CHAPTER - IV

IDENTIFICATION OF CHEMISTRY LABORATORY SKILLS

Introduction

One of the main purposes of this study was to identify chemistry laboratory skills at the senior secondary stage of the schools of the Union Territory of Delhi. In order to identify Chemistry laboratory skills, we must know what Chemistry laboratory skills and the laboratory experiences are ? Laboratory skills have been defined by Hearle* (1973) as, "Those skills which must be utilized to prepare, execute and bring to a conclusion any laboratory experience. The required skills are drawn primarily from the cognitive and psychomotor domains of learning". The laboratory experiences have also been defined by Hearle as "The learning experiences involving the performing of chemistry experiments".

On the basis of identified chemistry laboratory skills of senior secondary stage the Entry Level Test and Terminal Level Test, were constructed. Before constructing the tests, Chemistry laboratory skills were bifurcated into relevant and non-relevant for the study. From the relevant chemistry laboratory skills a list of skill categories had been prepared. On the basis of skill .....

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* Hearle R.J."The identification and measurement of high school chemistry laboratory skills" unpublished Ph.d. dissertation, University of Maryland(U.S.A), 1973.

categories the test items for the two tests were constructed.

(A) Analysis of Central Board of Secondary Education Syllabus for Entry level Test

First of all chemistry practical syllabus of class XI was taken up and it was analysed for all the chemistry laboratory skills experiment by experiment in all the fourteen prescribed experiments. Each experiment was taken up individually to find out what operations (Affective, cognitive & psychomotor) were involved in that particular experiment. On the basis of operations involved in each experiment a list was compiled of the needed chemistry laboratory skills for each experiment. These chemistry laboratory skills experimentwise are as following:-

Analysis of Chemistry practical Course (Class XI) for identifying chemistry laboratory skills.

(I) Acquaintance of Chemistry laboratory and basic laboratory techniques (bending, boring, sealing, cleaning of glass apparatus and burner, etc.).

Skills Involved:

1. Skill of proper selection of material namely glass tubes, corks, cork borers, (sealing wax/ plaster of paris), burner, sodium carbonate, chromic acid & brushes).

2. Skill of identifying and locating materials in a chemistry laboratory.
3. Skill of observing laboratory safety measure.
4. Skill of bending glass tubes at appropriate angle, and shapes.
5. Skill of boring corks at proper places and in proper sizes.
6. Skill of sealing leaks in an assembly of glass apparatus with sealing wax or plaster of paris.
7. Skill of cleaning glass apparatus with (cold/hot) water, sodium carbonate, chromic acid & brushes.
8. Skill of cleaning bunsen burner with the help of needles and brushes etc.

(II) Preparation, Collection and Study of some important Physical and chemical properties of at least three gasses, one each from the following groups:-

a) Chlorine, hydrogen chloride, sulphur Dioxide,
b) Carbon dioxide and hydrogen sulphide.
c) Hydrogen, oxygen.

Skills Involved

1. Skill of selection of proper chemicals/glassware and apparatus.
2. Skill of computing the proper quantities of chemicals to be used in preparing various gasses.

3. Skill of assembling the apparatus properly.
4. Skill of heating & cooling whenever necessary.
5. Skill of collecti ng the gasses by (upward/downward) displacement of air or water.
6. Skill of observing physical properties (colour, odour, heavyness etc.).
7. Skill of observing chemical properties by performing chemical test ((acidic/basic) nature, combustability/ support to combustion, reaction with other chemicals including water).
8. Skill of comparing (colours, odours, heavyness etc.) with gases having similar properties.
9. Skill of interpreting and drawing conclusions.
10. Skill of washing, drying and replacing the glassware properly.
11. Skill of making the assembly diagrams.
12. Skill of reporting the experiment.

(III) (a) Preparation of delute solutions of known concentration of sulphuric acid, hydrochloric acid and nitric acid.

(b) Reaction of dilute and concentrated acids on any two metals (magnesium, Zinc, Copper and Iron).

Skills Involved

1. Skill of Selection of proper chemicals, glassware and apparatus.

2) Skill of computing proper volumes of acids to be diluted.

3) Skill of transfering the acids from the bottle to the measuring flask.

4) Skill of diluting the acids properly.

5) Skill of making the volume upto mark.

6) Skill of shaking and making the solutions uniform.

7) Skill of calculating the proper quantity of metals and proper volumes of acids (concentrated/dilute).

8) Skill of observing whether the reaction takes place or not (evolution of a gas/heat) colour change/ formation of a precipitate).

9) Skill of observing & comparing the rates of reaction (slow/fast).

10) Skill of observing and testing the products formed in the reaction.

11) Skill of reporting the experiment properly.

(IV) Preparation of Crystals from impure samples of any two of the following substances, using simple laboratory processes (sedimentation, decentation, filteration and evaporation). Alum, copper sulphate, potassium Nitrate, Ferrous Sulphate from Kipp's waste.

Skills Involved

1) Skill of puryfing Impure samples of chemicals with the help of processes of sedimentation, decantation, filteration and evaporation.

2) Skill of purifying impure samples of chemicals by chemical treatment etc.

3) Skill of concentrating the solution to proper level by heating or cooling.

4) Skill of tieing a sample crystal to act as a nucleus for further growth of crystals.

5) Skill of keeping the concentrated solution properly till the crystals grow.

6) Skill of Removing the crystals, drying and preserving them.

7) Skill of reporting the shape and other characteristics of the crystals.

(V) Study of electrical conductivity of water and aqueous solutions of inorganic acids, sugar, salts and organic liquids.

Skills Involved

1) Skill of selecting proper chemicals, glassware and other apparatus.

2) Skill of preparing the solution of desired concentrations.

3) Skill of measuring the volumes properly.

4) Skill of connecting the apparatus in an electrical circuit and finding faults if any.

5) Skill of inserting the key or pressing the knob when desired.

6) Skill of observing the glow of the electrical bulb.

7) Skill of reporting the findings of the experiment properly.

(VI) a) Determination of the pH of following substances by using universal indicator solution or pH paper. i) Soils (ii) Acids and Bases of different dillution (iii) Vegetable and fruit juices.

b) Study of pH change by common-ion effect in case of weak acids and weak bases by above method.

Skills Involved:

1) Skill of selecting proper chemicals, glassware & apparatus.

2) Skill of extracting juices from vegetables & fruits and solutions from the soils.

3) Skill of adding universal indicator in proper proportions.

4) Skill of comparing the colours of the solution with the standard pH chart.

5) Skill of computing the proper quantity of chemicals.

6) Skill of plotting the graph.

7) Skill of interprating the graph.

8) Skill of reporting the findings of the experiment properly.

(VII) Determination of the melting point of a solid substance of low melting point (below 100°C) by glass capillary tube method.

Skills Involved:

1. Skill of selecting proper chemicals, glassware, & apparatus.
2. Skill of preparing capillary tube by fusing at one end by heating.
3. Skill of filling the capillary tube by substance.
4. Skill of setting up of a water bath.
5. Skill of heating the water bath.
6. Skill of observing the temperature at the time of melting of the substance.
7. Skill of reporting the findings of the experiment properly.

(VIII) Study of Solubility of a solid substance in water and plotting of solubility curve.

