# CHAPTER - V

## CONSTRUCTION OF TESTS-VALIDITY AND RELIABILITY

### Introduction

Three tests were constructed as a part of the study. The Entry Level Test was constructed to measure the achievement of students in chemistry laboratory skills at the begining of class XII. The Terminal Level Test was constructed to measure the achievement of students in chemistry laboratory skills at the end of class XII. Theory test (Pandit) was constructed to measure the theory achievement of students class XII.

### Entry Level Test

The Entry Level Test was constructed on the basis of needed chemistry laboratory skills for class XI. Among the 82 chemistry laboratory skills identified for the Entry Level Test, a test was constructed which consisted of 49 test items (15 manipulative type and 34 paper pencil type.) Subsequently the test was revised on the basis of suggestions of practising teachers and the faculty members of science education. Some of the suggestions made by them were that some test items(colour, odour, size) recognition are rather elementary but they make the test a good representative, students have no clear ideas about these experiments, Students feel skill

of measuring distances & pH are elementary and test items on volumeteric analysis and selection of glass apparatus were rated good. They wished there should have been more test items regarding volumeteric analysis, Test items regarding selection of chemicals, indications of (melting point/boilding point) & proper position of cork for boring were rated fairly good. Test items related fo calculation of amount dissolved, calculationof molarity from amount dissolved, calculation of molarity of unknown solution, choosing correct graph, Identifying a combustible gas were rated suitable to test the chemistry laboratory skills of class XI. Test items related to the heat indications of a chemical reaction, precipitating indications of a particular chemical change, identifying a particular solution with the help of litmus paper, identifying an electrolytic solution, reason to prepare original solution were also rated good. Test items related to heat of neutralisation and shift in Chemical Equilibrium were found to be difficult and unexpected one. These experiments are rearly done in practical classes. The items deleted in the first version of the Entry level, Test were comparison of heavyness, noting down the time, characterstics of the zones of a flame, scratcing technique of a glass tubing, application of pressure on a scratched

glass tubing, sequence of operations in calorific value determination, and calculation of heat of neutralisation.

The item of heavyness of liquids was dropped because experts expressed the opinion that responses may vary as per the individual and the test item is of an arbitrary nature. The test item on noting down time was dropped because there is not much of time study in the chemistry practical syllabus at this stage. The test item on study of zones of a flame, scratching technique and application of pressure on a glass tubing are too elementary since the student has been dealing with them for five years earlier. The test item on calorific value and heat of neutralisation were thought to be too lengthy for the time available for the test and therefore dropped. The test items on detecting the leak in an assembled apparatus, assembling the apparatus from the drawing and fitting up of wash bottle were split into two test items one dealing with the fitting up of the wash bottle and the second dealing with the detection of leaks in that assembly. The whole test was rated good by 25 experts for average students but commented that it does not pose any challenge to good students.

The second version of the Entry Level Test contained 42 test items (14 manipulative type and 28 paper pencil type). This test was also revised on the

basis of the opinions expressed by students and teachers. Some of the suggestions made by them were that test items regarding recognition of odour, bending a glass tube, weighing a substance are not reliable and cannot be done by everybody. Test items relating to the performing of volumetric titrations is not an easy test item. Test item relating to the finding of the correct graph has been objected on account of the sequence of data. The test item related to flame test has been objected since the results are not usually good. Some thought bending a glass tube, boring a cork are too elementary and as such should not be included in the test. Some experts pointed out that students are not at all concious about the quality of chemicals/glassware. They just work with whatever is provided to them. Some felt questions regarding melting and boiling points should be enlarged. Test item regarding the new compound formation and reasons for it should have been included. Experts expressed the oppinion that more test items on salt analysis should have been included. Some experts appreciated the presence of test items on chemistry laboratory skills of lower classes. They also expressed the oppinion that the test item regarding the combustability of a gas needs to be reworded.

The other suggestions were as following. The instructions regarding responses should be clear. The word odour should be used instead of smell. The word seat should be used instead of station. Some changes in the distractors of test items on boiling point/ melting point/litmus paper and characterstics of an acid were also suggested to be modified. Test item on volumeteric analysis was thought to be multiferious containing many skills. There were also suggestions that organic compounds should be included for odour recognition. The angle of bending a tube should not be specified. The dismentling of the apparatus was suggested to be included as one of the objectives in assembling the apparatus. Two experts expressed the oppinion that there should have been two or more test items about volumeteric titrations. Some experts felt many test-items were of a theortical nature.

The final version of the Entry Level Test contained 42 test items (14 manipulative type and 28 paper pencil type). The manipulative test items were recognition of(colour, odour) grading crystals of salts according to their size. Some of the other test items included in manipulative category were bending a glass tube, boring a cork. Assembling an apparatus from written instructions, identifying a leak in an assembled apparatus, measuring volumes in a graduated cylinder, weighing a

substance in a chemical balance, identifying a particular glass apparatus, measuring length and measuring pH of a solution and performing a volumeteric titration.

The paper pencil tests numbered twenty eight. They related to proper selection of chemicals and glassware, indications of boiling and melting points, proper position of a cork while boring, selection of proper measuring vessel, proper fitting of an apparatus, choosing a correct indicator, calculating the amount of substance required for preparation of a standard solution, calculating molarity of a solution from the amount dissolved, calculating the molarity of an unknown solution with the help of molarity equation, finding the correct graph related to a particular data, identifying a gas which supports combustion, identifying the correct heat indications of a chemical change, identifying the correct precipetating indications of a chemical change, identifying a solution with the help of colour change in a pH paper, identifying an electrolyte with help of glowing of a bulb, prepearing an origional solution, identifying a group in qualitative analysis, analysis of an individual radical, removing hydrogen sulphide from the salt solution, removing acidity from a solution, removing alkalnity from a solution, performing a flame

test, performing a charcoal cavity test, performing a borax bead test, Identifying strongest acid and strongest alkali, finding the shift in equilibrium of a chemical system.

## TERMINAL LEVEL TEST

The Terminal level Test was constructed on the basis of needed chemistry laboratory skills for Glass XII. Among the 50 relevant chemistry laboratory skills identified intially a test was constructed which consisted of 45 test items (16 manipulative tests items and 29 paper pencil test items).

The test items included in the first version were: The part (A) of the test contained following test items identifying the colour of a pigment - identifying the odour of a gas, - identifying a particular metal, - ranking salts according to their sizes, identifying a ring like shape, - identifying a surface with a rough texture, - assembling an apparatus from the diagram, - assembling an apparatus from the written instructions, identifying a boilding tube, comparision of heavyness of two similar bottles, - reading volumes of coloured and colourless solutions, selection of measuring vessel identifying an (acid/alkali) with the help of a pH paper, determining the weight of an object, measuring the length of a glass tubing, - performing a volumeteric titration.

The Part (B) of the test contained the following test items: selecting most appropriate measuring vessel, selecting most suitable solvent for the seperation of coloured pigments, selection of a measuring vessel. Differentiating a molar solution of an acid from a normal solution, calculating the amount required for a particular volume of a particular molarity, selecting appropriate quality of chemicals for a particular experiment, Finding the indications of a saturation point of a solution, skill of forming an emulsion, sequence of cleaning glassware, Indications of boiling point, indications of melting point, finding the correct sequence of coagulating power of different ions, skill of choosing coordinates of a graph, skill of interpreting a graph, skill of interpreting the data, skill of finding the hottest zone of the flame, preparing sodium extract of a salt/salt mixture, prepearing original solution of a salt, performing a group test, suppressing the ionisation, performing an individual test of a cation, performing confirmatory test of a cation, boiling off hydrogen sulphide, removing acidity, removing alkalnity, prepearing neutral solution, performing flame test, performing charcoal cavity test, performing borax bead test. The test was revised subsequently on the basis of comments and suggestions of practising teachers and faculty members of science education.

The suggestions made by them were as following. Shape of a crystal cannot be judged by a naked eye, Ring like shape can be judged if students are already exposed with that earlier, Instead of word texture rough surface should have been used. An apparatus can not be assembled only by seeing a picture, it needs a lot of previous practice, there is no standard size of boiling tube. Students are not aware how to read meniscus. Test item on Emulsion has not been stated clearly. Solvents are related to the nature of pigments. Students may have difficulty in answering the correct quality of chemicals. Some people felt test-item on melting point does not provide a skill others felt finding correct sequence of a chemical operation and inter-pretation of a graph is not a skill.

The three test items delected in the first version were comparision of heavyness of two exactly similar bottles. Selection of proper measuring vessels, Interpretion of a graph. Test items on identifying the molarity of an acid, and group test were modified. The test item on heaviness was deleted because the experts expressed the view that the test item is an arbitrary one and the individual reactions will greatly vary. The test item on selection of measuring vessels has been deleted on the

cements of experts that since it has been already covered in the Entry Level Test and also that the test item is an elementary one. Test item on interpretion a graph has been deleted on the advice of experts because they felt student will not able to interpret a curved graph. The test item on molarity of an acid has been deleted on the basis of coments of experts, because they felt the test items involves only recall and is more of a theoretical nature (knowledge type). The test item on group test was modified on the basis of coments of experts. The test items was of a recall nature and looked more like a theortical test item. The test item was modified so that deep thinking is involved.

