# THE MOLARITY CONCEPT: IDENTIFICATION OF A LEARNING HIERARCHY AND RELATED STUDENTS' ERRORS



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# THE MOLARITY CONCEPT: IDENTIFICATION OF A LEARNING HIERARCHY AND RELATED STUDENTS' ERRORS

by

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## ABSTRACT

The purpose of the present study is to identify learning hierarchy related to the concept of molarity. Gagné's learning hierarchy model is used to hypothesize the hierarchy to which, in turn, several validation methods are applied. The validation process facilitated the identification of specific errors that students made in solving problems related to the skills comprising the hierarchy and information was acquired regarding the applicability of Gagné's model to the concept of molarity.

The sample was comprised of 144 grade ten chemistry students. After instruction on molarity by the classroom teacher, the students were tested on the skills of the hierarchy and assigned individual remedial work from an instructional booklet. The booklet was designed to address the areas of incompetence identified from the students' test responses. The students were retested after the initial testing. The data were analyzed using two psychometric techniques and one transfer technique. Finally, incorrect test responses were scrutinized to detect the kinds of errors made.

The two psychometric methods, namely one developed by Dayton and Macready (1976) and the other by Airasian and Bart (1975), gave results which indicated that while the hypothesized hierarchy comprised of 14 skills is not supported in its entirety, a revised hierarchy omitting two of the skills is considered valid. The hierarchy was also investigated for transfer validity. Again, good support for the hierarchy was observed. Finally, a number of student errors were identified by the test data. These are reported.

## ACKNOWLEDGEMENTS

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# THE PROBLEM

## Introduction to the Problem

Teachers are concerned with effective instruction. Success in imparting knowledge might be enhanced if the following points are considered: (a) a reasonable grasp of the tenets and structure of the pertinent discipline, (b) familiarity with the current theories of instruction and learning, and (c) continuous evaluation by the experienced and informed to describe and judge the enterprise. A theory of instruction is prescriptive (Bruner, 1966, p. 40) when it suggests rules about the most effective way of transmitting knowledge. The purpose of this investigation is to seek such a prescription to help students learn elementary chemistry.

There is a belief that most students can master what they are taught (Bloom, 1968). Fiel and Okey (1975) in citing research on mastery learning claim that there is empirical support for the use of formative evaluation and remediation as an aid to learning. Improvement in learning was greater where remediation of prerequisite skills by additional instruction was employed. Structuring learning in particular sequences in order to determine which skills are prerequisite is, therefore, potentially useful as a diagnostic tool to identify misconceptions and difficulties. Trembath and White (1979) found that mastery *achievement* (the word they prefer over mastery learning because they are interested in single skill performance) was greater when instruction is based on a validated learning hierarchy and students demonstrate clearly their achievement on each task before proceeding to the next.

The sequence in which the material is encountered and mastered is a relevant factor in planning instruction. Motivation, individual differences, and the developmental level of the learner may also affect learning but these topics are outside the scope of this investigation. This study attempts to identify a valid sequence for the learning of an important concept in chemistry, namely, molarity.

There is a consensus that there is a need to identify effective sequencing principles but there is no agreement as to what these should be. Discussions of sequencing imply that there is an ideal way, in the sense of a Platonic realm, but as Schwab (1964, p. 11) notes this assumption is fruitless in that no particular classification scheme is "right". Nevertheless, one sequence might be more effective than another and the teacher should take this into account in order to offer the best instruction. Finding the best way to teach students has attracted considerable attention: Dewey (1916), Tyler (1950), Bruner (1960), Taba (1962), Ausubel (1963), Gagné (1965), Stake (1967), Bloom (1968), Block (1971), Lawson and Renner (1975), Scriven, (1975).

Evidently, sequencing is viewed as an important component of curriculum design but Briggs (1968) in a discussion of sequencing contended that the experiments conducted were too scattered to be of use. Doll (1978) illustrates the complexities by listing several approaches to sequencing: (a) movement from the simple to the complex, (b) new learning based on prerequisite learning, (c) movement from part to whole and from whole to part, (d) chronological ordering of events, (e) movement from the present to the past, (f) concentric movement in ever widening circles of understanding or involvement, and (g) movement from concrete experiences to concepts.

Posner and Strike (1976) advocate that the problem be approached by exploring the different ways in which content "can" be sequenced before deciding the way it "should" be sequenced. The five major categories of content sequencing they propose are: (a) world-related, (b) concept-related, (c) inquiry-related, (d) learning-related, and (e) utilization-related. They also note that many sequencing decisions exclude these major categories and are based instead on factors relating to implementation of a particular program in a specific situation.

Orlosky and Smith (1978) describe three major aspects of sequencing:

(a) Learning is self-ordered when situations are dealt with by individuals from moment to moment. Consequently, planned sequencing is superfluous because when knowledge is imperative the learner obtains the required knowledge in whatever sequence is appropriate.