Skills Involved:

1. Skill of selecting proper chemicals, glassware and apparatus etc.
2. Skill of taking measured volume of water.
3. Skill of weighing substances (Chemicals).
4. Skill of dissolving the chemicals in water properly.
5. Skill of heating the water.

6. Skill of noting down the temperature at which a particular amount of substance completely dissolves.
7. Skill of finding the saturation point for a particular volume of Water.
8. Skill of plotting the graph between temperature and amount of substance dissolved.
9. Skill of interpreting the graph.
10. Skill of reporting the findings of the experiment properly.

(IX) Determination of the clorific value of any one of the following:

Methylated spirit, wax, Kerosene oil, mustard oil,

(The above substances will be used as a source of heating to raise the temprature through a definite range of a given quantity of water or by any other suitable method).

Skills Involved:

1. Skill of selecting proper chemicals, glassware & apparatus.
2. Skill of taking the appropriate quantities of substances whose calorific value has to be found out.
3. Skill of taking the appropriate quantity of water.
4. Skill of burning the substances properly.
5. Skill of reading the thermometer and noting down the temperature.
6. Skill of calculating the calorific value of different substances by a given formula.

7. Skill of reporting the findings of the experiment properly.

(X) Study of the shift in equilibrium between ferric ions and thiocyanate ions by increasing the concentration of either of them.

Skills Involved:

1. Skill of selecting proper chemicals, glassware & apparatus.
2. Skill of weighing substances properly.
3. Skill of transfering the substances properly in measuring flasks.
4. Skill of adding distilled water properly and making up the volume upto mark.
5. Skill of measuring the volumes properly and transfering them into containers.
6. Skill of choosing a proper indicator and adding it in appropriate quantities.
7. Skill of observing the colours of solutions and changes taking place in them.
8. Skill of observing the colour concentrations.
9. Skill of matching the colours.
10. Skill of reporting the findings of the experiment properly.

(XI) Preparation of commonly used standard, molar solutions of Oxalic acid or Sodium carbonate.

Skills Involved:

1. Skill of selecting proper chemicals, glassware & apparatus.
2. Skill of weighing substances properly.
3. Skill of transfering substances properly in a measuring flask.
4. Skill of adding water and making up the volume.
5. Skill of shaking the measuring flask to make solution uniform.
6. Skill of calculating the amounts of substances to be taken for the preparation of standard or molar solutions.
7. Skill of labelling and storing the (Standard/molar) solutions.
8. Skill of reporting the findings of the experiment properly.

(XII) Study of Acid-Base single titration, i.e. Oxalic acid and sodium hydroxide or Hydrochloric acid and sodium carbonate.

Skills Involved:

1. Skill of selecting chemicals, glassware and apparatus properly.
2. Skill of Rinsing the apparatus properly.
3. Skill of measuring the volumes of solutions properly.
4. Skill of transfering the solutions to a burette and a titration flask.

5. Skill of deciding the right indicator and adding it.
6. Skill of adding (base/acid) from the burette in small amounts.
7. Skill of shaking after every addition of drops of (Base/acid).
8. Skill of observing the (colour changes/precipitation formed) in the titration flask.
9. Skill of finding the end point correctly.
10. Skill of finding the normality etc. of the other solution by using Normality equation.
11. Skill of finding the (amount dissolved per litre) by using normality equation.
12. Skill of reporting the findings of the experiment properly.

(XIII) Study of neutralization reaction of Sodium Hydroxide and Hydro chloride acid, and a roughx estimation of the heat of neutralization by simple calorimetric method.

Skills Involved:

1. Skill of selecting proper chemicals, glassware and apparatus.
2. Skill of rinsing various glass apparatus.
3. Skill of preparing various (standard/molar)solutions.
4. Skill of measuring different volumes of solutions.
5. Skill of deciding the type of indicator and the quantity to be taken.

6. Skill of adding (base/acid) from the burette in small amounts.
7. Skill of shaking after every addition of (Base/acid).
8. Skill of observing the (colour changes/precipitation formed) in the titration flask.
9. Skill of finding the end point correctly.
10. Skill of finding the normality ~~x~~ from the normality equation.
11. Skill of finding the amount dissolved per litre etc. of the other solution by using normality equation.
12. Skill of calculating the heat of neutralization.
13. Skill of reporting the findings of the experiment properly.

(XIV) <u>Elementary qualitative Analysis: determination of One basic and one acid radical from the following groups (Insoluble to be excluded).</u> Basic Radicals Pb^{+2}, Cu^{+2}, Cd^{+2}, As^{+3}, Fe^{+2}, Fe^{+3}, Al^{+3}, Ni^{+2}, Zn^{+2}, Mn^{+2}, Ca^{+2}, Ba^{+2}, Sr^{+2}, Mg^{+2}, NH^{+1},

Acidic Radicals : CO_3^{-2}, SO_3^{-2}, S^{-2}, Cl^{-1}, Br^{-1}, I^{-1}, NO_3^{-1}, SO_4^{-2}, PO_4^{-3}, BO_3^{-3}.

<u>Skills Involved:</u>

1. Skill of selecting proper chemicals, glassware and apparatus.
2. Skill of taking the right quantities of salt for preparation of a salt solution.
3. Skill of preparing the original salt solution.

4. Skill of performing group analysis tests.
5. Skill of performing radical analysis tests.
6. Skill of performing the confirmatory radical tests.
7. Skill of performing the technique of seperation sedamentation filteration, evaporation and decentation).
8. Skill of boiling off hydrogen sulphide gas.
9. Skill of removing acidity from a solution.
10. Skill of removing alkalinity from a solution.
11. Skill of preparing neutral solution.
12. Skill of performing the flame test.
13. Skill of performing chareoal cavity test.
14. Skill of performing borax bead test.
15. Skill of reporting the findings of the experiment properly.

A composite list of Chemistry laboratory for skills for Entry Level Test was compiled.

Comprehensive list of Chemistry laboratory skills for Entry Level Test

1. Skill of selection of materials, chemicals glassware & apparatus.
2. Skill of identifying and locating materials in a chemistry laboratory.
3. Skill of observing laboratory safety measures.
4. Skill of bending glass tubes at appropriate angles and shpaes.

5. Skill of boring corks at proper places and in proper sizes.
6. Skill of sealing leaks in an assembly of glass apparatus with the sealing wax or plaster of paris.
7. Skill of cleaning glass apparatus.
8. Skill of cleaning bunsen burner.
9. Skill of computing the proper quantities of chemicals to be used in preparing various gases.
10. Skill of assembling the apparatus properly.
11. Skill of heating & cooling whenever necessary.
12. Skill of collecting the gases.
13. Skill of observing physical properties (colour, odour heavyness, etc.).
14. Skill of observing chemical properties by performing chemical tests (acidic/basic) nature, combustability/ support to combustion, reaction with other chemicals including water).
15. Skill of comparing physical properties (colour, odour, heavyness) with other gases having similar properties.
16. Skill of interpreting and drawing conclusions of data.
17. Skill of Washing and cleaning the glassware properly.
18. Skill of drying & replacing the glassware.