The second version of the test contained 41 test items (14 manipulative test items and 27 paper pencil test items). The test was again revised on the basis of comments and suggestions of students, chemistry teachers and experts in science education. The comments and suggestions made by them were. Language needs improvement. Test item relating to the selection of solvent is just memory test item relating to the cleaning of glassware does not involve any skill. Some test-items on texture were rated easy while test item on plotting of graph were rated difficult. Test item relating to the recognition of(colour/ odour) a metal, ranking salts according to size, recognising a (ring shape/ rough) texture measuring length were rated

very simple for this level of students. Skill of interpreting data was also rated as very simple.

The final version of the test contained 41 test items (14 manipulative test items and 27 paper pencil test items). The test items in Section A (manipulative items) related to recognition of (colour, odour, metal) recognition of ring like shape and rough texture, ranking salts according to size, assembling an apparatus from picture & written instruction, identifying, a boiling tube, (among different tubes) an acid/alkali (with the help of pH paper), skill of reading volumes, determining weight, skill of measuring length. Skill of performing titration. The test items not included in the Entry Level Test were recognition of (a metal, ring like shape, texture of wood) and volume measurement of coloured solutions.

The paper pencil test-items in the test were selecting appropriate measuring vessel, suitable solvent, differentiating molar solution from a normal solution, calculating the correct amount of a substance dissolved, selecting appropriate quality of chemicals, indications of a saturation point, forming an emulsion, cleaning laboratory glassware, indications of (boilding point/melting point). Coagulating power of different ions, plotting a graph, Interpreting the graph, Interpreting the data, prepearing (Sodium extract/

original solution) performing a (group test/individual test/confirmatory test), suppressing the ionisation, boiling off hydrogen suphide removing (acidity/alkalinity) prepearing neutral solution, performing (flame test/ charcoal cavity test/boraxbead test). Most of the test items of the Terminal level test and Entry level test were identical except in the Terminal Level Test, the level of difficulty is of a higher order and details of the laboratory skills are somewhat different from Entry level test.

Theory-Test (Pandit)

The theory test was constructed from the composite syllabus of classes XI and XII. The entire theory syllabus was analysed by the researcher for the possible constructio n of test items. An initial test was constructed containing 100 questions. The test was shown to practising teachers and faculty members of science Education and it was subsequently revised on the basis of their comments. Some of the suggestions and comments made by them were that the test item on orbital needs change in the stem, test item on vander walls forces needs change in language. Vander walls forces should not be mixed with bonding forces. A simpler diatomic crystal should have been given. Test item on polar molecule and hydrogen bond needed some changes

in d$strators, $CH_4$ should be properly represented. Test-time on combustability of compounds should have included some carbonates. Test-item on Group II-A of the periodic table, was found to have inadequate data. Test item on catalyst had data which seemed ambiguous. 38 test items were too elementary and needed to be weeded out of the test.

The test items weeded out of the theory test (Pandit) were as following:

Recognition of a chemical formula of a compound, Interpretation of a chemical equation, characteristics of a theory, interpretation of a graph, characteristics of a physical change. The characteristics of an isotope, calculating the gram molecular weight, calculating density from a graph, calculating the molarity of a solution from the amount dissolved, calculating the number of atoms in a molecule, Finding the atomic weight of an element from the molecular formula of a compound, postulates of Kinetic Molecular theory, Indications of a chemical reaction, identifying an unknown compound from the data given, Finding the mass number of chlorine, choosing a suitable method for seperation of four pure solid substances, inserting the coefficients of molecules in a chemical reaction (or balancing a chemical reaction by hit and trial method), calculating the moles of a chemical compound on the basis of chemical reaction and data only. The name for process of seperating mixtures,

postulates of Dalton's atomic theory, calculating the percentage of a component of a mixture on the basis of given data for a mixture, calculating the heat of a solution from the given data, Numerical on Boyles law, Recognising the structural formulae of benzene, Recognising incorrect formula of a compound characteristics of a saturated solution, Assumption of kinetic molecular theory, characteristics of hydrolysis, choosing the correct name of a compound, finding electrons, protons in an isotope, Identifying a particle containing given number of electrons, protons and neutrons-Identifying the data for standard temperature & pressure, Finding the mass number of an isotope, atomic ratio between Group IA and VI A, identifying a polar molecule Finding pH value of a solution on the basis of given hydrogen ion concentration, completing a nuclear reaction.

Most of these test items were elementary and suitable for secondary classes only and many of the test items were repeated more than once. These 28 items have been deleted mainly on account of being too elementary. The practising teachers (schools/colleges/universities and faculty members of science education expressed the opinion that these test items were too elementary for students of class XII. They expressed the fear that if these test items were included in the theory test it may not be possible to correctly asses the achievement of a student in the theory test (Pandit).

The second version of the test was prepared which contained 62 test items. This test was also circulated to a group of students, practising chemistry teachers and faculty members of science education for comments and suggestions. The comments and suggestions made by them were:

The response on test item relating to catalyst was not expected to be good and therefore needed modification. Test item on Equilibrium constant also needed modification. Twenty two test items were eliminated from the second version of the theory test which were thought to be too elementary or were controversial or duplicate. The test items delected from the second version of the Theory Test were the following:

Electronic structure of a stable atom, the proper name of a chemical compound, indications of a chemical reaction, recognition of an ionization equation, characteristics of an isotope, shape of methane molecule. Calculating molarity from the amount dissolved, calculation of moles from chemical equation & data, calculation of moles from formula and data, chemical equilibrium, calculating the equilibrium constant, characteristics of a collodial dispersion, finding the boiling point of mercury on the basis of data., hydrogen bonding, calculating oxidation number of chemical formula., calculating the volume. of a gas from a Avagadros number and mass at standard

temperature and pressure. Calculating the molarity from the data with the help of molarity equation, calculating the pH from the hydrogen ion concentration, factors affecting equilibrium system, process of changing an atom into negatively charged ion, characteristics of a crystalline sodium chloride.

The final version of the test contained 40 test items. The test items were as following electronic structure, orbitals, crystals, vander walls forces, chemicals analysis test items rate of a reaction, equilibrium constant (two test/items) eleven test items on organic structures and their properties, combustability of compounds, solubality of a solvent, characteristics of Group II-A of periodic table, Reaction of double decomposition, Role of a catalyst, Ionic character, characteristics of Group VII-A of the periodic table, Reaction of neutralisation, chemical formula of an oxide relating to Group II-A Molecular crystals, electronic configurations, Allotropes, prediction of melting point of an element in Group VII-A, Reaction of oxidation, liquification of a gas, characteristics of I-A group elements in periodic table, covalent character, nuclear equation, nuclear reaction, characteristics of an in secticides, Enzymes. The rest contained six items related to knowledge

28 test items related to understanding and six test items related to application. The emphasis was to test the conceptual understanding of chemistry, related to chemical structures and properties and applications.

Validity of the Tests

Content validity of these three tests was established by asking a panel of knowledgeable and experienced science educaters and practising chemistry teachers (Schools/Colleges/Universities). Each test was validated by 30 experts (The Entry Level Test was validated by 7 Science Education Experts, 2 University chemistry teachers, 6 college Chemistry teachers, 15 school chemistry teachers) The Terminal Level Test and Theory Test (Pandit) were validated by 6 science education experts, 7 university chemistry teachers and 17 school chemistry teachers).

They were asked to indicate their agreement or disagreement with comments about the test items. They were also asked if the particular test item measures the skill it was designed to measure. They were further asked to comment if the particular test-item related to the category of chemistry laboratory skills to which it has been assigned to is agreeable or not.

Table 5.1

Validity of various test items of Entry Level Test

| Test Item No. | Agreement | Disagreement |
|---|---|---|
| 01 | 96-2/3% | 3 1/3% |
| 02 | 86 2/3% | 13-1/3% |
| 03 | 90% | 10% |
| 04 | 96-2/3% | 3-1/3% |
| 05 | 93-1/3% | 6-2/3% |
| 06 | 100% | 0% |
| 07 | 96-2/3% | 3-1/3% |
| 08 | 96-2/3% | 3-1/3% |
| 09 | 100% | 0% |
| 10 | 93-1/3% | 6-2/3% |
| 11 | 93-1/3% | 6-2/3% |
| 12 | 96-2/3% | 3-1/3% |
| 13 | 96-2/3% | 3-1/3% |
| 14 | 96-2/3% | 3-1/3% |
| P A R T - B | | |
| 15 | 83-1/3% | 16-2/3% |
| 16 | 90% | 10% |
| 17 | 90% | 10% |
| 18 | 93-1/3% | 6-2/3% |
| 19 | 90% | 10% |
| 20 | 96-2/3% | 3-1/3% |

| | | |
|---|---|---|
| 21 | 86-2/3% | 13-1/3% |
| 22 | 93-1/3% | 6-2/3% |
| 23 | 100% | 0.0% |
| 24 | 100% | 0.0% |
| 25 | 93-1/3% | 6-2/3% |
| 26 | 90% | 10% |
| 27 | 86-2/3% | 13-1/3% |
| 28 | 93-1/3% | 6-2/3% |
| 29 | 100% | 0.0% |
| 30 | 100% | 0.0% |
| 31 | 93-1/3% | 6-2/3% |
| 32 | 90% | 10% |
| 33 | 86-2/3% | 13-1/3% |
| 34 | 93-1/3% | 6-2/3% |
| 35 | 93-1/3% | 6-2/3% |
| 36 | 90% | 10% |
| 37 | 93-1/3% | 6-2/3% |
| 38 | 96-2/3% | 3-1/3% |
| 39 | 96-2/3% | 3-1/3% |
| 40 | 96-2/3% | 3-1/3% |
| 41 | 100% | 0.0% |
| 42 | 100% | 0.0% |

In the Entry Level Test the agreement of various test items by experts varied from 100% to 83-1/3% Eight test items had 100% agreement. Eleven test items had 96-2/3% agreement. Eleven test-items had 93-1/3% agreement, seven test items had 90% agreement, four test items had 86-2/3% agreement, one test items had 83-1/3% agreement.