(b) Macrosequencing, the second aspect of this model, is described as the organization of knowledge and the formulation of instruction to coincide with the developmental stage of the learner. This partioular aspect has a counterpart in the contention of Piaget (1964), that the most important determinant of an individual's readiness for new learning is whether an appropriate generalized intellectual structure has been acquired. Orlosky and Smith grant that macrosequencing is important when drawing up a program of studies, but reject the sequencing of content on a day to day basis.

(c) Microsequencing, the third aspect of sequencing identified by Orlosky and Smith, assumes that for any learning task, there is a hierarchy which proceeds from the very simple to the more abstract and to the more complex.

Selecting instructional strategies when the empirical evidence is insufficient must be largely intuitive. The present study attempts to identify a hierarchy for for the concept of molarity as it appears in introductory high school chemistry.

## Gagné's Hierarchical Model of Learning

Robert Gagné has written extensively on microsequencing and cumulative learning theory (Gagné, 1965). Cumulative learning is based on the premise that the learning of prerequisite skills enhances the learning of superordinate skills. In his most recent writings Gagné (1970, 1972, 1977) limits the kinds of learning that might occur, but places greater emphasis on microsequencing. "Within limitations imposed by growth, behavioral development results from the cumulative effects of learning" (Gagné, 1968a, p. 178). Gagné and his colleagues as early as 1962 found empirical evidence for the cumulative learning model from studies of mathematics learning by seventh grade students. Learning a specific complex skill requires prior learning of prerequisite skills. This remains the basic premise of the Gagné hierarchical model. The following question is posed: "Beginning with the final task, what kind of capability would an individual have to possess if he were able to perform this task successfully, were we to give him only instructions?" (Gagné, 1962, p. 356). This capability, Gagné claims, is measurable as a performance. By identifying the necessary skills the manifestation of competence can be hierarchically organized. Gagné also believes that if learning is accepted as a change in human behavior, then it may be possible to specify the conditions under which learning occurs. This contention appears in his major books: Conditions of Learning (1965, 1970, 1977) and Essentials of Learning for Instruction (1974). Gagné, although recognized as a behaviorist, realized that one prototype for learning as a whole was not possible. The controversy that all learning is either insight or conditioned response is unproductive (Gagné, 1970). However, he felt obligated to distinguish between different domains (Gagné, 1972). By 1977 Gagné limited his hierarchical model to one specific domain and the content within a particular hierarchy was decreased considerably.

Gagné identifies five major domains of learning: (a) motor skills, (b) verbal information, (c) intellectual skills, (d) cognitive strategies, and (e) attitudes. Generalizations about critical conditions for learning can be made within these categories, but not across them (Gagné, 1972). Gagné presently restricts his hierarchical model of learning to the intellectual skill domain. For example, being able to verbalize a relationship for molarity is quite different from showing that one can use the relationship to find the molar concentration of a solution. The latter is what Gagné means by intellectual skills to which the hierarchical model is restricted. The former is in another domain of learning.

Within the domain of intellectual skills, Gagné distinguishes eight separate types of learning. These learning types, which are represented in Figure 1, are hierarchically related, successive categories being prerequisite to the next. The four upper levels, namely, higher-order rules; rules; concepts; and discriminations; respectively, are the primary focus of instruction in school. Superficially, restricting the hierarchical model to intellectual skills appears to limit its power; however, Gagné believes that the learning of intellectual skills is critical for learning in the other domains. In the evolution of the model, Gagné (1973) suggested that learning hierarchies are best suited for single lessons rather than curriculum units. Griffiths (1979) in his study on the mole concept in chemistry maintains that the optimum amount of content has not been satisfactorily established. The position taken in this investigation is that the amount of content should be large enough to be of practical use in the classroom, but small enough to allow sufficient control for testing purposes.

A learning hierarchy using Gagné's method is developed by asking what the learner must be able to do to learn a new skill. The resulting hierarchy may be linear or branched. Branching implies that several independent skills are prerequisite to the next higher one. Within the learning hierarchical model the order in which these independent skills are acquired is unimportant if they are acquired before the higher skill. The possibility of disjunctive branching must be considered where either one subordinate skill or another (but not both) is sufficient for acquiring the superordinate skill. Resnick (1973) suggests that research is

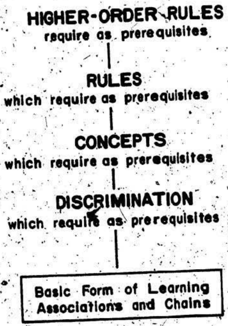



Figure I. Summary of interdependence of intellectual skills.
Gagné (1977)

needed to determine the frequency of such disjunctive branches. There are few references to disjunctive branching in the current literature.

