out				

14	Writing down observation made at every stage of the experiment				
15	Writing down inferences made form observation				
	Measurement Skill	**4**	**3**	**2**	**1**
16	Using exact quantities of required reagents				
17	Being accurate on the drops of reagents to be added to sample before adding in excess				
	Controlling Variables	**4**	**3**	**2**	**1**
18	Washing test tubes properly and rinsing with distilled water before use to avoid contamination				
19	Rinsing the test tubes after each test				
20	Shaking the test tube on addition of a reagent into a substance in a test tube				
	Experimenting/Manipulative Skill	**4**	**3**	**2**	**1**
21	Setting up heating apparatus				
22	Holding test tubes in a slanting position with test tube holder and heating				
23	Folding filter paper and fixing it in a funnel for filtration of mixtures				
24	Heating substances in a conical flask				
	Communicating Skill	**4**	**3**	**2**	**1**
25	Using the correct technical terms in reporting results of experiment e.g 'decolourization' instead of 'disappear'				
26	Describing briefly and correctly observations made				
27	Using the correct chemical symbol and formulae in recording the tests carried out				
	Inference Skill	**4**	**3**	**2**	**1**
28	Inferring/ naming correctly the gas evolved through its colours, odours or action on some compounds				
29	Confirming the ions present in a sample of salt through its reaction with some reagents				
30	Inferring correctly, the nature of gas evolved in terms of acidic, alkaline or neutral through its action on red or blue litmus paper				
	Interpretation of Data	**4**	**3**	**2**	**1**
31	Making generalization based on data or observation				
32	Explaining correctly the observations made from reactions.				
	Prediction	**4**	**3**	**2**	**1**
33	Suspecting correctly the ions present in a sample of salt from the observation made before confirmatory test				
34	Suspecting correctly the compound(s) in a sample of a salt given from the physical state of the sample				
35	Suspecting correctly the nature of gas evolved				

Appendix B

A MARKING GUIDE FOR QUALITATIVE AND QUANTITATIVE ANALYSIS OBSERVATION SCHEDULE (QQAOS)

QUANTITATIVE ANALYSIS ITEMS

1. (a) Stating that there is effervescence or evolution of gas --- --- - 4 marks
   (b) Not using the correct terminology (effervescence) --- --- 3 marks
   (c) Being silent about effervescence --- --- --- --- 2 marks
   (d) Being completely silent about gas --- --- --- --- 1 marks

2.	(a)	Stating correctly the colour of precipitate formed ----- --- -----	4 marks
	(b)	Stating incorrectly the colour of ppt formed --- --- ---	2 marks
	(c)	Stating that there is ppt but silent about the colour --- ---	3 marks
	(d)	Silent about precipitate (ppt) and its colour --- --- ---	1 marks
3.	(a)	Stating correctly the gas evolved and its colour ---- --- ---	4 marks
	(b)	Stating correctly the gas evolved but incorrectly the colour of the gas ---	3 marks
	(c)	Stating incorrectly the gas evolved but getting the colour correct ---	2 marks
	(d)	Silent about gas evolved and its colour --- ---	1 marks
4.	(a)	Stating correctly the gas evolved and its odour correctly --- ---	4 marks
	(b)	Stating correctly the gas evolved but incorrectly the odour of the gas- -	3 marks
	(c)	Stating the gas evolved but silent about the odour --- ---	2 marks
	(d)	Silent about the gas evolved and the odour --- ---	1 marks
5.	(a)	Stating the effect of solutions on the colour of both blue and red litmus paper correctly - - -	4 marks
	(b)	Stating the effect of solutions on blue litmus paper correctly but silent on red litmus paper - - -	3 marks
	(c)	Stating incorrectly the effect of solutions on either one of the two- -	2 marks
	(d)	Silent about the effect of solutions on litmus paper- - - -	1 marks
6.	(a)	Recognizing correctly the effect of gases evolved on the colour of both litmus paper - - - - - - -	4 marks
	(b)	Recognizing correctly the effect of gases evolved on either on of them -	3 marks
	(c)	Recognizing incorrectly the effect of gases evolved on the colour of both litmus paper - - - - - -	2 marks
	(d)	Silent about the effect of gases evolved on the colour of both litmus -	1 marks
7.	(a)	Stating correctly the effect of adding reagent to sample in drop-wise and in excess -- - - - - -	4 marks
	(b)	Stating the effect of adding reagents to samples drop wise but not in excess-	3 marks
	(c)	Stating correctly the effect of adding reagents to samples in excess but not in drop wise - - - - - -	2 marks
	(d)	Silent about both-- - - - - - -	1 marks
8.	(a)	Stating correctly the effect of gasses evolved in limewater - - -	4 marks
	(b)	Stating wrongly the effect of gases evolved in limewater- - -	3 marks
	(c)	Stating the effect of gases on limewater but with wrong formula of limewater -	2 marks
	(d)	Silent about the effect of gases evolved on limewater - - -	1 marks
9.	(a)	Ability to fold the filter paper correctly and fix in a funnel and ability to pour the mixture gradually to avoid mixing up- - -	4 marks
	(b)	Ability to fold filter paper and fix in the funnel but not able to pour mixture gradually - - - - - -	3 marks
	(c)	Ability to fold filter paper but not able to fix in the funnel - - -	2 marks
	(d)	Inability to even fold the filter paper --- --- --- - -	1 marks
10.	(a)	Stating correctly the gas evolved and the odour of the gas evolved - -	4 marks
	(b)	Stating correctly the gas evolved but wrongly the odour of the gas evolved-	3 marks
	(c)	Stating incorrectly the gas evolved but correctly the odour of the gases evolved-	2 marks
	(d)	Stating both the colour and odour of the gas evolved wrongly-- -	1 marks
11.	(a)	Correct grouping of solution based on their action on red or blue litmus paper-	4 marks
	(b)	Wrong grouping of solutions based on their actions on red or blue litmus paper-	3 marks
	(c)	Grouping correctly but not based on their actions on red or blue litmus paper-	2 marks
	(d)	Not carrying out any test at all.- - - - - -	1 marks
12.	(a)	Tabulating the work into 3 and writing the heading correctly- - -	4 marks