Table 5.2

Validity of Various Test Items of Terminal Level Test.

| Test Item No. | Agreement | Disagreement |
|---|---|---|
| 01 | 96-2/3% | 3-1/3% |
| 02 | 100% | 0.0% |
| 03 | 96-2/3% | 3-1/3% |
| 04 | 80% | 20% |
| 05 | 86-2/3% | 13-1/3% |
| 06 | 96-2/3% | 3-1/3% |
| 07 | 96-2/3% | 3-1/3% |
| 08 | 96-2/3% | 3-1/3% |
| 09 | 90% | 10% |
| 10 | 93-1/3% | 6-2/3% |
| 11 | 100% | 0.0% |

| | | |
|---|---|---|
| 12 | 96-2/3% | 3-1/3% |
| 13 | 90% | 10% |
| 14 | 93-1/3% | 6-2/3% |

P A R T - B

| | | |
|---|---|---|
| 15 | 86-2/3% | 13-1/3% |
| 16 | 86-2/3% | 13-1/3% |
| 17 | 93-1/3% | 6-2/3% |
| 18 | 93-1/3% | 6-2/3% |
| 19 | 96-2/3% | 3-1/3% |
| 20 | 100% | 0.0% |
| 21 | 80% | 20.0% |
| 22 | 96-2/3% | 3-1/3% |
| 23 | 86-2/3% | 13-1/3% |
| 24 | 86-2/3% | 13-1/3% |
| 25 | 96-2/3% | 3-1/3% |
| 26 | 90% | 10% |
| 27 | 90% | 10% |
| 28 | 96-2/3% | 3-1/3% |
| 29 | 96-2/3% | 3-1/3% |
| 30 | 96-2/3% | 3-1/3% |
| 31 | 96-2/3% | 3-1/3% |
| 32 | 96-2/3% | 3-1/3% |
| 33 | 96-2/3% | 3-1/3% |
| 34 | 100% | 0.0% |

| | | |
|---|---|---|
| 35 | 93-1/3% | 6-2/3% |
| 36 | 96-2/3% | 3-1/3% |
| 37 | 96-2/3% | 3-1/3% |
| 38 | 100% | 0.0% |
| 39 | 93-1/3% | 6-2/3% |
| 40 | 83-1/3% | 16-2/3% |
| 41 | 90% | 10% |

In the Terminal Level Test the agreement on various test items varied from 100% to 80%, Five test items had 100% agreement, Seventeen test items had 96-2/3% agreement, six test items had 93-1/3% agreement, Five test items had 90% agreement, Five test items had 86-2/3% agreement, one test items had 83-1/3% agreement, and two test items had 80.0%, agreement.

Table 5.3

Validity of various Test Items of Theory test (Pandit)

| Test Item No. | Agreement | Disagreement |
|---|---|---|
| 01 | 90% | 10% |
| 02 | 80% | 20% |
| 03 | 90% | 10% |
| 04 | 80% | 20% |
| 05 | 93-1/3% | 6-2/3% |

| | | |
|---|---|---|
| 06 | 90% | 10% |
| 07 | 93-1/3% | 6-2/3% |
| 08 | 93-1/3% | 6-2/3% |
| 09 | 100% | 0.0% |
| 10 | 93-1/3% | 6-2/3% |
| 11 | 96-2/3% | 03-1/3% |
| 12 | 96-2/3% | 3-1/3% |
| 13 | 100% | 0.0% |
| 14 | 96-2/3% | 3-1/3% |
| 15 | 96-2/3% | 3-1/3% |
| 16 | 93-1/3% | 6-2/3% |
| 17 | 100% | 0.0% |
| 18 | 100% | 0.0% |
| 19 | 96-2/3% | 3-1/3% |
| 20 | 90% | 10% |
| 21 | 86-2/3% | 13-1/3% |
| 22 | 93-1/3% | 6-2/3% |
| 23 | 96-2/3% | 3-1/3% |
| 24 | 86-2/3% | 13-1/3% |
| 25 | 90% | 10% |
| 26 | 93-1/3% | 6-2/3% |
| 27 | 96-2/3% | 3-1/3% |
| 28 | 93-1/3% | 6-2/3% |
| 29 | 90% | 10% |
| 30 | 100% | 0.0% |

| | | |
|---|---|---|
| 31 | 100% | 0.0% |
| 32 | 96-2/3% | 3-1/3% |
| 33 | 96-2/3% | 3-1/3% |
| 34 | 93-1/3% | 6-2/3% |
| 35 | 90% | 10% |
| 36 | 93-1/3% | 6-2/3% |
| 37 | 96-2/3% | 3-1/3% |
| 38 | 96-2/3% | 3-1/3% |
| 39 | 90% | 10% |
| 40 | 96-2/3% | 3-1/3% |

In The Theory Test (Pandit) the agreement on various test items ranged from 100% to 80%. Six test items had 100% agreement, twelve test items had 96-2/3% agreement ten test items had 93-1/3% agreement, Eight test items had 90% agreement, two test items had 86-2/3% agreement and the rest two test items had 80% agreement.

Reliability of Tests (ELT, TLT & Th.T)

The realiability of all the tests was calculated by Split half technique by dividing all the tests into two equal halves (in terms of marks). The reliability of the tests was calculated using Spearman Brown Prophecy Formulae:

$$\gamma = \frac{N\Sigma xy - [\Sigma x][\Sigma y]}{\sqrt{[N\Sigma x^2 - (\Sigma x)^2][N\Sigma y^2 - (\Sigma y^2)]}}$$

where N = Total Sample (students)

where X = sum of the first half (marks)

Y = Sum of the second half (marks)

$EX^2$ = Sum of the squares of first half (marks)

$EY^2$ = Sum of the squares of second half (marks)

r = correlation coefficient.

$$\text{Reliability} = \frac{nr}{(1+(n-1)r)}$$

n = number of equal portions in which the test was divided.

In case of split half technique n=2

$$\text{Reliability} = \frac{2r}{(1+r)}$$

The reliability of the three tests in the total sample is as shown in the Table 5.4.

Table 5.4

Reliability of various tests in the total sample

| Tests | Total Sample | Reliability |
|---|---|---|
| Entry Level Test | 107 | 0.410 |
| Terminal Level Test | 107 | 0.647 |
| Theory Test | 107 | 0.902 |

The Entry Level Test included those test-items which reflect those basic skills which a student is expected to master by the time he or she has completed class XI chemistry practical course. This test also included some chemistry laboratory skills of class IX and X chemistry practical course which are elementary but are often repeated in higher class experiments. This may be the reason for slightly low value of reliability in case of Entry Level Test.

The Terminal Level Test included those test items which reflect those basic skills which a student is expected to master by the time he or she completes the practical chemistry course of class XII. Most of the test items are of a similar nature as Entry Level Test but the difficulty level is a little higher. This test was administered a few weeks before the actual practical examination of the Board (CBSE)*. The material and other cooperation was available and therefore the response has been discriminating and therefore a good reliability value.

The Theory Test (Pandit) contained those testitems which were related to the theory knowledge. A student acquires knowledge about these test items during the study of chemistry theory in classes XI and XII. Most of the

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* (CBSE) stands for Central Board of Secondary Education.

students take more interest in theory than the practicals and when the test was administered they were very well prepared as they had to appear in the class XII examination of the Central Board of Secondary Education, New Delhi. That might be the reason for a very high reliability value of the theory test (Pandit).

Item Analysis (Difficulty & Discriminating Values )

In a total sample of 107 students, 29 top and 29 bottom achievers were identified (27% of the sample) and their responses to different test items were analysed. The difficulty and discriminating values of various test items of various tests were calculated by using:

Psychometeric Research and Service chart showing the Davis Difficulty and discriminating Indices for item analysis and instructions for its use by A. Edwin Harper (Jr) S.P.Sangal and B. Das Gupta published by psychometeric Research & Service Unit, Research and Training School, Indian Statistical Institute Calcutta-35 (INDIA). The difficulty and discriminating values of Entry Level Test are given in the Table 5.5.