19. Skill of making the assembly diagrams.

20. Skill of computing proper volumes of acids to be diluted.

21. Skill of transfering the acids from the bottle to the measuring flask.

22. Skill of diluting the acids properly.

23. Skill of making the volume upto mark.

24. Skill of shaking and making the solutions uniform.

25. Skill of calculating the proper quantity of metals and proper volumes of acids (concentrated/dilute) for a particular chemical reaction.

26. Skill of observing whether reaction takes place or not (evolution of (a gas/heat), absorption of heat, colour change, formation of a precipitate) etc.).

27. Skill of observing and comparing the rates of reaction (slow/fast).

28. Skill of observing and testing the products formed in the chemical reaction.

29. Skill of purifying impure samples with the help of processes of sedimentation, decentation, filteration and evoporation and crystalisation.

30. Skill of purifying impure samples by chemical treatment etc.

31. Skill of concentrating the solution to proper level by heating & cooling.

32. Skill of tieing a sample crystal to act as a nucleus for further growth of crystals.

33. Skill of keeping the saturated solution properly till the crystals grow.

34. Skill of Removing the crystals, drying and preserving them.

35. Skill of preparing the solutions of desired concentration.

36. Skill of measuring the volumes properly.

37. Skill of connecting the apparatus in an electrical circuit and finding faults if any.

38. Skill of inserting the key or pressing the knob when desired.

39. Skill of observing the glow of the electric bulb.

40. Skill of extracting juices from vegetables & fruits and solutions from the soil.

41. Skill of adding universal indicator or other chemicals in proper proportions.

42. Skill of comparing the colours of the solution with the standard pH chart.

43. Skill of computing proper quantity of chemicals.

44. Skill of plotting the graph.

45. Skill of interpreting the graph.

46. Skill of preparing capillary tube by fusing at one end by heating.

47. Skill of filling the capillary tube by the chemical substance.

48. Skill of setting up of a water bath.

49. Skill of heating the water bath.

50. Skill of observing the temperature at the time of melting of the substance.

51. Skill of weighing the substances.

52. Skill of dissolving the chemicals in water.

53. Skill of heating the water.

54. Skill of noting down the temperature at which a particular amount of substance completely dissolves.

55. Skill of finding saturation point for a particular volume of water.

56. Skill of taking appropriate quantitites of substance whose calorific value has to be found out.

57. Skill of taking the appropriate quantity of water.

58. Skill of burning the substance properly.

59. Skill of calculating calorific value of different substances by given formula.

60. Skill of choosing proper indicators.

62. Skill of observing colours of solutions and changes taking place in them.

63. Skill of observing colour concentration.

64. Skill of matching the colours.

65. Skill of calculating the amount of substances to be taken for the preparation of (Standard/molar)solutions.

66. Skill of labelling and storing the (standard/molar) solutions.

67. Skill of Rinsing the appratus properly.

68. Skill of adding (base/acid) from the burette in small amounts.
69. Skill of finding the end point correctly.
70. Skill of calculating the normality.
71. Skill of finding amount dissolved per litre etc.of other solution by uing normality equation.
72. Skill of calculating the heat of neutralization.
73. Skill of preparing the original salt solution.
74. Skill of performing the group analysis tests.
75. Skill of performing Radical analysis tests.
76. Skill of performing the conformatory tests for radicals.
77. Skill of boiling of hydrogen sulphide gas.
78. Skill of removing acidity from the solution.
79. Skill of removing alkalnity from the solution.
80. Skill of preparing neutral solution.
81. Skill of performing the flame test.
82. Skill of performing charcoal cavity test
83. Skill of performing boarax bead test.

These skills were divided into two categories relevant and non-relevant to the study. The non-relevant skills were left out. The relevant skills were examined for the repetion. Those skills which were of a repetitive nature were clubed together. The skills which were of repetitive nature were:

- Selection of Chemicals/Glassware/apparatus etc.
- Skill of assembling the apparatus from written instructions or pictures.

- Skill of boring corks.
- Skill of testing the air tightness.
- Skill of heating & cooling.
- Skill of locating the materials in a laboratory.
- Skill of weighing & measuring volumes etc.
- Skill of reporting the experiment etc.

The relevant skills were listed out and they were identified among 14 experiments. Out of 128 chemistry laboratory skills 46 of them were of a repetitive nature. In all 82 non-repetitive chemistry laboratory skills were identified in the chemistry practical syllabus of class XI.

The relevant chemistry laboratory skills for the Entry level test were as follows :-

1. Skill of bending glass tubes.
2. Skill of boring corcks.
3. Skill of sealing leaks in a glass apparatus.
4. Skill of computing the proper quantities of chemicals for preparation of gases.
5. Skill of assembling the appratus properly.
6. Skill of collecting gases ((upward/downward) displacement).
7. Skill of observing physical properties,(colour,odour, heavyness).
8. Skill of observing chemical properties (acidic/basic) nature, (Combustability/support co combustion) solubality, reaction with other chemicals).

9. Skill of comparison of physical properties (colour, odour, heavyness) with gases having similar properties.
10. Skill of Interpreting & drawing conclusions from the data.
11. Skill of making the assembly diagrams.
12. Skill of computing the proper volumes tobe diluted.
13. Skill of diluting the acids properly.
14. Skill of making up the volumes upto mark.
15. Skill of taking appropriate quantities of chemicals for interaction.
16. Skill of finding indications of a chemical reaction.
17. Skill of observing the rate of reaction.
18. Skill of testing the products formed in a reaction.
19. Skill of concentrating the solutions to saturation level.
20. Skill of preparing solutions of desired concentration.
21. Skill of measuring volumes properly.
22. Skill of observing the glow of the electric bulb.
23. Skill of plotting the graph.
24. Skill of interpreting the graph.
25. Skill of observing temperature.
26. Skill of weighing substances.
27. Skill of choosing a proper indicator.
28. Skill of calculating the amounts of substance to be baken for the preparation of standard/molar solotions.

29. Skill of observing colour changes.

30. Skill of observing precipitation for-mation.

31. Skill of finding the end point.

32. Skill of finding the normality, by using normality equation.

33. Skill of Finding the amount dissolved per litre etc.of the other solution by using normality equation.

34. Skill of preparing various (standard/molar) solutions.

35. Skill of computing the heat of neutralization.

36. Skill of preparing original salt solution.

37. Skill of group analysis tests.

39. Skill of performing confirmatory tests of radicals.

40. Skill of boiling off hydrogen sulphide gas.

41. Skill of removing acidity from the solution.

42. Skill of removing alkalnity from the solution.

43. Skill of preparing neutral solution.

44. Skill of performing the flame test.

45. Skill of performing charcoal cavity test.

46. Skill of performing borax Bead test.

Out of 82 chemistry laboratory skills 46 of them were found relevant to the study. Thirty six were found non-relevant to the study. The chemistry laboratory skills identified from the practical course of class XI and found to be non-relevant for the present study were as given overleaf:

1. Skill of identifying and locating materials in a chemistry laboratory.
2. Skill of observing laboratory safety measures.
3. Skill of cleaning bunsen burner.
4. Skill of drying & replacing the glassware.
5. Skill of making the assembly diagram.
6. Skill of computing proper volumes of acids to be diluted.
7. Skill of transfering acids from one vessel to another.
8. Skill of diluting acids properly.
9. Skill of making the volume upto mark.
10. Skill of shaking and making solutions uniform.
11. Skill of observing and comparing the rates of reaction.
12. Skill of observing and testing the products formed in the reaction.
13. Skill of purifying impure samples with the processes of seperation.
14. Skill of purifying impure samples by chemical treatment.
15. Skill of concentrating the solution to proper level.
16. Skill of tieing a sample crystal in a saturated solution.
17. Skill of keeping the saturated solution undisturbed.
18. Skill of removing, drying and preserving the crystals.
19. Skill of connecting the appratus in an electrical circuit and finding faults if any.