	(b)	Mudding up of tests and observation- - - - -	3 marks
	(c)	Muddling up the 3 activities together- - - -- -	2 marks
	(d)	Not tabulating at all- - - - - - -	1 marks
13	(a)	Consistently writing concisely the test carried out - - - -	4 marks
	(b)	Inconsistently writing correctly the tests carried out- - - -	3 marks
	(c)	Consistently writing the tests carried out wrongly- - - -	2 marks
	(d)	Not writing the test carried out at all- - - - -	1 marks
14	(a)	Consistently writing observation made at every stage of the experiment correctly-	4 marks
	(b)	Inconsistently writing observation made at every stage of the experiment correctly- - - - - - -	3 marks
	(c)	Consistently writing wrongly the observation made at every stage or very rarely- - - - - - -	2 marks
	(d)	Not writing observation made at all - - - - -	1 marks
15	(a)	Consistently writing inferences made from observations correctly- -	4 marks
	(b)	Inconsistently writing correctly inferences made from observation- -	3 marks
	(c)	Consistently writing wrongly inferences made from observation- -	2 marks
	(d)	Not writing inferences made at all- - - - - -	1 marks
16.	(a)	Consistently adding reasonable quantities of reagents to samples- -	4 marks
	(b)	Inconsistently adding reasonable quantities of reagent to sample - -	3 marks
	(c)	Consistently over pouring of quantities of reagents to samples - -	2 marks
	(d)	Consistently pouring less quantities of reagents to samples- - -	1 marks
17.	(a)	Consistently adding adequate drops of reagents to the samples- -	4 marks
	(b)	Adding adequate drops of reagents to the samples but not consistent- -	3 marks
	(c)	Adding excess drops of reagents to the samples most of the time- -	2 marks
	(d)	Always adding excess drops of reagents to the samples- - -	1 marks
18.	(a)	Washing test tubes with soap solution and rinsing with distilled water -	4 marks
	(b)	Washing test tubes with soap solution and rinsing with ordinary water -	3 marks
	(c)	Washing test tube without soap but rinsing with distilled water - -	2 marks
	(d)	Using test tubes without washing it- - - - -	1 marks
19	(a)	Consistently rinsing test tubes with distilled water after each test- -	4 marks
	(b)	Inconsistently rinsing test tubes with distilled water after each test- -	3 marks
	(c)	Consistently rinsing test tubes with ordinary water after each test- -	2 marks
	(d)	Not rinsing the test tube at all after reach use- - - -	1 marks
20	(a)	Shaking the test tube each time a reagent is added- - - -	4 marks
	(b)	Shaking the test tube on adding of a reagent but not consistent - -	3 marks
	(c)	Shaking the test tube on adding of a reagent rarely - - -	2 marks
	(d)	Not shaking the test tube at all- - - - - -	1 marks
21.	(a)	Ability to connect the Bunsen burner, open the gas cylinder, light and regulate a flame - - - - - -	4 marks
	(b)	Ability to connect the Bunsen burner, open the gas cylinder, light but unable to regulate a flame- - - - - -	3 marks
	(c)	Ability to connect the Bunsen burner, open the gas cylinder, but not light a flame- - - - - - -	2 marks
	(d)	Inability to connect the Bunsen burner and open the gas cylinder- -	1 marks
22.	(a)	Proper holding of the test tube in a slant position with test tube holder while heating and directing the mouth of the tube away from people- -	4 marks
	(b)	Proper holding of the test tube in a slant position with test tube holder while heating but with the mouth of the tube towards someone- -	3 marks
	(c)	Holding the test tube vertically with test tube holder while - - -	2 marks