Table 5.5

Difficulty & Discriminating Values of Various Test Items of Entry Level Test

| S. No. | Test Item No. | $P_H$* | $P_L$** | Discriminating Index | Difficulty Index |
|---|---|---|---|---|---|
| 01 | 01 | 91 | 82 | 10 | 75 |
| 02 | 02 | 91 | 63 | 25 | 65 |
| 03 | 03 | 91 | 49 | 35 | 61 |
| 04 | 04 | 100 | 100 | 100 | 0 |
| 05 | 05 | 100 | 72 | 40 | 75 |
| 06 | 06 | 97 | 86 | 20 | 82 |
| 07 | 07 | 95 | 72 | 25 | 72 |
| 08 | 08 | 100 | 86 | 30 | 82 |
| 09 | 09 | 91 | 86 | 10 | 75 |
| 10 | 10 | 100 | 55 | 50 | 69 |
| 11 | 11 | 95 | 86 | 15 | 82 |
| 12 | 12 | 10 | 03 | 10 | 18 |
| 13 | 13 | 86 | 25 | 25 | 61 |
| 14 | 14 | 82 | 82 | 05 | 69 |
| 15 | 15 | 54 | 17 | 25 | 42 |
| 16 | 16 | 03 | -10 | -10 | 18+ |
| 17 | 17 | 36 | 36 | 05 | 42 |

* $P_H$ is the percent of correct answers pby high achievers (upper 27% of the total sample).

** $P_L$ is the percent of correct answers by low achievers (Lower 27% of the total sample).

| | | | | | |
|---|---|---|---|---|---|
| 18 | 18 | 08 | -06 | 01 | 18+ |
| 19 | 19 | 86 | 24 | 45 | 52 |
| 20 | 20 | 82 | 22 | 45 | 52 |
| 21 | 21 | 31 | -10 | 25 | 25+ |
| 22 | 22 | 26 | 03 | 30 | 25 |
| 23 | 23 | 86 | 22 | 45 | 52 |
| 24 | 24 | 17 | -10 | 10 | 18+ |
| 25 | 25 | 82 | 49 | 25 | 58 |
| 26 | 26 | 86 | 49 | 30 | 61 |
| 27 | 27 | 91 | 68 | 25 | 69 |
| 28 | 28 | 82 | 22 | 45 | 52 |
| 29 | 29 | 58 | 68 | 05 | -68 |
| 30 | 30 | 82 | 36 | 30 | 55 |
| 31 | 31 | 95 | 77 | 25 | 75 |
| 32 | 32 | 31 | -06 | 25 | 25+ |
| 33 | 33 | 49 | 13 | 25 | 39 |
| 34 | 34 | 63 | 03 | 40 | 39 |
| 35 | 35 | 22 | -06 | 20 | 25+ |
| 36 | 36 | 77 | 08 | 45 | 45 |
| 37 | 37 | 68 | 49 | 10 | 55 |
| 38 | 38 | 95 | 40 | 50 | 61 |
| 39 | 39 | 49 | 45 | 05 | 48 |
| 40 | 40 | 49 | 26 | 15 | 42 |
| 41 | 41 | 91 | 40 | 40 | 61 |
| 42 | 42 | 26 | 08 | 20 | 31 |

Twenty five test-items of the Entry Level test had appropriate* discriminatory and difficulty indices and they need no explanation to be included in the final version of Entry Level Test.

Seventeen of the test items could be graded as low on discrimination and difficulty indices. They have been included in the Entry Level Test because these test-items measure some of the basic chemistry laboratory skills for which a student has to depend on some of his senses namely, colour, odour, size and shape etc. In human beings these senses are not as perfect as in the case of many species of the animal world because of may reasons. Some of the people who have these sense perfect may not be using them properly. The using of these senses properly is itself a big laboratory skill.

The discriminating Index of test item No.1 is zero whcih is considered low, yet it has been included in the final version of Entry Level Test because not only colour recognition is important, but also the recognition of shades of colours. This is an elementary skill of all sciences.

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* A test item having a discriminating index and difficulty index as 25 is called a proper test item.

The difficulty Index of test item $No_4$ is zero which gives a clue that the test item is a very difficult one and is also highly discriminating. It has been included in the final version of Entry Level Test because bending a glass tube is a very difficult taks and since every student can not do it therefore highly discriminating task. The student should be discriminating enough to select the right quality of the glass tubing, select the proper zone of the flame for heating, catching, and bending the tube properly, (pose and angle) allowing it to cool properly. The skill of bending a glass tube is of basic importance to a student of chemistry at all stages of academic career and therefore has been included in the final version of the Entry Level Test.

The discriminating Index of test item No.6 is 20 which shows that the item is not sufficiently discriminating. Setting up of a wash bottle, a student of chemistry starts doing from class IX. Most of the students are able to set up the wash bottle and therefore the test item is not sufficiently discriminating. The particular task involves the selecting of the apparatus, fitting up the various pieces in a sequence, testing the air tightness and function of the wash bottle. Keeping in view the number of skills involved the test item has been retained in the final version of Entry Level Test. Fitting up a wash bottle is like fitting

up a machine, unless a student had earlier experience he gets confused. The material and visual instruction from the picture are not enough. What matters is the practice (quickness and dexterity with which he does it).

The discriminating Index of test item No.9 is 10 which shows that the test item is not discriminating. Most of the students at class XII are abhe to read the volume of coloured solutions. In reading the volume of coloured solutions. One has to take the upper meniscus and also to read the volume at 90° angle. The test item has been fetained in the final version of the Entry Level Test because reading volume of coloured solutions is an important chemistry laboratory skill.

The discriminating index of test item No.11 is 15 which shows that the test item is not sufficiently discriminating. Most of the students at class XII are able to locate a round bottomed flask in a similar set of glass apparatus. The student will be able to locate if he is sufficiently aware of the shape of the round bottom flask and its utility. Some of the students may even get confused since there are various types of flasks i.e. round bottom flask, measuring flask, titration flask, distillation flask etc. That may be one of the reasons for low discrimination value. The item has been retained in the final version of Entry level test mainly because the recognition of this type of apparatus with a wide variety of name sakes is a very important chemistry laboratory skill.

The discriminating and difficulty Indices of test item No.12 are 10 & 18 respectively which shows that the test item is not sufficiently discriminating and also at the same time very difficult. Most of the students of class XII are able to measure the distances but very few of them do accurately. In measuring distances the scale of measurement should be accurate, it should be used properly, the observation should be noted and recorded properly, the proper units of measurement, should also be recorded. The test item has been solely retained in the final version of Entry Level Test because measuring distances is a fundamental skill for a student of science.

The discriminating index of test item No.14 is 05 which shows that the item is not very discriminating. Most of the students are able to perform the volumeteric titrations but many of them do not perform it accurately. The performing of voluemeteric titrations includes selecting the known and unknown solutions. Rinsing the apparatus, taking these solutions is the burette and the titration flask, selecting and adding the indicator in proper proportions, titrating the known solution against the unknown solution slowly and gradually in stages and finding the end point by change of colour or formation of a precipitate and finally calculating the results. The whole task is a complex one, consisting of a cluster of chemistry laboratory

skills of varying nature and difficulty. It is for this reason that the test item has been included in the final version of Entry Level Test.

The discriminating and difficulty indices of test item No.16 are - 10 & 18+ which shows that the test item is not at all discriminating and also not very difficult. Most of the students are not aware about the quality and brand of chemicals. They are all the time working with the chemicals of whatsoever variety they are provided at this stage. They presume that whatsoever chemicals are provided to them must be the right type of chemicals and they need not bother about its quality and condition. In fact most of the Indian University students prepear the solutions at the postgraduate stage and become familiar with various quality of chemicals at this stage only. With the change in emphasis on originality in practical work a student should be aware about the quality of chemicals. The results of a chemical experiment will ultimately depend on the quality of chemicals, apart from the quality of glassware/apparatus and human factors. In view of this thinking the item has been retained in the final version of Entry Level Test.

The discriminating index of test item No.17 is 05 which clearly shows that the item is not discriminating. The students at this stage are able to find the boiling point of a solution but are not aware of the physical phenomena undergoing at the time. This is due to the lack of coordination between the practical laboratory skill and theortical know-

ledge. Many students are not aware which particular phenomena should be recognised as boiling. The test item has been retained in the final version of Entry Level Test because determination of boilding point of a solution is a very important chemistry laboratory skill in all disciplines of science and also in daily life.

The discriminating and difficulty Indices of test Item No.18 are 01 & 18+ which shows that the test item is not even margionally discriminating and also very difficult. The students at this stage are able to find the melting point of a particular solid or are familiar with the procedure but many fail to find it correctly and accurately because of the lack of knowledge of clear indications of melting point. The melting point is the average of temperatures at which it starts melting and completely melts. Usually students take the temperature at which solid starts melting as the melting point. The test item has been retained in the final version of Entry Level Test because skill of finding melting point of a solid substance, is very important chemistry laboratory skill for a student of class XII.