20. Skill of inserting the key or pressing the knob when desired.
21. Skill of extracting juices from vegetables, fruits and solutions from the soil.
22. Skill of adding universal indicator or other chemicals in proper proportions.
23. Skill of preparing capillary tube.
24. Skill of filling the capillary tube by a chemical substance.
25. Skill of setting up a water bath.
26. Skill of heating the water bath.
27. Skill of dissolving chemicals in water.
28. Skill of heating the water.
29. Skill of finding temperature of dissolution of a substance.
30. Skill of taking appropriate quantities of chemicals for determination of clorific value.
31. Skill of taking appropriate quantity of water.
32. Skill of burning the substance properly.
33. Skill of adding indicators in appropriate quantities.
34. Skill of observing colour concentration.
35. Skill of labelling & storing the regants.
36. Skill of rinsing the apparatus properly.
37. Skill of adding volume of (acid/base) from the burrette in small quantities.

Forty six of the chemistry laboratory skills were taken up for categorisation. The 36 chemistry laboratory skills identified for the Entry level test were categorised into 8 main categories and 34 sub-categories.

(B) Analysis of Central Board of Secondary Education Syllabus for Terminal level test

Chemistry practical syllabus for class XII of the Central Board of Secondary Education was analysed for the possible Chemistry laboratory skills similarly as was done in Class XI (from core experiments and optional experiments). Class XII has three types of experiments namely core experiments, optional experiments and projects. The chemistry practical syllabus of Class XII has 12 core experiments, 10 optional experiments and 10 suggested projects. During the academic session all students have to perform 12 core experiments and either take up a project or perform 3 optional experiments in lieu of a project. Projects were not taken into account for finding the chemistry laboratory skills since no definite strategy or course of action is expected to be followed in the case of projects. Each experiment was analysed for the possible chemistry laboratory skills needed to complete it. Chemistry laboratory skills identified in the Chemistry practical course of class XII for Terminal level test are given overleaf:

(I) Preparation of double salt of Ferrous Ammonium sulphate or Potash Alum.

Skills Involved:

1. Skill of calculating the required proportions from chemical formula for the preparation of a saturated solution.
2. Skill of weighing substances precisely.
3. Skill of dissolving and preparing saturated solution.
4. Skill of evaporating and crystalising the substances.
5. Skill of purifying the substances.

(II) Study of interaction of metals (any three) with salt solutions.

Skills Involved:

1. Skill of identification of the metals.
2. Skill of selection of chemicals etc. of proper quality size, shape etc.
3. Skill of preparation of solutions.
4. Skill of observing the metallic deposits formed and in some cases the changes of colour taken place in them.
5. Skill of arranging metals in a sequence on the basis of well defined observations.

(III) Preparation of the Sols & process of dialysis

Skills Involved:

1. Skill of selection of the chemicals, parachment paper etc. of proper quality.
2. Skill of preparation of various solutions.
3. Skill of tieing the precepitate in the paraechment paper.
4. Skill of testing the presence of ions in water.

(IV) Comparison of the precipitation values of various chlorides.

Skills Involved:

1. Skill of proper selection of chemicals etc.
2. Skill of preparation of various solutions.
3. Skill of measuring and adding quantities of the solution.
4. Skill of comparison of the precipitating values of various chlorides.

(V) Comparison of the effectiveness of a number of oils and emulsifying agents in forming emulsion

Skills Involved:

1. Skill of selection of proper oils.
2. Skill of forming emulsions.
3. Skill of comparison of the their emulsifying properties.

(VI) Effect of concentration and temperature on the rate of reaction.

Skills Involved :

1. Skill of selection of proper chemicals glassware, apparatus etc.
2. Skill of preparing various solutions of different concentrations.
3. Skill of measuring the volumes properly.
4. Skill of noting down the time used correctly.
5. Skill of reading and adjusting the temperatures properly.
6. Skill of collecting, tabulating the data properly.
7. Skill of calculating and interpreting the data properly.
8. Skill of using graph and its interpretation.

(VII) Effect of catalyst on the reaction.

Skills Involved:

1. Skill of selection of proper chemicals/glassware/ apparatus etc.
2. Skill of selection of the right catalyst.
3. Skill of weighing different amounts of catalyst.
4. Skill of comparison of the times of reaction.
5. Skill of measuring the time.
6. Skill of collecting, tabulating the data.
7. Skill of calculating and interpreting the data properly.

8. Skill of using the graph and its interpretation.

(VIII) Seperation of coloured substances by chromatography.

Skills Involved:

1. Skill of selection of proper substances/pigments solutions for use.
2. Skill of selection of proper chromatographic paper apparatus etc.
3. Skill of marking of the baseline, points etc. on the chromatographic paper.
4. Skill of preparation of the proper solvent.
5. Skill of adjusting the chromatographic apparatus properly.
6. Skill of spotting, measuring, and tabulating the data.
7. Skill of calculation of Rf value and interpreting the data.
8. Skill of comparison of the Rf value.

(IX) Identification of Carbohydrates, fats, proteins in food stuffs

Skills Involved:

1. Skill of selection of the proper chemicals/ apparatus/glassware.

2. Skill of taking the right quantities of testing materials.
3. Skill of adding the right quantities of reacting materials.
4. Skill of performing the analytical tests (Qualitatively).
5. Skill of verifying and confirming the tests.

(X) Preparation of Molar solutions and study of Redox titrations.

Skills Involved:

1. Skill of calculating the right quantities of chemicals required.
2. Skill of proper selection of chemicals/apparatus/ glassware etc.
3. Skill of preparation of solutions.
4. Skill of Measuring the volumes correctly.
5. Skill of finding out the end point correctly.
6. Skill of adding the right amount of indicator.
7. Skill of collecting and tabulating the data.
8. Skill of interpreting the data and calculating results.

(XI) Qualitative Analysis (Inorganic Salts)

Skills Involved:

1. Skill of taking the right quantities of salt, for preparation of salt solution.
2. Skill of preparing the original salt solution.
3. Skill of performing group analysis tests.
4. Skill of performing radical analysis tests.
5. Skill of verifying and confirming the tests.
6. Skill of separation (filteration, sedementation, decantation and evaporation).
7. Skill of boiling off hydrogen sulphide gas, from the solution.
8. Skill of removing acidity from the solution.
9. Skill of filteration, evaporation etc.
10. Skill of removing alkalnity from the solution.
11. Skill of preparing neutral solutions.
12. Skill of performing the flame tests.
13. Skill of performing charcoal cavity tests.
14. Skill of performing Borax bead tests.

(XII) Organic element Detection.

Skills Involved:

1. Skill of taking right quantities of chemicals.
2. Skill of cutting the sodium metal piece.

3. Skill of fusing organic compounds properly with mettalic sodium.
4. Skill of breaking the ignition tube.
5. Skill of filteration of the solution.
6. Skill of performing the individual tests of elements.