Not only does the Gagnéan hierarchical model require that acquisition of higher skills demands possession of a lower prerequisite skill(s) but, also that learning the subordinate skill(s) facilitates the learning of the superordinate skill. Possession of the prerequisite skill(s), however, does not ensure that the superordinate skill will be learned. A psychometric relationship requires that students possessing the superordinate skill must also possess the subordinate skill. Furthermore, if it can be shown that learning the prerequisite skill enhances the learning of a superordinate skill, then a transfer relationship can be established. Hence, two distinct approaches to establishing a hierarchical relationship between skills have been identified in this discussion. Their relative merits will be discussed in the next chapter. Some researchers have focused on the psychometric characteristics of the hierarchies generated while others, such as Gagné, have stressed the importance of transfer. The present study addresses both aspects as do Griffiths (1979), and Bergan and Jeska (1980).

Gagné's hierarchical model implies that most individuals learn by a series of small steps but there are other possibilities. For example, Ausubel (1968) believes that the direction of the hierarchy is from the complex to the simple and has written on the validity of "conceptual schemes" using this approach. Some educators (Ingle & Shayer, 1971; Herron, 1975) have suggested sequencing bases on the developmental stage of the learner. Nevertheless, for the molarity concept, given that it involves the use of a series of rules, Gagné's hierarchical model is considered by the present investigator to be the most promising.

**Need for the Study**

In the first of seven position papers prepared for the Science Council of Canada on science education, Page (1980, p. 10) writes as follows: "If Canada is to deal effectively with its future, then a citizenry able to comprehend science issues is a necessity." Aikenhead (1980), in a similar vein, fears that many major decisions about science-related issues, for example, nuclear energy as a source of fuel, bioengineered food production, acid rain, and insecticide poisoning are made by people who misunderstand science. There is a need to adopt a curriculum which focuses on the relationship between science and society. Wise decisions about such matters require some theoretical understanding as well. For example, decisions about acceptable levels of environmental pollutants require familiarity with the notion of "concentration" in solutions.

Concentration is usually expressed using the term "molarity". It is defined as the number of moles of solute per liter of solution. The ability to calculate the aqueous concentration of a solute is fundamental to learning chemistry. For example, equilibrium calculations related to the strength of weak acids and the solubility of sparingly soluble salts require a thorough grounding in this area.

In addition to these applications of the molarity concept there is a necessity to continue to investigate how people learn and how to improve instruction. A particular area of current interest in this regard is the identification of misconceptions.

## Purpose of the Study

Learning the concept of molarity can be said to represent acquisition of an intellectual skill in the Gagnéan sense if the student is able to demonstrate a specific capability. Thus a learning hierarchy for molarity might be constructed using a task analysis technique with subsequent testing to determine validity. This is the major purpose of the present study. A secondary purpose using the student responses to the test items used, is to identify the kinds of errors associated with the molarity concept. Methods used to validate the hierarchies and the current literature on misconceptions are discussed in Chapter 2.

## Definition of Terms

For clarification, the following glossary of terms used frequently in this thesis is provided:

*Capability:* the ability to perform a given task under specified conditions. For example, given the volume and molarity of a solution calculate the number of moles of specified ion present.

*Hierarchical connection:* a connection between two skills such that learning the lower skill is necessary for learning the upper skill and/or it enhances the learning of the upper skill.

*Hypothesized hierarchy:* a learning hierarchy proposed for molarity. The hierarchy in this study contains 14 elements.

*Instructional Booklet:* a remedial booklet on each of the 14 skills. Only those skills in which the student was found to be deficient were assigned. Each student was given a complete booklet together with instructions to read sections related the specific deficient skills.

*Intellectual skill:* knowing *how* as opposed to knowing *that* (Gagné, 1977). For example, the ability to calculate molarity rather than merely state an algorithm to determine it.

*Learning hierarchy:* an arrangement of subordinate/superordinate pairs of intellectual skills organized in a way such that the subordinate skill in each pair is necessary for the learning of the superordinate skill and/or exhibits transfer of learning to the superordinate skill.

*Molarity:* the number of moles of solute per liter of solution. The abbreviation often used for molarity is "M".

*Posttest:* a test given two days after the material in the Instructional Booklet had been assigned.

*Pretest:* a test given after normal classroom instruction but before remediation.

*Subordinate skill:* the lower skill in a hierarchical connection between two skills.

*Superordinate skill:* the upper skill in a hierarchical connection between two skills.

*Task analysis (Gagnéan):* the process of constructing a hierarchy by successively asking the following question, "What would the individual have to do in order to achieve a particular capability?"

*Validated hierarchy:* a hierarchy of intellectual skills in which subordinate skills are found to be empirically necessary for, and/or which significantly enhance learning of directly related superordinate skills.

**Delimitations of the Study**

Restriction of the sample to one grade level (grade 10) is an important delimitation. Students of different chronological age, different academic backgrounds and venue of instruction (school or university) may respond differently. Additionally, the small number of different schools makes generalization tenuous beyond the present sample.