The discriminating and difficulty Indices of test item No.24 are 10 & 18+ which shows that the test item is not discriminating and not very difficult also. Students

at this stage are able to calculate the molarity of a solution from the amount of substance dissolved per litre but some are not able to calculate it correctly. In calculating the molarity of a solution a student should be able to calculate the molecular weight of a substance and also should know the amount of substance dissolved per litre, and then calculate the molarity with the help of a formula. The test item has been retained in the final version of Entry Level Test because calculating the molarity of a solution is an important chemistry laboratory skill.

The discriminating and difficulty indices of test item No.29 are 05 & -68 which shows that the item is not very discriminating and at the same times very difficult. The students at this stage are able to write the correct answer, but the distractors are not sharp enough which makes it less discriminating and more difficult. The item has been retained in the final version of Entry Level Test because identification of correct indications of a particular chemical change is a very important chemistry laboratory skill. Unless and untill one is not able to identify the correct indications of a chemical change one can not decide whether the change has started taking place or not.

The discriminating index of test item No.35 is 20 which shows that the test item is not discriminating enough. The

students are by and large able to test the absence of hydrogen sulphide from the salt solution though not thoroughly. Perpetual presence of hydrogen sulphide apparatus in a chemistry laboratory contimnates almost every chemical substance in a chemical laboratory particularly solutions. In the schools the heating devices and testing techniques are not good enough to remove the hydrogen sulphide completely and alsotest its absence from the solution thoroughly. The item has been retained in the final version of Entry Level Test because testing of hydrogen sulphide in a salt solution is a very important chemistry laboratory skill at all stages in the life of a chemist.

The discriminating index of test item No.37 is 10 which shows that the test item is not discriminating enough. The students are able to remove the alkalnity of a salt solution but not compleely. The removal of alkalinity has to be normally tested with the help of a pH paper. The exactness of the outcome is not there and probably that is the reason for test item not being discriminating enough. The/item test has been retained in the final version of Entry Level Test because removing of alkalinity from a solution is an important chemistry laboratory skill.

The discriminating Index of test item No.39 is 05 which shows that the test item is not discriminating enough. The

students are able to perform the charcoal cavity test but are not able to observe the colour of the residue correctly. The charcoal cavity test includes the mixing up of chemicals and then placing them in the cavity of a charcoal block. Then blowing the flame on the cavity and observing the colour of the residue. The operations are many but easy. All students perform the test and enjoy doing it and therefore not discriminating. The/item has been retained in the final version of Entry Level Test solely/because charcoal cavity test is not only a usual test but a confirmatory test sufficiently reliable. In a single task a number of skills are involved.

The discriminating Index of test item No.40 is 15 which shows that the test item is not discriminating enough. The students are able to perform the borax bead test but usually the observation of colour is faulty. Like charcoal cavity test, borax bead test is also a confirmatory test, and highly reliable. The single task involves a number of skills i.e. taking a pinch of salt, mixing borax with it and then heating the mixture in reduced flame and finally observing the colour of the bead, and drawing inference on the basis of the colour of the bead. All students enjoy performing this test and get the bead of desired colour and is therefore not discriminating enough. The/item has been retained

in the final version of Entry Level Test because of its vital importance in the salt analysis in particular and chemistry practicals in general.

The discriminating index of test Item No.42 is 20 which shows that the item is not discriminating enough. The students are not by and large aware of the indications of shift in equilibrium of a chemical change. Students are not generally aware that by changing the conditions in a chemical system it results in the change of colour or formation of precipitate and these are the indications of change in a chemical Equilibrium. Most of the students are not able to do this experiment but some talented students enjoy and appreciate doing this experiment. The item has been retained in the final version of Entry Level Test because the skill of finding the shift in chemical Equilibrium of a chemical system consists of a number of skills which are very important for a student of chemistry.

Table 5.6

Discriminating & Difficulty Indices of various test items of Terminal Level Test.

| S.NO. | Test Item No. | Pu | PL | Discriminating Index | Difficulty Index |
|---|---|---|---|---|---|
| 01 | 01 | 95 | 86 | 15 | 82 |
| 02 | 02 | 77 | 82 | 05 | -69 |

| | | | | | |
|---|---|---|---|---|---|
| 03 | 03 | 91 | 95 | 10 | -82 |
| 04 | 04 | 86 | 24 | 45 | 55 |
| 05 | 05 | 79 | 31 | 30 | 52 |
| 06 | 06 | 72 | 93 | 25 | -69 |
| 07 | 07 | 100 | 100 | 100 | 00 |
| 08 | 08 | 100 | 100 | 100 | 00 |
| 09 | 09 | 91 | 54 | 30 | 65 |
| 10 | 10 | 95 | 95 | 05 | 82 |
| 11 | 11 | 65 | 86 | 20 | -65 |
| 12 | 12 | 86 | 52 | 25 | 61 |
| 13 | 13 | 100 | 86 | 30 | 82 |
| 14 | 14 | 86 | 86 | 05 | 75 |
| 15 | 15 | 82 | 72 | 10 | 65 |
| 16 | 16 | 49 | 13 | 25 | 39 |
| 17 | 17 | 72 | 49 | 15 | 55 |
| 18 | 18 | 26 | 08 | 20 | 31 |
| 19 | 19 | 63 | -06 | 35 | 35+ |
| 20 | 20 | 63 | 03 | 50 | 39 |
| 21 | 21 | 72 | 36 | 25 | 52 |
| 22 | 22 | 40 | 22 | 15 | 39 |
| 23 | 23 | 77 | 26 | 35 | 52 |
| 24 | 24 | 63 | 22 | 25 | 45 |
| 25 | 25 | 68 | 17 | 35 | 45 |
| 26 | 26 | 68 | 17 | 35 | 45 |
| 27 | 27 | 86 | 36 | 35 | 58 |

| | | | | | |
|---|---|---|---|---|---|
| 28 | 28 | 63 | 13 | 35 | 42 |
| 29 | 29 | 82 | 31 | 35 | 55 |
| 30 | 30 | 77 | 26 | 35 | 50 |
| 31 | 31 | 68 | -01 | 40 | 35+ |
| 32 | 32 | 82 | 08 | 55 | 45 |
| 33 | 33 | 82 | 22 | 40 | 52 |
| 34 | 34 | 91 | 45 | 35 | 61 |
| 35 | 35 | 91 | 36 | 45 | 58 |
| 36 | 36 | 54 | 08 | 40 | 39 |
| 37 | 37 | 40 | 36 | 05 | 42 |
| 38 | 38 | 86 | 08 | 60 | 48 |
| 39 | 39 | 68 | 45 | 15 | 52 |
| 40 | 40 | 82 | 08 | 55 | 45 |
| 41 | 41 | 59 | -03# | 35 | 35+ |

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Twenty seven test items of the Terminal Level Test have appropriate discriminatory and difficulty Indices They need no explanation to be included in the final version of Terminal Level Test. Thirteen of the test items which are graded as low on discrimination and difficulty Indices have been included in the final version of the Terminal Level Test because these test-items measure some of the basic chemistry laboratory skills for which a student has to depend on some of his senses namely colour, odour, size, shape. Human beings have damaged these senses and

are not as perfect as in the case of many species of the animal world. Some of the people who have these senses perfect may not know their proper use. The use of these senses properly is itself a big laboratory skill.

The test items No.1 has discrimination Index as 15 and is not discriminating enough, yet it has been included in the final version of Terminal Level Test because colour recognition is a very important chemistry laboratory skill for a student of class XII all his life. The reason for not being discriminating enough can be many, defect in senses of observation, difficulty in recognition of almost identical colours and their shades.

The discriminatory and difficulty Indices of test item No.2 are 05 & -69 which indicates that the test item is not discriminating enough and is also very difficult one. Most of the students at this stage are able to report the odour of the gas correctly and is therefore not much discriminating. The odour recognition is a very complex laboratory skill because of many factors. The gas whose odour has to be recognised must not be poisonous, injurious or irritating. The test item has been included in the final version of Terminal Level Test because odour recognition though usual is also a very important chemistry laboratory skill for a student all his life.

The discriminating and difficulty indices of test item No.3 are 10 & -82 which shows that the test item is not discriminating enough and is also very difficult. Most of the students at this stage are able to identify by preliminary examination a particular metal correctly and is not therefore discriminating enough. Metal recognition is also a very complex chemistry laboratory skill as in the recognition of metal one has to take into account many of the physical and chemical properties of the metal i.e. colour, density, ductility, malleability, reaction with water, acids, alkalies etc. It is only after many such tests that one can identify a particular metal. The test item has been retained in the final version of Terminal Level Test because metal recognition is a very important laboratory skill in all sciences.

The discriminating and difficulty Indices of test item No. 07 & are 100 and 00 which reveals that the test item is highly discriminating and also very difficult. An apparatus can not be assembled only by seeing a picture. Fitting up an apparatus is like fitting up of a simple machine. A machine can be opened and fitted up by hit & trial method though not correctly at the first instance. Assembling apparatus is a very difficult task. Inspite of the fact that a student may be aware of the sequence of

assembly, but more important is the skill, quickness and the dexterity with which he assembles the apparatus from the diagram. Keeping in view the fact that assembling an apparatus is a very important chemistry laboratory skill, it has been retained in the final version of Terminal Level Test.