OPTIONAL EXPERIMENTS

(I) Diffusion of solids in liquids

Skills Involved:

1. Skill of proper selection of chemicals and apparatus/glassware etc.
2. Skill of finding out crystals of similar size.
3. Skill of addition of water with least disturbance.
4. Skill of performing various laboratory operations like, heating, stirring and covering the beaker.
5. Skill of measuring the time taken in each case.
6. Skill of comparing the rates of diffusion in each process.
7. Skill of arranging the rates of diffusion in a sequence.

(II) Minimum quantity of Mangenese Dioxide in the preparation of Oxygen.

Skills Involved:

1. Skill of proper selection of chemicals and appratus/ glassware.

2. Skill of Assembling the apparatus in proper form.
3. Skill of heating the chemical mixture.
4. Skill of addition of a proper amount of a catalyst by varying the amounts.
5. Skill of observation of the evolution of oxygen gas.
6. Skill of collection of oxygen gas by the right method to avoid leakage, dissolution or accidents.
7. Skill of recording and tabulating the results.

(III) Determination of the Rate of flow of solutions and liquids horizontally.

Skills Involved:

1. Skill of proper selection of chemicals and apparatus.
2. Skill of keeping the glass plate horizontally and checking it with the help of a spirit level.
3. Skill of cleaning the burette and attaching a fine jet to it.
4. Skill of marking the boundary of the water drop.
5. Skill of measuring the distance from the centre of the drop to the boundary of the drop.

(IV) Foaming Capacity of Different Soaps.

Skills Involved:

1. Skill of proper selection of chemicals and apparatus glassware.
2. Skill of accurate measurement of volumes and weights.
3. Skill of heating of the solution for complete dissolution.
4. Skill of shaking of the solutions vigorously.

(V) Tea Leaves and their variation in Taste.

Skills Involved:

1. Skill of selection of proper chemicals, apparatus and glassware.
2. Skill of refluxing.
3. Skill of seperation by decentation and filteration.
4. Skill boiling the contents with constant stirring till no precipitate is obtained.
5. Skill of decolourising the solution by animal charcoal.
6. Skill of extracting the desired component with chloroform.
7. Skill of dissolutionof the residue.

(VI) Rates of Evaporation of different liquids.

Skills Involved:

1. Skill of selection of proper chemicals, apparatus and glassware.
2. Skill of measuring accurate volumes and weights.
3. Skill of exposing the liquids to atmosphere.
4. Skill of making the time study of evaporation.
5. Skill of calculating the rate of evaporation/ unit time.

(VII) Effect of metal coupling on the rusting of iron.

Skills Involved:

1. Skill of proper selection of chemicals, apparatus and glassware.
2. Skill of boiling the solutions.
3. Skill of preparing the agar-agar solution.
4. Skill of adding proper amounts of chemical solutions.
5. Skill of cleaning the iron nails with organic solvents.
6. Skill of drying the iron nails in an oven.
7. Skill of twisting the nails and coupling them with zinc and copper wires.

8. Skill of adding agar-agar solution in petri dishes carefully.
9. Skill of observing the colour of the patch.
10. Skill of drawing the conclusions on the basis of observation.

(VIII) Effect of Acids and Bases on the tensile strength of Fibers.

Skill Involved:

1. Skill of selection of proper chemicals apparatus and glassware.
2. Skill of selection of threads of uniform length and diameter.
3. Skill of adjusting the length of the thread with the apparatus.
4. Skill of noting the minimum weights required for breaking each thread.
5. Skill of tabulating the values and finding tensile strength.

(IX) Preparation of Rayon thread

Skills Involved:

1. Skill of proper selection of chemicals, apparatus and glassware.
2. Skill of preparing a saturated solution.

3. Skill of addition of NaOH to obtain $Cu(OH)_2$ solution.
4. Skill of washing the precipitate to remove SO_4^{2} solutions.
5. Skill of Transfering the precipitate in a conical flask and addition of 50% Ammonia solution.
6. Skill of preparation of "Schweitzer solution".
7. Skill of cutting a thread into pieces and dissolving the pieces.
8. Skill of Filling the viscose solution into the syringe and forcing it out in dilute sulphuric acid.
9. Skill of removing the container from the water bath after change of colour.

(X) Analysis of Fruit and Vegetable Juices for contents.

Skills Involved:

1. Skill of proper selection of chemicals, apparatus and glassware.
2. Skill of measuring volumes and weights correctly.
3. Skill of preparing solutions of proper concentration.
4. Skill of recognising physical properties (rings, red precipitate, silver miror, blue colour, pungent odour, voilet colour, oily surface).
5. Skill of performing the confirmatory tests.
6. Skill of deduction of results on the basis of tests.

A composite list of chemistry laboratory skills was compiled for class XII which contained 146 chemistry laboratory skills. 62 chemistry laboratory skills were of a repetitive nature. The chemistry laboratory skills which were of a repetitive nature were almost similar as mentioned in the analysis of chemistry laboratory skills for entry level test.

List of Chemistry laboratory skills identified from Chemistry practical course of class XII.

1. Skill of proper selection of chemicals, apparatus and glassware.
2. Skill of finding the crystal size.
3. Skill of addition of a liquid properly.
4. Skill of laboratory operations like (heating, stirring, covering the vessel etc).
5. Skill of measuring time.
6. Skill of arranging rates in a sequence.
7. Skill of comparing rates on the basis of data.
8. Skill of assembling the apparatus.
9. Skill of addition of a solid substance.
10. Skill of observation of the varying amounts of gases.
11. Skill of collecting the gas with precautions.
12. Skill of recording and tabulating the data.

13. Skill of keeping the glass plate at level.
14. Skill of cleaning the burette with the jet.
15. Skill of Marking the boundary of a water drop.
16. Skill of measuring the distance.
17. Skill of measuring of weights & volumes.
18. Skill of shaking the solution.
19. Skill of refluxing the solution.
20. Skill of seperation of a liquiid and a solid by filteration.
21. Skill of seperation of a liquids and a solid by decentation.
22. Skill of boiling a solution with constant stirring.
23. Skill of decolourising a substance by animal charcoal.
24. Skill of extraction of an organic compound with chloroform.
25. Skill of dissolution of the residue.
26. Skill of exposing liquids to atmosphere.
27. Skill of making time study of evaporation.
28. Skill of calculating of evaporation/unit time.
29. Skill of preparing agar-agar solution.
30. Skill of cleaning of iron nails.
31. Skill of drying a substance in an oven.
32. Skill of twisting the nails and coupling them with copper/zinc wires.