The restricted set of subordinate concepts relating to molarity is also delimiting in that no claims can be made from these results about the hierarchy of other concepts in chemistry; or for any other subject for that matter. Furthermore, any hierarchy developed and validated may not be exclusive. It is possible that other hierarchies for the concept might be valid.

**Limitations of the Study**

A wide variation of performance for different skills is desirable when testing for a hierarchical relationship. In the present study control over sample selection and the pool available for testing was a limitation but there is no reason to believe the sample was unduly biased. The broad features are described below.

After pretesting, an instructional booklet designed for remediation was given to each student. Those skills where mastery had not been demonstrated by the pretest were indicated. Each student tested was given a personalized booklet. However, because there was no control over whether or not the booklet was actually used by the students the transfer effect may be suppressed.

The testing procedure itself may impose further limitations on the study. Students who answer correctly the two items for each specific skill are classified as having mastered that skill. Ideally, a student would get both items for a skill correct or both incorrect. However, in some cases one response may be correct and the other incorrect. Identical items testing the same skill are not used in case the student may recall the first encounter. The nature of the material is such that equivalent items are relatively easy to construct; hence, non-equivalence of the items is excluded as an explanation for the discrepancy between the two responses.

**Research Questions**

1. Does the arrangement of intellectual skills comprising the hypothesized hierarchy represent a learning hierarchy which is valid psychometrically?
2. Is there significant positive transfer between subordinate skill(s) and the related superordinate skill in the hypothesized hierarchy?
3. What student errors about molarity can be identified from the test responses?

**Summary and Overview**

The role of sequencing in learning and some different views of learning theory have been presented. The selection of the Gagnéan model as being potentially useful for investigating molarity in a high school chemistry course has been discussed in the context of the difficulties which some students experience.

Different methods for validating learning hierarchies have been proposed by researchers. Some of these techniques, with particular emphasis on those used in this study, are included in the next chapter along with a description of empirical studies relating to hierarchies in science. The experimental design of the study is presented in Chapter 3 with the analyses of the results in Chapter 4. The study is summarized in the final chapter, Chapter 5, and the major conclusions presented. Recommendations for further research are also included.

# Chapter 2

# HIERARCHIES: VALIDATION AND METHODOLOGY

## Introduction

There has been considerable discussion of the basic hierarchical model in the literature. Substantial reviews have been offered by Briggs (1968), Resnick and Wang (1969), Walbessar and Eisenberg (1972), White (1973), Linke (1975), Cotton, Gallagher, and Marshall (1977), Jones and Russell (1979) and Bergan (1980). However, most of these investigators were critical of the statistical methods used for validation of the hierarchies. In this chapter the research on techniques of validation is discussed, the specific models used in the present study are described in more detail, and some of the studies of learning hierarchies in science are presented. Finally, investigations of the application of hierarchy theory in identifying errors are examined.

## The Validation of Learning Hierarchies

White (1974a) was critical of all of the statistical indices applied in the learning hierarchy research which appeared in the sixties. According to White, decisions with respect to mastery were (a) subjective, (b) derived from empirical data which were often collected prematurely before the hierarchy was checked for "common sense" validity, (c) elements of proposed hierarchies were loosely defined, and (d) verbal information or rote knowledge was often included. To overcome these deficiencies, White (1974b, p. 2) recommended a nine stage procedure for the identification and validation of learning hierarchies. A later modification of White's model which attempted to allow for the mode of instruction eliminated two stages (White & Gagné, 1978).

Linke (1975) was also critical of current learning hierarchy validation studies. He identified three important deficiencies: (a) inadequate scope,

(b) inappropriate validation technique, and (c) lack of replicative data. Linke constructed a hierarchy comprised of a comprehensive network of graphical skills. Parallel studies showed a consistency which substantiated the postulated hierarchy and thus added confirmatory evidence for Gagné's model of hierarchical learning.

A learning hierarchy consists of a network of connections and the methods used for validation can be classified as follows: those which use psychometric techniques and those which consider transfer properties. The former are based on the supposition of a relatively inviolate sequence and are sometimes referred to as inclusion techniques. They typically may utilize scaling techniques or contingency tables, or matrices. Studies by White and Clarke (1973), Linke (1975), Beeson (1977), Guttman (1944), and Resnick and Wang (1969) are typical of the latter.

White and Clarke (1973) developed an inclusion technique which improved the existing methodology by allowing for errors of measurement and providing a test of statistical significance. Although the White and Clarke method has been widely used it has not been employed in the present thesis for reasons which will be elaborated on in Chapter 4.