The discriminating and difficulty Indices of test item No.08 are 100 and 00. The values clearly show that the test item is highly discriminating and also very difficult. The Assembling of apparatus is a very difficult task. Inspite of the fact that a student may be aware of the sequence of the assembly, but what is more important is the skill, swiftness and dexterity with which he assembles the apparatus from the written instructions. Fiting up of an apparatus is a very difficult task, it requires planning, (how to fit up various parts), Caution (to fit up parts slowly and carefully), verification (whether the assembly is proper, leak proof and as per the requirements). Assembling apparatus is a very important chemistry laboratory skill for a student all his life and has therefore been retained in the final version of Terminal Level Test.

Discriminating Index of test Item No.10 is 05 which indicates that the test item is not discriminating enough. The task of reading the volume of coloured and colourless solutions in a burette is a usual task though it involves very important

skills. In case of colourless( except mercury) solutions, the lower meniscus has to be taken into account and in case of coloured solutions including colourless mercury the upper meniscus has to be taken into account for reading the volume. A student at this tage must be able to read the volume of colourless & coloured solutions in a burette, Inspite of the fact that the test Item is not discriminating enough it has been included in the final version of Terminal Level Test, because every student should know when to take upper meniscus and lower meniscus for the reading the volumes of a solution.

The discriminating and difficulty Indices of test item No.11 are 20 & -65 which clearly shows that the test item is not discriminating enough and at the same time is a very difficult one. Finding out whether a particular solution is acidic or alkaline with the help of a pH paper is a usual task in chemistry laboratory at this stage, therefore it is not discriminating enough. All the students are not able to do it properly. The skills involved are the selection of the pH paper, Immersing it in the solution (acid/alkali), drying it up and then comparing the colour of the pH paper with the standard pH colour chart, to find (from the pH value) whether particular solution is acidic or alkaline.

The discriminating Index of test item No.14 is 05 which clearly shows that the test item is not discriminating enough. Volumeteric titration is usually performed by most students at this stage. The task involves the preparation of standard solution, selection of the proper indicator, Rinsing the burette and pipette and adjusting the volume. Taking the unknown solution in the titration flask, adding the right quantity of indicator to it, titrating the unknown solution with the known solution slowly and gradually and finding the end point with the help of colour change or formation of a precipitate. Finding the (Normality/ Molarity) of the unknown solution with the help of Normality or Molarity Equation. Then computing the value of amount dissolved per litre of the unknown solution, percentage purity of the unknown solution, or water molecules attached to the crystel of the unknown substance etc. In view of the facts that this test item is composed of so many skills and its importance in the chemistry practicals, the test irem has been retained in the final version of Terminal Level Test.

The discriminating index of test item No 15 is 10 to which clearly shows that the test item is not discriminating enough. Selection of the most appropriate measuring vessel is usually done by most students, therefore is not discriminatly enough. The test item involves the selection of the best

possible measuring vessel among many alternatives for the smooth and accurate chemical operations. The quickness and the precision are important factors in measuring the volumes. The test item has been retained in the final version of Terminal Level Test because selection of proper measuring vessel is an important chemistry laboratory skill for a student of chemistry all his life.

The discriminating index of test item No. 17 is 15 which clearly shows that the test item is not discriminating enough. Difference between Molar solution and standard solution is within the comprehension range of students at this stage Molar solution is related to molecular weight while standard solution is related to equivalent weight. The test item has been solely retained in the final version of Terminal Level Test because with the introduction of molarity in the volumeteric analysis, a student should be able to differentiate between a molar and a standard solution and also find the relation between a molar solution and a standard solution in case of various solutions.

The discriminating index of test item No.18 is 20 which is slightly lower than average 25. The test item is not therefore sufficiently discriminating. The calculation of the amount of a chemical substance to be dissolved in a litre is simple. Once a student is aware of the equivalent weight of a chemical substance be can calculate the amount of a

chemical substance in a few minutes. The test item has been solely retained in the final version of Terminal Level Test because for the preparation of a standard solution one should necessarily be able to calculate the amount of chemical substance dissolved.

The discriminating index of test item No.22 is 15 which clearly shows that the test item is not discriminating enough. The operations of cleaning glassware are known to most of the students and are therefore not discriminating enough. The test item has been retained in the final version of Terminal Level Test mainly because the sequence of cleaning glass apparatus is an important chemistry laboratory skill. The operation involves cleaning with(cold/hot) water, sodium carbonate or chromic acid in this sequence. A student should know why is it necessary to clean a glass vessel in a certain sequence. Ordinary dirt can be removed by washing it with (cold/hot) water. Greasy particles can be removed by washing it with sodium carbonate. Particles permanently sticking to the vessel can be removed by chromic acid wash.

The discriminating index of test item No.37 is 05 which clearly shows that the test item is not discriminating enough. Removing alkalinity of a solution is within the comprehension range of a student of class XII, the student should be able to assess the extent of alkalinity in the solution with the help of a pH paper and should be able to select and .....

add proper chemicals to remove alkalinity. A student removes the alkalinity of solutions so many times and is therefore not discriminating. The test item has been retained in the final version of the Terminal Level Test because removing alkalinity is an important chemistry laboratory skill of permanent importance.

The discriminating index of test item No.39 is 15 which clearly shows that the test item is not discrimination enough. Performing flame test of salts is usual test in salt analysis and is therefore not discriminating enough. Flame test involves cleaning the tip of the platinum wire by acids, taking a little amount of salt on the tip of the platinum wire, putting the platinum tip in the proper zone of the flame, observing the colour of the flame by naked eye or through coloured glasses. Every student enjoys doing this experiment and observing the colour in the flame. The test item has been retained in the final version of Terminal Level Test because flame test involves so many skills which are very important in a chemistry laboratory and is also a confirmatory test for salt analysis.

Table 5.7

Discriminating & Difficulty Indices of various test items of Theory test (Pandit)

| S No. | Test Item No. | $P_h$ | $P_l$ | Discriminating Index | Difficulty Index |
|---|---|---|---|---|---|
| 01 | 01 | 91 | -15 | 65 | 80+ |
| 02 | 02 | 40 | 03 | 40 | 31 |

| | | | | | |
|---|---|---|---|---|---|
| 03 | 03 | 95 | 08 | 70 | 52 |
| 04 | 04 | 95 | -01 | 50 | 45 |
| 05 | 05 | 91 | 22 | 55 | 55 |
| 06 | 06 | 95 | 03 | 80 | 48 |
| 07 | 07 | 77 | -01 | 45 | 39 |
| 08 | 08 | 100 | 03 | 90 | 52 |
| 09 | 09 | 91 | 03 | 80 | 45 |
| -10 | 10 | 30 | -10 | -10 | 18+ |
| 11 | 11 | 77 | 08 | 55 | 45 |
| 12 | 12 | 95 | 22 | 60 | 58 |
| 13 | 13 | 95 | 17 | 60 | 55 |
| 14 | 14 | 95 | 26 | 60 | 58 |
| 15 | 15 | 95 | 26 | 60 | 58 |
| 16 | 16 | 91 | 22 | 55 | 55 |
| 17 | 17 | 91 | 22 | 55 | 55 |
| 18 | 18 | 100 | 08 | 90 | 58 |
| 19 | 19 | 86 | 03 | 70 | 45 |
| 20 | 20 | 91 | 13 | 60 | 52 |
| 21 | 21 | 95 | 08 | 70 | 52 |
| 22 | 22 | 100 | 100 | 100 | 00 |
| 23 | 23 | 100 | 13 | 90 | 58 |
| 24 | 24 | 100 | 100 | 100 | 00 |
| 25 | 25 | 86 | 03 | 80 | 45 |
| 26 | 26 | 95 | 03 | 80 | 48 |
| 27 | 27 | 79 | 26 | 35 | 52 |

| | | | | | |
|---|---|---|---|---|---|
| 28 | 28 | 95 | - 01 | 50 | 45+ |
| 29 | 29 | 03 | 08 | 05 | -18 |
| 30 | 30 | 79 | - 01 | 45 | 39 |
| 31 | 31 | 100 | 17 | 80 | 58 |
| 32 | 32 | 91 | - 24 | 40 | 42 |
| 33 | 33 | 95 | 13 | 70 | 55 |
| 34 | 34 | 95 | 08 | 70 | 52 |
| 35 | 35 | 95 | -10 | 45 | 45 |
| -36 | 36 | -24 | -33 | -05 | 05 |
| 37 | 37 | 100 | -10 | 45 | 52 |
| 38 | 38 | 91 | -20 | 40 | 42 |
| 39 | 39 | 95 | -01 | 50 | 45 |
| 40 | 40 | 77 | 08 | 55 | 45 |

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35 test items of the theory test have appropriate discriminatory and difficulty Indices. These test item need no explanation to be included in the final version of Theory test (Pandit). Five of the rest items which are graded as low on discrimation and difficulty indices have been included in the final version of Theory Test (Pandit ) mainly because these test items measure some of the basic understanding of chemistry theory concepts at this stage.