33. Skill of observing the colour.

34. Skill of drawing conclusions on the basis of observation.

35. Skill of selection of threads of uniform length and diameter.

36. Skill of adjusting the length of the thread.

37. Skill of noting the weight required for breaking the thread.

38. Skill of tabulating the values and finding the tensils strength.

39. Skill of preparing a saturated solution.

40. Skill of addition of a regant to obtain another solution.

41. Skill of washing the precipitate to remove undesired ions.

42. Skill of transfering the precipitate and dissolving it.

43. Skill of preparing a special solution.

44. Skill of cutting and dissolving the pieces of thread.

45. Skill of filling the viscose solution in an injection syringe and injecting them into an acid solution.

46. Skill of preparing solutions of proper concentration.

47. Skill of recognising rings.

48. Skill of recognising silver miror.

49. Skill of recognising oily surface.

50. Skill of deduction of results.
51. Skill of performing confirmatory tests.
52. Skill of calculating the required proportions for a saturated solution.
53. Skill of evaporating a solution and crystalising.
54. Skill of purifying substances.
55. Skill of identification of metals.
56. Skill of observation of the metallic deposits.
57. Skill of arranging metals in a sequence on the basis of reactivity.
58. Skill of testing the precipitate/ions.
59. Skill of comparing of the precipitating values/ emulsifying properties.
60. Skill of Forming an emulsion.
61. Skill of reading and adjusting the temperature.
62. Skill of collecting, calculating, tabulating and interpreting the data properly.
63. Skill of using graph and interpretating it.
64. Skill of selection of chromatographic paper/ apparatus.
65. Skill of marking base line, points on chromatographic paper.
66. Skill of selection and preparation of a solvent.
67. Skill of adjusting the chromatographic apparatus properly.

68. Skill of spotting and measuring the coloured spots.

69. Skill of calculating of Rf value and interpreting the data.

70. Skill of comparisons of Rf values.

71. Skill of finding the end point correctly.

72. Skill of preparing the original solution.

73. Skill of performing group analysis tests.

74. Skill of performing individual radical tests.

75. Skill of performing the confirmatory tests.

76. Skill of preparing of neutral solutions.

77. Skill of boiling off hydrogen sulphide gas from the solution.

78. Skill of removing acidity.

79. Skill of removing alkalinity.

80. Skill of performing of flame test.

81. Skill of performing charcoal cavity test.

82. Skill of performing borax bead test.

83. Skill of cutting of sodium metal.

84. Skill of fusing the organic compound with sodium metal.

85. Skill of breaking the ignition tube.

86. Skill of individual tests of organic elements.

The composite list of chemistry laboratory skills was screened to eliminate the repetitive chemistry laboratory skills. Out of the rest 86 chemistry laboratory skills identified only 42 were found to be relevant to the study and 44 were found to be irrelevent to the study.

List of non-relevant chemistry laboratory skills for Terminal level test.

The chemistry laboratory skills identified from the practical course of class XII and found to be non-relevant for the present study were as follows:-

1. Skill of addition of a liquid properly.
2. Skill of laboratory operations heating, cooling etc.
3. Skill of measuring time.
4. Skill of addition of a solid substance.
5. Skill of observation of the varying amounts of gases.
6. Skill of collecting the gas with precaution.
7. Skill of keeping the glass plate at level.
8. Skill of cleaning burrette with jet.
9. Skill of marking the boundary of a water drop.
10. Skill of shaking the solution.
11. Skill of refluxing the solution.

12. Skill of seperation of a solid and liquid by decantation.
13. Skill of separation of a solid and liquid by filteration.
14. Skill of boiling a solution with constant stirring.
15. Skill of decolourising a substance with animal charcoal.
16. Skill of extraction of an organic compound with chloroform.
17. Skill of dissolution of the residue.
18. Skill of exposing liquids to atmosphere.
19. Skill of making time study of evaporation.
20. Skill of calculating of evaporation/unit time.
21. Skill of preparing Agar-Agar solution.
22. Skill of cleaning iron nails.
23. Skill of drying iron nails in an oven.
24. Skill of twisting the nails and coupling them with copper/zinc wires.
25. Skill of selection of threads with uniform length and diameter.
26. Skill of adjusting the length of the thread.
27. Skill of noting the weight required for breaking the thread.
28. Skill of addition of a reagent to obtain another solution.

29. Skill of washing the precipitate and removing the undesired ions.
30. Skill of transfering the precipitate and dissolving it.
31. Skill of preparation of a special solution.
32. Skill of cutting and dissolving the pieces of threads.
33. Skill of filling viscose solution in an injection syringe and injecting them into an acid solution.
34. Skill of recognising a silver miror.
35. Skill of recognising an oily surface.
36. Skill of calculating required proportions for a saturated solution.
37. Skill of evaporating a solution.
38. Skill of crystalising.
39. Skill of purifying a substance.
40. Skill of arranging metals in the basis of reactivity.
41. Skill of reading the temperatures.
42. Skill of adjusting the temperature.
43. Skill of marking the base line and points on a chlromatographic paper.
44. Skill of adjusting the chromotographic apparatus properly.

Some of the other non-relevant chemistry laboratory skills usually needed for doing practical work in a chemistry laboratory are as follows:-

1. Listening.
2. Asking question.
3. Discussion.
4. Explanation.
5. Research
6. Analyzing.
7. Planning Ahead.
8. Designing new problem.
9. Inventing.
10. Synthesizing.
11. Caliberation.
12. Criticism against design, procedure or finding.
13. Writing the report.
14. Reporting the findings.

The 42 relevant laboratory skills were categorised into 8 groups and 41 sub-groups.

Relevant Chemistry Laboratory skills for Terminal level test - Comprehensive List of Skills (ClassXII)

1. Skill of calculating the proper quantity of chemicals.

2. Skill of weighing substances.
3. Skill of identification of metals.
4. Skill of proper selection of chemicals (quality).
5. Skill of selection of proper apparatus.
6. Skill of preparation of solutions of different concentrations.
7. Skill of observing metallic deposits and colour change therein.
8. Arranging metals in a sequence on the basis of reactivity.
9. Skill of testing the precipitate on the parchment paper.
10. Skill of testing the ions in water.
11. Skill of measuring the volume.
12. Skill of comparison of the precipitating values.
13. Skill of forming an emulsion.
14. Skill of noting down the time.
15. Skill of reading and adjusting the temperature.
16. Skill of collecting and tabulating the data properly.
17. Skill of calculating and interpreting the data properly.
18. Skill of plotting a graph and interpreting it.
19. Skill of selection of proper solvent and its preparation.
20. Skill of measuring and tabulating the data.

21. Skill of finding the end point of a volumeteric titration correctly.
22. Skill of preparing the original solution.
23. Skill of performing group tests.
24. Skill of performing radical tests.
25. Skill of boiling off hydrogen sulphide from a solution.
26. Skill of removing acidity from a solution.
27. Skill of removing alkalinity from a solution.
28. Skill of preparing neutral solution.
29. Skill of performing the flame test.
30. Skill of performing the charcoal cavity test.
31. Skill of performing Borax, bead test.
32. Skill of comparing the crystal size.
33. Skill of comparing the rates of diffusion.
34. Skill of assembling the apparatus.
35. Skill of collection of oxygen gas by right method.
36. Skill of measuring the distance.
37. Skill of observing the coloured patch.
38. Skill of drawing conclusions on the basis of observation.
39. Skill of selection of threads of uniform length and diameter.
40. Skill of preparing a saturated solution.
41. Skill of recognising rings.
42. Skill of performing confirmatory tests.

The relevant chemistry laboratory skills identified have been categorised on the basis of rising hierarchy of skills. The simple ones which require simple observations have been placed earlier and the skills which are complex or are composed of many skills, have been placed at the end.