	(d)	Holding the test tube with ordinary paper but unable to heat- - -	1 marks
23.	(a)	Clamping a funnel, folding filter paper properly and fixing it in the funnel -	4 marks
	(b)	Clamping a funnel, not folding filter paper properly and fixing it in the funnel-	3 marks
	(c)	Clamping a funnel but unable to fit a filter paper into it- - -	2 marks
	(d)	Inability to clamp a funnel and fit a filter paper in it- - - -	1 marks
24.	(a)	Using tripod stand with wire guaze and placing conical flask on it- -	4 marks
	(b)	Using a tripod stand without wire guaze and placing conical flask on it- -	3 marks
	(c)	Holding the conical flask with ones hand while heating- - -	2 marks
	(d)	Inability to heat substances in a conical flask- - - -	1 marks
25	(a)	Consistently using correct technical terms like gases evolved- - -	4 marks
	(b)	Insistently using correct technical terms- - - - -	3 marks
	(c)	Rarely using correct technical terms- - - - -	2 marks
	(d)	Not using technical terms at all- - - - - -	1 marks
26	(a)	Consistently describing briefly and correctly observations made like precipitate which turned green on cooling - - - -	4 marks
	(b)	Inconsistently describing briefly and correctly observations made like precipitate which turn green on cooling - - - -	3 marks
	(c)	Consistent wrong description of the observation made - - -	2 marks
	(d)	No description of the observation made- - - - -	1 marks
27	(a)	Consistently using correct chemical symbols and formulae in recoding either observation or inference - - - - -	4 marks
	(b)	Consistently using either correct chemical symbols or formulae in recording either observation or inference- - - - -	3 marks
	(c)	Inconsistently using correct chemical symbols and formulae in recording observation and inference- - - - -	2 marks
	(d)	Consistent wrong use of chemical symbols and formulae in recording observation and inference - - - - - -	1 marks
28	(a)	Inferring correctly the gas evolved through its colour, odour or action with a reagent - - - - - - -	4 marks
	(b)	Inferring correctly the gas evolved though any two of its colour, odour and its action with reagents- - - - - -	3 marks
	(c)	Inferring correctly the gas evolved through any two of its colour, odour and its action with reagents- - - - - -	2 marks
	(d)	Inferring correctly the gas evolved though any two of its action with reagent -	1 marks
29.	(a)	Consistently confirming correctly the ions present in a sample of salt though its reactions with reagents - - - -	4 marks
	(b)	Inconsistently confirming correctly the ions present in a sample of salt though its reactions with reagents - - - -	3 marks
	(c)	Consistently confirming wrongly the ions present in a sample of salt through it reactions with reagents - - - - -	2 marks
	(d)	Not confirming at all the ions present in a sample of salt through its reactions with reagents- - - - - - --- --- ---	1 marks
30.	(a)	Inferring correctly the nature of gas evolved through its action on litmus paper-	4 marks
	(b)	Inferring incorrectly the nature of gas evolved though its action on litmus paper-	3 marks
	(c)	Inferring correctly the nature of gas evolved without its action on litmus paper -	2 marks
	(d)	No inference about the nature of gas evolved at all --- --- --- -	1 marks
31.	(a)	Making accurate generalization based on data or observation - -	4 marks
	(b)	Making practical inaccurate generalization based on data or observation-	3 marks
	(c)	Making completely wrong generalization based on data or observation -	2 marks
	(d)	Making no generalization based on data or observation --- --- ---	1 marks

32	(a)	Consistently explaining the observation made form reactions - -	4 marks
	(b)	Inconsistently explaining the observation made form reactions - -	3 marks
	(c)	Observing correctly some of the ions present but not all --- --- ---	2 marks
	(d)	Consistently observing wrongly the ions present --- --- --- -	1 marks
33	(a)	Consistently suspecting correctly the ions present in a sample of salt from observation made before confirmatory test. - - -	4 marks
	(b)	Suspecting correctly the ions present in a sample of salt from observation made before confirmatory test but not consistent- - - -	3 marks
	(c)	Suspecting correctly some of the ions present but not all- - -	2 marks
	(d)	Consistently suspecting wrongly the ions present --- --- --- -	1 marks
34	(a)	Consistently stating correctly the compounds in a sample of salt -	4 marks
	(b)	Inconsistently stating correctly the compounds in a sample of salt- -	3 marks
	(c)	Stating wrongly the compounds in a sample of salt - - -	2 marks
	(d)	No idea of the sample of salt form the physical state --- --- --- -	1 marks
35	(a)	Consistently suspecting correctly if the nature of gas evolved is acidic, alkaline or natural gas - - - - - -	4 marks
	(b)	Inconsistently suspecting correctly if the nature of gas evolved is acidic, alkaline or natural gas - - - - - -	3 marks
	(c)	Consistent wrong suspicion that the nature of gas evolved is acidic, alkaline or natural gas - - - - - -	2 marks
	(d)	Not suspecting the nature of gas evolved. --- --- --- - -	1 marks