The discriminating and difficulty indices of test item No. 10 are -10 & 18+ which clearly shows that the test item is not at all discriminating and is also difficult. Most of the students are familiar with the concept of hydrogen bond and therefore not discriminating enough and at the same time is a very difficult concept, because it acts in different ways in difficerent types of compounds. The test item has been included in the final version of Theory Test (Pandit) because hydrogen bond is found in most of the organic and a good number of inorganic compounds.

The discriminating and difficulty Indices of test item No.22 are 100 and 00. The test item is highly discriminating and at the same time very difficult. Since the group characteristics of Periodic Table are vitally important for a student of chemistry, good students remember them on the finger tips while careless students confuse the characteristics of one group with the other. Therefore the test item is highly discriminating and at the same time very difficult. Every group has so many characteristics and is so difficult to remember facts and figures. Apart from facts and figures there are so many generalizations and patterns that it is difficult to remember even that. Many a times a student confuses the

order, i.e. whether the melding points etc. are increasing or decreasing. The test item has been included in the final version of Theory Test (Pandit) because unless a student is aware of the group characteristics of the periodic table he can not make any headway in the knowledge of chemistry.

The discriminating and difficulty indices of test item No.24 are 100 and 00. The test item is highly discriminating and at the same time very difficult. The identification of a catalyst in a chemical reaction is difficult, therefore highly discriminating. A student should know the reaction mechanism of a chemical process. He should be able to identify from the partial chemical Equations whether a particular chemical substance is taking part in the chemical process or just acting as a catalyst (to speed up or slow down the chemical process). Most of the students are not able to identify a catalyst from partial chemical equations. Therefore the test item is highly discriminating. The test item has been included in the final version of Theory Test (Pandit) mainly because every student should be aware of mechanism and the purpose of a catalyst and also the identification of a catalyst in a chemical equation.

The discriminating and difficulty Indices of test/item No.29 are 05 and -18 which clearly shows that the test item is not discriminating enough and at the same time very difficult. Recognising type of bond in a particular chemical compound is a very difficult concept. The bond formation in a compound is a result of electron transfer or electron sharing etc. A student is able to recognise the type of bond in a chemical compound from the structural formula itself. On this account the recognition of the type of bond is easy and therefore not discriminating enough. The test item has been retained in the final version of Theory Test (Pandit) mainly because recognising the type of a bond in a chemical compound/ molecule is an important chemistry theory concept for a chemist throughout his academic life.

The discriminating and difficulty Indices of test item No.36 are -05 & 05 which clearly shows that the test item is not discriminating at all and at the same time very difficult. Co-valent character though within the knowledge of the most of students is also difficult concept. Some of the characterstics of covalant character of compounds are high melting and boilding points, coloured substances, sharp colour, non-polar nature, non-electrolytic nature and non-soluble nature in water etc. and therefore not discriminating enough. The test item has been mainly

retained in the final version of Theory Test (Pandit) because most of the physical and chemical properties of organic compounds, are due to covalent character of compounds and therefore very important for a student of chemistry all his life.

Marking Scheme for the Various tests and other factors

We shall describe here how different test items were rated (marks allotted) and the reasons for that rating. The rating has been made on the basis of rising hierarchy of skills of each test item and the number of skills involved in that test item. The exact details of all the test items of the Entry Level Test and Terminal Level Test are given in this chapter earlier. Criteria for allotting the marks to factors of socio-economic status and out of school activities have also been made in this chapter.

(A) Marking Scheme for Entry Level Test :

The entry level test consists of 42 test items divided into two parts. The part-A of the test consists of 14 manipulative test-items (seven of them are tasks with multiple choice answers and seven of them are tasks to be performed and or results to be recorded). The part-B of the test consists of 28 multiple choice test items. The skills of the test have been divided into 8 broad

categories and 34 sub-categories. 8 test items have been alloted 1-1/2 mark each because in these test items they have to make simple observations. (These test items are no. 1, 2, 3, 9, 11, 15, 16, 19). The skills involved in these test-items are colour recognition, odour recognition, size discrimination, volume reading, apparatus recognition, selection of proper glass tubing, selection of proper chemicals, selecting proper position of the cork for boring.

Nineteen test-items have been allotted 2 marks each because in these test items they have to make measurements, draw inferences from the given data, and make calculations (These test item Nos. are 12, 17, 18,20, 21, 22, 23, 27, 28, 29, 30, 31, 34, 35, 36, 37, 38, 39 & 40). The test items are meant to measure distance, finding indications of boiling point, finding indications of melting point, selecting proper assembly of apparatus, choosing correct indicator, calculating the amount of substance required, identifying the characteristics of a gas, identifying indications of a chemical change, identifying a solution with the help of colour change, identifying an electrolytic solution, analysing an individual radical, boiling off hydrogen sulphide gas from a solution, Removing acidity from a solution, Removing alkalnity from a solution, performing flame test, performing charcoal cavity test, performing borase bead test.

Four test items have been allotted 2-1/2 marks each because these test-items involve tasks where measurements have to be made by comparison, calculations from data, selection of proper graph from the given data (These test item Nos. are 13, 24, 25 & 26). All these test items involve complex skills Measurement of pH of a solution with the help of a pH paper, calculating molarity from the amount dissolved in a solution, calculating the molarity of an unknown solution from the molarity of a known solution with the help of molarity equation, finding the correct graph related to a particular data.

Four test-items have been allotted 3 marks each because certain very complex laboratory operations have to be conducted. (manipulative nature) or some thinking operations have to be done (cognitive nature) (The test item Nos. are 4, 5, 32 & 33). They are bending of a glass tube, drilling a cork, preparing original salt solution, analysing a particular group in qualitative analysis. In all these manipulative & cognitive items more than one operations are involved in each case (All these operations involve a cluster ofskills).

Seven test-items have been alloted 4 marks each because some highly complex operations have to be performed (manipulative nature). Or some very complex thinking operations have to be done (cognitive nature). (These test items nos. are 6, 7, 8, 10, 14, 41 & 42). They are fitting

up a wash bottle, verifying the assembled apparatus, identifying a leak in an assembled apparatus, weighing a substance in a chemical balance, performing volumeteric titrations. Finding the strongest acid and the strongest alkali, finding the shift in chemical Equilibrium of a chemical system.

Table 5.8

Break up score for various test items

| S.No. | Description of Test Item | Score/ item | No.of Item | Total Score |
|---|---|---|---|---|
| I. | Simple observation/ operation | 1-1/2 | 8 | 8x1-1/2 = 12.00 |
| II. | Manipulation | 2 | 19 | 19x2 = 38.00 |
| III. | Complex operation | 2-1/2 | 4 | 4x2-1/2 = 10.00 |
| IV. | Complex manipulation/ operation | 3 | 4 | 4x3 = 12.00 |
| V. | Very complex manipulation/ operation | 4 | 7 | 7x4 = 28.00 |
| | | | Total: | =100.00 |

(B) Marking Scheme - Terminal Level Test

The Terminal Level Test consists of 41 test items. The part-A of the test consists of 14 manipulative test-items (nine of them are tasks with multiple choice answers, and five are tasks to be performed or results to be recorded). The part-B of the test consists of 27 multiple choice paper pencil test-items. The laboratory skills of the entire test have been divided into eight broad categories and 41 sub-categories.

Six test-items have been allotted 1-1/2 mark each, because in these test-items they have to make simple observations/selections. (These test items Nos. are 1, 2, 3 15, 16 & 19). The test-items relate to colour recognition, odour recognition, metal recognition, selecting appropriate measuring vessel, selecting suitable solvent, and selecting most appropriate chemicals.

Thirteen test-items have been allotted 2 marks each because in these test-items they have to use the skill of discrimination between things, make calculations, select the right characteristics of a phenomena, select the right sequence in a laboratory operation (The test-item nos. are 4, 5, 6, 17, 18, 20, 21, 22, 23, 24, 25, 36 & 37). The test-items relate to comparison of crystal size, comparison of shapes, comparison of textures, discrimination of Molar and Normal solutions, calculating correct amount of chemical, indications of a saturation point, forming an emulsion, cleaning laboratory glassware, characterstics of a boiling point, characteristics of a melting point, correct sequence of coagulating power, removing acidity of a solution, removing alkalinity of a solution.

Twelve test-items have been allotted 2-1/2 marks each because in these test-items they had to use the skill of plotting/interpreting (graph/data), preparing (sodium extract/original salt solution/neutral solution), perform

group test, suppressing the ionisation, boiling off hydrogen sulphide, performing (flame test/charcoal cavity test/ borax bead test) (These item nos. are 26, 27, 28, 29, 30, 31, 32, 35, 38, 39, 40 & 41).