(C) Bifurcation of chemistry laboratory skills into relevant and non-relevant.

The criteria for bifurcating chemistry laboratory skills into relevant and non-relevant are many.

The relevant chemistry laboratory skills were categorised into relevant and non-relevant on the following criteria. The relevant chemistry laboratory skills for this study are the ones:

- For which test items can be easily constructed.
- which are less time consuming (optimum time required).
- have definite outcomes.
- have outcomes which are measurable by standard and easy means.
- they should be relevant to the age group.

Non-relevant skills for this study were the ones:

- for which test items are difficult to construct within the parameters of this study.
- Are too elementary skills to be taken note of.

- Are too much time consuming.
- Have out comes not expected (the outcomes may elicit various responses i.e. dexterity, fineness, smoothness, especially when the margin of contrasts are not sharp).
- Have outcomes which may not be easily measurable by standard and easy methods.
- Skill though usual may not be assesed at this age group.

Most of the chemistry laboratory skills in the non-relevant category are those for which test items can not be framed easily. Test items can not be easily framed for chemistry laboratory skills such as locating materials in a chemistry laboratory, skill of transfering liquids/ solutions from one vessel to another vessel. Skill of shaking solutions uniformly. Skill of reporting the experiments/results properly. Some other non-relevant chemistry laboratory skills were of a manipulative nature which take a lot of time to complete. In view of the time constraint they were considered non-relevant i.e. skill of conentrating the solutions, skill of growing crystals, there is yet another category of non-relevant chemistry laboratory skills for which the exact specifications of testing can not be specifically laid down i.e. skill of reporting the shape

of crystals, skill of drying and preserving the crystals skill of keeping the saturated solution undisturbed for growing the crystals, skill of inserting the key or pressing the knob in an electrical circuit when desired, skill of extracting juices from vegetables and fruits, skill of adding universal indicator in a proper quantity, skill of filling a capillary tube by a chemical substance, skill of setting up of a water bath properly, skill of taking appropriate quantities of chemicals and solutions, skill of labelling and storing the (standard/molar) solutions, skill of rinsing the apparatus.

D. Categorisation of chemistry laboratory skills

The relevant chemistry laboratory skills have been grouped into two groups i.e. manipulative chemistry laboratory skills, (psychomotor domain) and cognitive skills (cognitive domain).

Categorised List of Relevant Chemistry Laboratory Skills for Class XI (Entry level Test)

1. Determine simple properties (Requires no equipment or supplies).

A. Colour B. Odour C. Size.

2. Perform simple operations.

   A. Bending a glass tube.

   B. Drilling a cork.

   C. Detecting a leak in an assembly of appratus.

   D. Recognition of a particular equipment.

3. Assemble laboratory Equipment.

   A. From written instructions.

   B. From picture (verifying the assembly).

4. Perform complex Manipulations.

   A. Determine complex properties (requires equipment and supplies).

      1. Length
      2. Volume
      3. Weight
      4. pH

   B. Proper selection of equipment, glassware and chemicals.

   C. Perform volumeteric titrations.

5. Making Interpretations/decisions on the basis of recorded observations, data and pictures.

   A. Indications of a chemical reaction.

   B. Decision about whether a solutionis (acidØ base) on the basis of pH.

   C. Decision about how to Control(Acidity/alkalnity)

D. Shift in chemical equilibrium on the basis of colour change.

E. Indications of a melting and boiling point.

6. Making calculations:

A. Amount dissolved in a standard solution.

B. Molarity from amount dissolved in a molar solution.

C. Molarity of an unknown solution by molarity equation.

7. Plotting/Interpreting/Selecting correct graph on the basis of recorded data.

8. Performing complex tests/chemical operations.

A. <u>Analytical Tests</u>

1. Group tests
2. Individual test.
3. Confirmatory test.
4. Flame test
5. Borax, bead test
6. Charcoal cavity test.

B. <u>Chemical Operations</u>

1. Preparation of original salt solution.
2. Boiling off Hydrogen sulphide gas.
3. Removing acidity from a solution.
4. Removing alkalnity from a solution.

The entry level test chemistry laboratory skills were categorised in Eight main categories and 34 sub-categories. The chemistry laboratory skills have been arranged in a rising hierarchy, the simple ones find the place earlier and the most complex ones at the end.

The first category consists of observing simple physical properties of colour, odour, size with the help of human senses. (No equipment or supplies are desired). These skills have been clubed together because all these skills involve simple observation by human senses and reporting them.

The second category consists of performing simple laboratory techniques of bending a glass tube, boring a cork, detecting a leak in the assembly of apparatus and recognising of a particular equipment. These skills involve not only observation but also performing the tasks. Since all of them are of a identical nature they have been clubed together in a group. Simple equipment or supplies are needed to perform these laboratory operation.

The third category consists of assembling laboratory equipment from written instruction and pictures. Assembling the apparatus requires proper planning,

execution and verification. This task can not be done all at once. It needs thorough practice many a times. Keeping in view the nature of operations these skills have been clubed together.

The fourth category consists of performing complex laboratory manipulations like determining complex properties (length, volume, weight & pH), proper selection of (equipment/glassware/chemicals), and performing volumeteric titrations. All these manipulations require equipment and materials. These are complex tasks which need to be done precisely. All the tasks involve many skills. Determination of length, volume, weight & pH needs a lot of practice and precision. Proper selection of (equipment/ glass ware/chemicals) is also a complex task which involves many skills. This task also needs a lot of earlier practice. Volumeteric titration is also a complex task which involves many skills, many of them are of a higher hierarchy. To find the end point in a volumeteric titration one needs a lot of practice and precision. Since these chemistry laboratory skills require observations comparisons, manipulations, recording of data and finally the deduction of results. Keeping in view the complexity of the skills and the manipulative nature of the skills and the result orientation of these tasks they have been clubed together.

The fifth category consists of making (interpretations/decisions)on the basis of recorded (observations/data) and pictures. There are five sub categories in this category. In each sub-category a number of skills are involved. In the case of indications of a chemical reaction one has to know k what the indications of a chemical reaction are, the evolution or absorption of heat, change in colour of formation of precipitate. Unless these indications are not available. One cannot predict a chemical reaction. Similarly in other sub-categories one can take the decision only if certain observations/data/decisions are available then alone certain interpretations or decisions can be taken. Most of these skills are of cognitive domain where some sequence and logic has to be established before any interpretations are made or decisions taken.

Since these chemistry laboratory skills are of a cognitive nature where certain thinking has to be done in a systematic way on the basis of data before any decisions are to be arrived at. Many possibilities are to be ruled out if they do not stand the test. Since the identical nature of these chemistry laboratory skills they have been clubed together.

The sixth category consists of making calculations of amount dissolved in a standard solution, molarity of a

solution from the amount dissolved, Molarity of an unknown solution with the help of molarity equation. All these skills are of a computational nature. In the case of amount dissolved in a standard solution, the equivalent weight has to be divided by normality. In the case of molarity of a solution from the amount dissolved, the amount dissolved has to be divided by the molecular weight. In the case of finding molarity of an unknown solution from molarity equation; the molarity of an unknown solution can be calculated by inserting the coefficient of unknown solution, the volume of the unknown solution on one side. The coefficient of the known solution, the molarity of the known solution, and the volume of the known solution on the other side. Thus from the five known data's the sixth one can be found out. Since all these chemistry laboratory skills involve computational skills and are also related to volumeteric titrations they have clubed together.