Linke (1975), recognizing the difficulty of insisting on perfect hierarchical dependence allowed up to 2% exceptions while Beeson (1977) allowed 5% exceptions in addition to measurement error. Both Linke and Beeson reporting separately on their studies describe an unexpected phenomenon where 10% exceptions are allowed. When few subjects possess the higher skill the power of the test is found to be lower than might be expected. When most subjects possess the lower skill, higher values than expected are obtained.

Guttman (1944) applied a scalogram analysis to a learning hierarchy by examining the responses to several test items forming a sequence in situations where individuals who made correct responses to later items had also made correct responses to earlier items. The derived "scale" represents a linear learning hierarchy. Resnick and Wang (1969) adapted Guttman's coefficient of reproducibility but, as White (1974a) pointed out, this coefficient is difficult to interpret when a hierarchy is branching and complex. Proctor (1970) objected to the arbitrary permissible value Guttman assigned to his "index of reproducibility". He suggested, rather, an estimate of probability. Although his idea was not applied directly to the validation of learning hierarchies, it was incorporated by Dayton and Macready (1976a) to extend scaling to hierarchies of any configuration by allowing for different distinct response patterns. Errors arising from students' guessing or forgetting can be accommodated in the Dayton and Macready model. The latter researchers (Dayton & Macready, 1980) in proposing a new scaling model incorporated Goodman's (1975) contribution to the theory of scaling. Goodman himself allowed for the inclusion of a category of intrinsically unscalable respondents. However, a deficiency of the Goodman model is that it accommodates only response errors from the scale-type respondents.

Gagné (1970) considers transfer of learning between related skills to be an important component of the testing procedure which determines the validity of a hierarchy. Gagné's learning hierarchy model also makes the assumption that each subordinate skill is necessary to the aquisition of a related superordinate skill. However, possession of the subordinate skill does not assure mastery of the superordinate skill. Nevertheless, the transfer of learning theory hypothesizes that mastery of a subordinate skill facilitates the learning of a related superordinate skill. Ideally, the results of a transfer type test applied to the data would show that individuals who possess the subordinate skill will be able to learn the superordinate skill. The validity of a particular hierarchy is difficult to accept because tests often give conflicting results. A hierarchy may be judged valid on one test and invalid on another.

Gagné and his collaborators devised an index called Proportion Positive Transfer (Gagné, 1962; Gagné & Paradise, 1961; Gagné, Mayor, Garstens, & Paradise, 1962). It was observed that the skills formed a sequence such that individuals did not learn a later skill in the sequence if they had not learned the related earlier skills. This was taken to imply that learning earlier skills facilitated learning later skills. However, White (1974a) contended that the transfer index determined by Gagné and his callaborators is extremely limited. While positive correlation is a necessary criterion, it is not sufficient to demonstrate hierarchical relationship. Furthermore, the index does not allow for errors of measurement and does not have a sampling distribution. Hence, the index is too fragile to be of substantial use. The proposal of Eisenberg and Walbesser (1971) designed to address difficulties associated with indices of positive transfer is also flawed (Caple & Jones, 1971; White, 1974a).

Phillips and Kelly (1975) suggest that Gagné's hierarchies are a blend of logical and psychological relationships between skills. His procedure generates hierarchies consisting of primarily logical relationships within the subject matter itself. Therefore, the identification of valid transfer relationships are irrelevant because such relationships would inevitably represent conceptual truths. Nevertheless, conceptual truths for the neophyte are likely to differ from those of an expert and prerequisites exhibiting positive transfer, once they are learned, contribute to the learner's psychological structure.

Posner and Strike (1976) also fault Gagné for his mix of psychological and logical relationships. They confirm the usefulness of this blend in curriculum development but they consider it important that the instructional designer distinguish between "logical prerequisites" and "empirical prerequisites" because each require different criteria for justification. "Logical prerequisites" are elements of a learning-related category of sequencing principle. They are concerned with the *a priori* properties of concepts and require only logical analysis for justification. On the other hand, "empirical prerequisites" are concerned with skills that can be shown to facilitate the learning of later skills. They require empirical evidence for justification.

Griffiths (1979, 1982) is wary of studies where either the psychometric or the transfer definition of hierarchy dependence is exclusively applied. He maintains that validation methodology requires both approaches. He also argues that dependency relationships claimed by psychometric validation do not necessarily mean that learning a second skill requires mastery of the subordinate skill or that learning a second skill is aided by learning a subordinate skill. A few investigators have reported both types of validation (Wiegand, 1973; Griffiths, 1979; Bergan & Jeska, 1980). The present study uses both procedures and the validation techniques used are detailed below.