Five test items have been allotted 3 marks each (These item nos. are 9, 11, 13, 33 & 34). They relate to identifying an apparatus, identifying an acid/alkali, measuring the length of glass tubing, performing individual test for a cation, performing a confirmatory test for a cation. In most of the test items students have to make observations and then comparisons. In some of the test-items they have to think about more than one test, make observations and comparisons.

Five test items have been allotted 4 marks, each (These test items are nos. 7, 8, 10, 12 & 14). The test-items relate to assembling of apparatus from pictures, assembling of apparatus from written instructions, reading volume, of (colourless/coloured) solutions, determining the weight of an object and performing the volumeteric titrations. In most of the test-items students have to make the observation and then (implement/interpret) these observations in a sequence as in the form of assembling apparatus, operating equipment and then finalising the task.

Table 5.9

Break of up score for various test items of Terminal Level Test

| S.No. | Description of the test item | score/ item | no.of item | Total Score |
|---|---|---|---|---|
| I. | Simple observation/ operation | 1-1/2 6 | 6x1-1/2 | = 9.00 |
| II. | Manipulation | 2 13 | 13x2.0 | = 26.00 |
| III. | Complex Operation | 2-1/2 12 | 12x2-1/2 | = 30.00 |
| IV. | Complex manipulation/ operation | 3 5 | 5x3 | = 15.00 |
| V. | Very complex manipulation/operation | 4 5 | 5x4 | = 20.00 |
| | | | TOTAL | =100.00 |

(C) Marking Scheme - Theory Test (Pandit)

The theory test consisted of forty test items. All of them were of multiple choice having four alternatives each. Seven test items related to chemical bonding, five test items related to organic structures (functional groups), five test items related to periodic classification of elements (characteristics of the groups), four test items related to chemical structures (molecular, ionic etc.) three test items were related to analytical chemistry, two test items were related to electronic structures, two test items related to nucler chemistry, one test item each related to Isomerism, combustion, organic analysis, chemical kinetics (catalysis), Arhenious theory, oxidation,

states of matter, chemistry in Industry & Bio-chemistry.

All these test items were of equal difficulty level.

Table 5.10

Break up of Score for various test items

| S.No. | Description | Score item | Item No. | Total score |
|---|---|---|---|---|
| I. | Multiple choice test item | 2-1/2 | 40 | 40x2-1/2 = 100.00 |
| | | | TOTAL | = 100.00 |

D) Marking Scheme - Socio Economic Status

The Socio economic status of students has been decided on the basis of five criteria i.e. (i) Father's profession, (ii) Mother's Profession, (iii) Family income monthly, (iv) Father's education, (v) Mother's education. Sixty five marks have been alloted to these five criteria as follows:-

Table 5.11

Categorywise break-up of marks to determine socio economic status are as following

| S.No. | Description | Minimum Marks | Maximum Marks |
|---|---|---|---|
| 1. | Father's profession | 6 | 15 |
| 2. | Mother's profession | 6 | 15 |
| 3. | Family Income (Monthly) | 4 | 15 |
| 4. | Father's educatim | 4 | 10 |
| 5. | Mother's education | 4 | 10 |
| | | 24 | 65 |

This criteria has been arrived after studying a number of socio-economic status scales and consulting psychologists, educationists, and research workers in the field. Some of the socio-economic status scales studied for the purpose were:

1. Kupuswamy socio-Economic Status Scale (urban) published by "Mansayan" 32, Netaji Subhash Marg, Delhi-6.
2. Socio-economic status by S.N.Rao, published by Rupa Psychological Centre, B-19/160 B, [illegible], Deoriabir, Bhelupura Varanasi-221001 (U.P).
3. Socio-Economic status scale questionnaire by S.L.Jalota, R.N.Pandey, S.D.Kapoor, & R.N.Singh published by the psycho-centre, T-22, Green Park, New Delhi-16.
4. Socio-Economic scale questionnaire (urban) by S.D.Kapoor, M.C.Kochar published by The Psycho Centre, T-22, Green Park, New Delhi-16.
5. Socio-Economic Scale questionnaire (urban) by S.Jalota, R.N.Pandey S.D.Kapoor & R.N. Singh published by the Psycho-Centre, T-22, Green Park, New Delhi-16.

Most of these socio-economic status scales were unsuited for this study because the monthly family income ranges of these scales are too low and the professional and educational status of the sample of this study does not match with the criterion

mentioned in these socio-economic scales. The sample of students on whom this study was conducted were highly urbanised. Taking these factors into view these socio-economic scales were thought not relevant and a new socio-economic scale was arrived at.

The criteria for father's/mother's profession is as under:-

Table 5.12

Criteria categorywise for Father's/Mother's profession

| Category | Description | Marks alloted |
|---|---|---|
| I. | Specialist | 15 |
| II. | Professional | 12 |
| III. | Semi-professional | 10 |
| IV. | Technician | 8 |
| V. | Skilled worker | 7 |
| VI. | Semi skilled worker/clerical/shop owner/farm owner/others | 6 |

The criteria for the family income (monthly) is as given overleaf.

Table 5.13

Criteria Categorywise for family income (Monthly)

| Category | Description | Marks alloted |
|---|---|---|
| I. | Above Rs. 5,000/- | 12 |
| II. | Rs. 4,000/- to Rs. 5,000/- | 12 |
| III | Rs. 3,000/- to Rs. 4,000/- | 10 |
| IV | Rs. 2,000/- to Rs. 3,000/- | 8 |
| V | Rs. 1,500/- to Rs. 2,000/- | 6 |
| VI | Rs. 1,000/- to Rs. 1,500/- | 4 |

The criteria for Fathers/Mothers Education is as under:-

Table 5.14

Criteria categorywise for Father's/Mother's education

| Category | Description | Marks alloted |
|---|---|---|
| I. | Post graduate professional/degree/ M.Sc., Ph.D | 10 |
| II | Professional degree/M.Sc./M.A,LLB/ M.A.,B.Ed. | 8 |
| III | M.A./M.Com | 7 |
| IV | B.Sc./Diploma Engineering/BA,LLB/BA, B.Ed. | 6 |
| V | B.A./B.Com/Language Honours | 5 |
| VI | Intermediate pass or below | 4 |

The criteria for socio-economic status is judged by adding the individual scores of each student(Father's profession (A), Mother's Profession(B), Family Income (Monthly) (C), Father's Educational qualifications(D), and Mother's Educational qualifications (E). The total score is arrived at by adding (A+B+C+D+E). The category of socio economic status to a student is alloted as per the ranges given below:

Table 5.15

Criteria for Socio-economic status category

| S.No. | Range of scores(A+B+C+D+E) | Category |
|---|---|---|
| 1. | Above 40 | I |
| 2. | 34 - 40 | II |
| 3. | 27 - 33 | III |
| 4. | 21 - 26 | IV |
| 5. | 14 - 20 | V |
| 6. | Below 14 | VI |

(E) Marking Scheme - Out of School Activities

The position of each student in hobbies (ordinary and scientific), involvement in scientific activities,

involvement in work experience/vocational job is judged on the basis of criteria given below:

Table 5.16

Criteria for judging the position of each student on Hobbies/Scientific activities/vocational Education/ Work experience/Vocational job.

| S.No. | Description | Marks alloted |
|---|---|---|
| 1. | Hobby ( ordinaryh) | 1 per activity. |
| 2. | Hobby ( Scientific) | 2 per activity. |
| 3. | Scientific activity | 1 per activity |
| 4. | Work experience/Vocational job | 2 marks. |
| | Total | 20 Marks |

Ordinary hobbies include, reading, travelling, stamp collection etc. scientific hobbies include photography, Electric gadetry, reading science magazines, visiting Science Museum/Science Exhibitions/listening popular Science lecture/watching science programmes on the television/ listening science programmes on the radio.

Scientific activity includes orionthology, electronic repairs, radio repairs, flying, making project in a science club.

Work experience/vocational job includes soap making, prepearing electronic instruments, weaving, paramedical jobs, dyeing and colour printing, binding woodwork, willow work, Weaving, Ink making, shampoo making etc.

There is a provision of six hobbies in the bio-data form. The scientific Activities included in the bio-data form are watching educational televison, listening to school educational broadcasts, reading science magazines, Involvement in science club, visited/participated in science museum/exhibition listening popular science lecture, watching popular science television programme, listening popular science radio programmes.

The criteria for judging the category of each student in Hobbies/scientific activities/work experience/ vocational job is as under :

Table 5.17

Categories of students in out of school scientific activities.

| S.No. | Description | Category |
|---|---|---|
| 1. | Above 18 marks | I |
| 2. | 15 - 18 Marks | II |
| 3. | 11 - 14 Marks | III |
| 4. | 9 - 10 Marks | IV |

| | | |
|---|---|---|
| 5. | 7-8 Marks | V |
| 6. | Below 7 marks | VI |

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The idea to develop a marking scheme for the out of school activities and grade each student in one of the six categories is to know how laboratory skills are influenced by out of school activities (Hobbies(Ordinary/ scientific), scientific activities and work Experience/ Vocational Job.

The idea is also to know if they at all make any significant contribution to the development of the laboratory skills. In all criteria, professional/educational, out of school activities, ones with scientific background have been given higher weightage.

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