The seventh category consists of selecting plotting and interpreting correctly the graph on the basis of recorded data.

In this category of chemistry laboratory skills one has to understand that graph is a very big reseach tool at

the senior secondary stage. In order to plot a graph one has to know that the two axis of a graph symbolise, which data to take on X-axis and which data on Y-axis. From the graph one should know whether the variables are directly or inversely related. What pattern of changes the variables manifest during the entire data (whether curved, or has sharp bends, etc.). One should also be clear whether a particular graph is suitable for a particular data or not, if not, is there need of using a scale etc. All these chemistry laboratory skills involve (selecting/ plotting/interpreting) graph. With the help of these skills graph has to be used as a research tool. Keeping in view the total purpose of these skills they have been clubed together.

The eighth category consists of complex analytical tests and chemical operations. The complex analytical tests consist of performing group tests, individual tests, confimatory tests, flame tests, charcoal cavity tests and Borax bead tests. The chemical operations involved are the preparation of original salt solution, boiling off hydrogen sulphide gas. Removing acidity from a solution and removing alkalnity from a solution. All these skills have been clubed together because all of them are used while

analysing a salt or a mixture of salts. These skills are also of a complex type involving a cluster of small skills and also skills which are of higher hierarchy. There is a certain sequence in these skills. Keeping in view the total purpose and the nature of these skills they have been clubed together.

The terminal level test chemistry laboratory skills were categorised into eight main categories and forty one sub-categories.

Categorised list of relevant chemistry laboratory skills for class XII (Terminal Level Test).

1. Determine simple properties (Requires no equipment or supplies).
   - A. Colour
   - B. Odour
   - C. Size
   - D. Shape
   - E. Texture
2. Making comparisons (Requires no equipment or supplies)
   (A) Size (B) Texture (C) Hardness (D) Shape (E)Glassware
3. Assemble Laboratory Equipment
   - A) From written instructions
   - B) From pictures.

4. Perform complex manipulations

A) Determine Complex properties (Requires equipment or supplies).

(i) length (ii) volume (iii) Weight (iv) pH (v) Boiling point (vi) Melting point.

B) Proper selection of chemicals and equipment.

C) Perform complex operation

(i) Cleaning of glassware (ii) Forming an emulsion (iii) Volumeteric titrations.

5. Making Interpretations/decisions on the basis of recorded observations and data.

A) Indications of a saturation point.

B) Decisions about whether a solution is (acid/base) on the basis of pH.

C) Skill of deciding molarity of a solution on the basis of recorded observations.

D) Skill of finding the correct sequence of coagulating power of different ions.

6. Making calculations:

Amount of chemicals required for a particular volume of a particular molarity.

7. Plotting/Interpreting/Selecting correct graph on the basis of recordéd data.

8. Performing Complex tests/chemical operations.

A) Analytical Tests.

(1) Group test (2) Individual test (3) Confirmatory test (4) Flame test (5) Charcoal cavity test (6) Borax Bead test.

B) Chemical Operations.

1. Preparing original salt solution.
2. Preparing sodium extract of a salt mixture.
3. Preparing neutral $FeCl_3$ solution.
4. Boiling off Hydrogen sulphide gas.
5. Removing acidity from a solution.
6. Removing alkalnity from a solution.
7. Supressing th e ionisation by common ion effect.

These skills have been arranged in a rising hierarchy, the simple ones find the place earlier and the most complex ones at the end.

The first category of skills consists of observing simple physical properties of colour. Odour, size, shape and texture. With the help of human senses. These skills are used, to have direct unaided observations and are of a simple nature. Since the nature of these skills is to make simple observations and report them they have been clubed together.

The second category of skills consists of comparing sizes, texture, hardness, shape and glassware. These types of skills involve observation of different sizes, textures, shapes, and types of hardness or glassware. After observing different variations in these one has to compare the various (sizes, shapes, textures) and find out which ones are (smaller/bigger), (smooth/uneven) (ring like/square like) rectangular/or other geometrical shapes). One has also to a find whether a particular laboratory equipment is a (test tube/boiling tube, round bottomed flas/flat bottomed flask) etc. Since the nature of these skills is to observe and then compare. On the basis of observation and comparisons one has to come to a conclusion. In view of the nature of these skills they have been clubed together.

The third category of skills consists of assembling laboratory equipment from written instructions or pictures. The assembly of apparatus is a very complex skill which involves not only observation/comparison/planning/execution but also verification.

Acquisition of the skill of assembling apparatus will depend upon the practice one has, the dextrity and carefulness of his operations. It is basically a psychomotor skill. Since the skill is a complex one where

observation, comparisons, planning, execution and verification play a very important part they have been clubed together.

The fourth category of skills consists of performing complex manipulations of determining of length, volume, weight, pH, melting point & boiling point. It also includes proper selection of chemicals and equipment and performing complex operations of cleaning glassware, forming an emulsion and performing volumeteric titrations. All these skills consist of Cluster of many skills and require material and equipment. These skills have been clubed together because all of them involve many smaller skills of observation, comparison, determination & deduction of results. Since the nature of these skills relate to some determinations, selections or complex operations they have been clubed together.

The fifth category of skills relate to interpretations/decisions on the basis of recorded observation and data. These skills have been clubed together because all of them are complex cognitive skills. Interpretations/ decisions can be arrived at, only when certain observations/ data/figures are properly arranged in a sequence. Certain inferences are drawn from them. On the basis of some similarities or dismilarities or occurences of certain

patterns at regular intervals. Some generalisations are accepted and others are rejected. Since all these skills involve certain mental operations they have been clubed together.

The sixth category of skills relates to making calculations relating to the preparation of a molar solution. The skills are of a computational nature. From the molecular weight and molarity the amount to be dissolved in a particular volume can be calculated. Since these chemistry laboratory skills are of a computational nature, where certain results are found out, they have been clubed together.

The seventh category of skills relates to (plotting/ interpreting/selecting correct) graph on the basis of recorded data. All these skills have been clubed together. Apart from being cognitive skills they involve multifarious skills. The selecting/plotting/interpreting a graph is an important research tool. One can perform these skills only when one is clear what the two axis mean, What data to take on which axis, how to plot the data, whether there is a need to choose a scale, how to interpret the graph, whether the two variables are directly related or inversely related. What is the shape of a graph, a straight line, a curve, or a bed of many lines, what do the bends or breaks in a graph signify. Keeping in view the fact that (Selecting/plotting/interpreting) a graph is a big research

technique, all these skills have been clubed together.

The eighth category of skills consists of performing complex tests and chemical operations. All these skills are related to salt analysis. They are complex skills consisiting of many simpler skills clubed together. The salt analysis is performed in a certain sequence. These tests have also been arranged in that sequence. Each test is composed of many tests. The other part of the category of skills are related to chemical operations (preparing an original salt solution/boiling off hydrogen sulphide Removing acidity from a solution/removing alkalnity from a solution). All these chemical operations are done while performing the salt analysis. These chemical operations consists of mahy smaller operations or tests. All these tests have been clubed together because these relate to salt analysis, and are complex skills of higher hierarchy.