**The Ordering-Theoretic Method**

The psychometric method of hierarchy validation developed by Bart and Krus (1973) and Airasian and Bart (1975) is called the ordering-theoretic method. This method validates a hierarchy by considering relationships between pairs of skills. The method is simple to apply and has been shown to yield similar results to the more complicated White and Clarke test (Griffiths, 1979). The validity of the proposed hierarchy in the ordering-theoretic method is based on the scores represented in matrices for pairs of skills. This method, however, also suffers from the arbitrary tolerance level assigned to the critical cell which contains those subjects who fail the lower skill and pass the upper skill, and hence are anomalous. If the hypothesized lower skill is prerequisite to the hypothesized upper skill then the frequency of this cell under ideal conditions is expected to be

| | | UPPER SKILL RESULT | |
|---|---|---|---|
| | | Fail | Pass |
| LOWER SKILL RESULT | Fail | C | D |
| | Pass | B | A |

Figure 2. An ordering-theoretic skills matrix.

Note: A, B, C, and D represent cell frequencies.

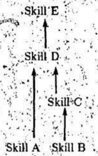
zero. To allow for experimental conditions and errors of measurement Airasian and Bart (1975) set a tolerance level. For example, three subjects falling in the critical cell in a experiment where the sample size is 100 subjects and the tolerence level is set at 2% would be sufficient to reject the hypothesized hierarchical connection.

Wood (1975) devised a significance test for the ordering-theoretic method by computing the total number of hierarchical relationships between all task pairs and then determining the chance probability of obtaining an observed number of hierarchical relationships. However, as Cotton *et al.* (1977) point out, this procedure rules out confirmation of simple hypotheses where the number of relationships is small. Rather than compare connections between pairs of skills, the Dayton and Macready model considers the hierarchy as a whole. This model will be described in some detail because it is the principal method used in the present study.

## The Dayton and Macready Model

The Dayton and Macready model has substantial advantage over the White and Clarke model and the ordering-theoretic method. The hierarchy is considered as a whole rather than in terms of pairs of skills and it allows direct comparison of intact hierarchies. Statistical tests are provided to determine goodness of fit between the data and the proposed hierarchy (Dayton & Macready, 1976b). The method is described below.

Assuming that the proposed hierarchy is valid, the Dayton and Macready model looks at the probability of obtaining all possible response patterns. An illustration involving five skills (A, B, C, D, and E) in a hierarchy is given below.




Regardless of the configuration of a five skill hierarchy, 32 (2 raised to the fifth power) response patterns are possible. If a score of 1 represents mastery of the skill and 0 represents non-mastery, then only eight of these 32 patterns could imply connections that would satisfactory support the proposed hierarchy. These are as follows: 00000, 10000, 01000, 11000, 01100, 11100, 11110, and 11111. If the hierarchy is valid it is possible to express the probability of obtaining a specific response pattern mathematically. Where "u" represents a particular pattern, assuming the hierarchy is valid, in Dayton and Macready notation, the expression becomes:

$$P(u) = \sum_{j=1}^{q} P(u \mid v_j) : \theta_j \tag{1}$$

where $v_j$ represents the set of "q" true response patterns and $\theta_j$ represents the probability that the "jth" true vector pattern occurs.

A second equation can be constructed to allow for misclassification parameters:

$$P(u \mid v_j) = \prod_{j=1}^{k} \alpha_i^{a_{ij}} (1-\alpha_i)^{b_{ij}} \beta_i^{c_{ij}} (1-\beta_i)^{d_{ij}} \tag{2}$$

where $\alpha_i$ represents the probability that a subject will produce a correct response to a skill which, if the hierarchy is valid, he or she should not to be able to produce. $\beta_i$ represents the opposite: the probability that a subject will produce an incorrect response to a skill for which, if the hierarchy is valid, he or she should be able to demonstrate mastery.

The second equation evaluates the misclassification parameters $\alpha_i$ and $\beta_i$ where each is raised to the power required to fit all "true" response patterns to a observed data vector. Similarly, $(1-\alpha_i)$ and $(1-\beta_i)$ are respectively raised to the number of "correct" responses in each case. The second equation is the product of all these response patterns. If this product is multiplied by the probability that the jth true pattern vector occurs $(\theta_j)$ and the result summed for all true vector patterns (q) then, the result is the probabilistic model represented by the first equation.

Maximum likelihood estimates of the various parameters in the probabilistic model are obtained and these are used to compute the response frequency that could be expected for every possible response pattern. The goodness of fit between observed and hypothesized response patterns is then calculated. A likelihood ratio expressed in the form of a chi square is used to determine the goodness of fit.

Dayton and Macready assume that every effect has a cause. Granting the premise that the hierarchy is valid provides a deductive argument which gives a rationale for accepting or rejecting the hierarchy entirely. On the basis of this analysis, it is not possible, therefore, to make decisions about individual connections. However, examination of the parameters generated by the analysis may suggest further hypotheses for the same skills or a subset of them, and hence allow decisions about individual connections.

**Methodology and Rationale of Testing for Transfer**

Psychometric definitions of hierarchical dependence have been propounded by many researchers. The importance of testing for the transfer of learning has been widely acknowledged but different views of transfer as a validation tool have been expressed. Resnick (1973) notes that learning psychologists and instructional designers consider two tasks hierarchically related if learning the subordinate task produces positive transfer to learning of the superordinate task. On the other hand, evaluators seeking to construct diagnostic and placement tests for individualized instruction use the argument that two tasks are hierarchically related if those who can perform the superordinate skill can reliably perform the subordinate task. The latter approach is better suited to psychometric techniques. White and Gagné (1974) contend that experimental validation of transfer procedures are more definitive than psychometric validation. However, they agree with Carroll (1973) that experimental validation of transfer is laborious. The objections made by White (1973) to the simple indices devised to test for transfer, including Gagné's Index of Proportion Positive Transfer, have been referred to earlier in this discussion. Other methods which quantify the amount of transfer have been developed.

Resnick (1973) expresses the opinion that the most appropriate means to test for positive transfer is to directly compare randomly assigned groups of students:

one group is taught in the sequence of a hypothesized hierarchy and the other groups with deliberately scrambled sequences. The rate of individual learning with respect to single tasks and to a whole set can then be determined.

A transfer experiment of this type was used on preschoolers (Uprichard, 1970) to find an efficient way to teach "set" relations. The skills making up the hierarchy were taught in all possible sequences. The efficiency was evaluated using the following criteria: the time required to learn the task based on a posttest which established performance acceptability and which also tested for transfer. Thus, the most efficient sequence was identified and support gained for the existence of the hierarchy. This procedure has drawbacks because hierarchies containing many skills are very cumbersome and time consuming to investigate. Apart from practical considerations an ethical question emerges. Despite the absence of empirical data this researcher considers it morally indefensible to use an instructional sequence other than that which one considers superior. A procedure devised by Griffiths (1979) avoids this difficulty. It is described in more detail in Chapter 3 because it is used in this study.

Testing for evidence of positive transfer on a psychometrically validated hierarchy has been proposed by White & Gagné ( 1974). The proposition involves two groups who are thought to be ready to learn the lower skill of the connection pair to be investigated. One group is taught the lower skill of the pair, and then the upper skill. The second group is taught the upper skill only. Positive transfer will be demonstrated if more of the first group acquire the upper skill. They concede that this method would interfere substantially with normal classroom teaching. Hence, it is not surprising that no published accounts of studies employing this method were found in the literature. White and Gagné suggest that the validation of hierarchies has been sufficiently researched to accept their usefulness but note the need to investigate a hierarchy of elements to see whether they mediate transfer upwards rather than using only the negative approach which posits that learners cannot acquire a skill unless they possess all of the relevant subordinate skills.

Bergan (1980) poses the possibility that prerequisite skills may not be the only variable responsible for positive transfer between skills. Accordingly, Bergan used path analysis to quantify relationships among variables operating within and outside the equation model.

**Identification of Hierarchies in Science Education**

Gagné's earliest attempts to furnish supporting evidence for his theory of how people acquire knowledge and master complex skills were devoted to investigating hierarchies involving mathematical skills. Publications since that time attest to the wide appeal of his model. Boblick (1971) reported on a non-mathematical hierarchy in which the terminal skill was the ability to write chemical formulae. No reference was made to its validation.

The best known application of the Gagnéan hierarchical model in science is "Science A Process Approach" (SAPA), a curriculum project developed in 1965. It involved hundreds of skills for children from Kindergarten to Grade Six. The rationale was that children would develop reasonable facility in the early years with basic processes: observing, classifying, measuring, communicating, inferring, predicting, using space-time relationships, and using numbers. Then integrated processes could be developed: controlling variables, formulating hypotheses, interpreting data, defining operationally, and experimenting. This vast enterprise resulted in a huge network of skills which the authors claimed was integrated. Gagné (1973b, p. 25) himself later admitted that the instructional units were too large. One infers from Gagné's remarks that SAPA is not really a learning hierarchy at all because the contents of individual lessons were not designed as learning hierarchies. Gagné recommended that fewer elements be represented in a hierarchy.

Most investigators applying the learning hierarchical model to the learning of science concepts have followed Gagné's advice, that is, to limit the content to relatively smaller units. Investigations which have been published include Okey and Gagné's (1970) study concerning solubility product problems; Seddon's (1974) hierarchy for chemical bonding; White's (1974a) hierarchical study involving kinematics; Linke's (1975) study on graphical skills; Beeson's (1977, 1981) hierarchy for electrical skills; Gower, Daniels, and Lloyd's (1977) two-hierarchical analysis involving the mole concept; Griffiths' (1979) investigation of a hierarchical model of the mole concept; Whelan's (1982) study dealing with stoichiometry; Pottle's (1982) hierarchy involving conservation of mechanical energy; and Grant's (1983) hierarchy related to the food web concept. The foregoing list does not include all the early investigations of learning hierarchies in science. Earlier studies carried out by Merrill (1965), Kolb (1967), and Raven (1972) were shown to be flawed by the use of faulty experimental designs as well as weak statistical procedures (White, 1973). For this reason they are not reviewed here.

Transfer in a learning hierarchy for the solubility product concept was investigated by Okey and Gagné (1970). Two groups were compared. One group was tested after it had received instruction. This testing was used to identify skills giving difficulty. The second group was instructed using revisions which took the experience of the first group into account. This group was then tested and achievement scores showed that the second group scored higher. The investigators suggested that the second group performed better because the hierarchy derived from the first group promoted transfer of learning for the second group. Griffiths (1979) criticized this study on the following grounds: (a) the terminal skill was insufficiently defined which allows a wide range of results,

(b) specific transfer effects between skills within the hypothesized hierarchy were not investigated, and (c) the acceptable performance criterion of less than 80% on some lower skills, even after remediation, is considered too low.

Seddon (1974) claimed that a study which he conducted on student understanding of chemical bonding using the "Kimball Charge Cloud Model" supported the Gagnéan hierarchical model. The purpose of the study was to test the relative effectiveness of the following as predictors of achievement on the posttest: (a) a general chemistry test given before the study, (b) intelligence as measured by a standardized intelligence test, (c) age, and (d) the pretest of the study. The author prepared a self-instructional unit for the subjects tested. The sample consisted of students between the ages of fifteen and nineteen. The subjects were given an author-constructed pretest before using the prepared unit. The same test was used for the posttest. A regression analysis showed general chemistry knowledge to be the best predictor. Because the relationship between the skills of the posttest were not specifically examined Griffiths (1979) suggests that the claim of support for the Gagnéan model is unjustified.

A study by Gower *et al.* (1977) identifies a hierarchy for the mole concept. The top skill of the hierarchy was concerned with the concept of molar mass. The authors admitted that they initially indicated two independent hierarchies: concepts based on empirical evidence and the other on theoretical concepts. The data were obtained by requiring the subjects to respond to a set of items representing the elements of the hypothesized hierarchy. A consistency ratio technique which was applied as a measure of hierarchical dependency was claimed by the authors as acceptable evidence for the validation of the hierarchies. Griffiths (1979) strenuously disagrees and argues that the study yields no definite conclusions about either the empirical hierarchy or the theoretical hierarchy. For example, analysis of the data shows that only 12 out of 18 connections in the "validated" hierarchy give a consistency ratio of 0.85 or more. In the case of the theoretical hierarchy only 7 out of 22 connections meet the critical value for the consistency ratio. Griffiths also faults the study for the test items arguing that they do not test the kinds of capabilities claimed and only the items at the comprehension level test the acquisition of intellectual skills in the Gagnéan sense. For the other intellectual skills investigated, namely recall, application, and analysis, the authors appear to have a different understanding of the term as used by Gagné.

To test Gagné's theory, Linke (1975) used larger samples and emphasized the replication of results. To this end, he tested 416 grade eight students, 204 in Brisbane and 212 in Adelaide, on graphical interpretation skills. The program of instruction was based on a hierarchy hypothesized by Linke. The White and Clarke test was applied to the data but allowance was made, in addition to measurement error, for 1% and 2% exceptions. The statistical power of the test was calculated for each connection. Linke claimed that most of the postulated connections were valid. Moreover, both groups yielded similar results. Linke considered this finding to be particularly important because of the difference in the formal curricular background between the two groups. Linke, himself, noted that the power of the test, that is, the unrealistically high and low levels obtained, was suspect. He thought that the alternative hypothesis did not adequately cope with the difficulty of the lower skills and was, perhaps, too sensitive to the difficulty of the upper skills. The number of exceptions allowed in the critical cell seems high. For example, one connection which was declared valid allowed sixteen exceptions. Linke attributed this inconsistency to guessing and chance mistakes.

Research in the hierarchy field has been primarily concerned with mathematics and the physical sciences but Beeson (1977) has applied Gagnéan-hierarchical theory to non-mathematical areas of the science curriculum. He proposed a hierarchy concerning electric circuits. Beeson distinguished between intellectual skills and verbal information in the hierarchy, as did Gagné (1972) and White (1974c) who limited their hierarchies to intellectual skills. Beeson used only one item to test verbal information using the argument that parallel, but not identical, test items for verbal elements are impossible to construct. Other investigators, (Hedges, 1966; Bloom, Hastings, & Madaus, 1956; Hopkins & Stanley, 1981) disagree contending that such construction is indeed possible. Grant (1983) criticized Beeson's use of only one item to test verbal information arguing that the validity of the connections were subjective decisions, the implication being that more than one item to test verbal information would be significantly less subjective. This researcher considers that the decision remains arbitrary. It is worth noting that the final form of Beeson's (1981) validated hierarchy in electrical science omitted several connections that were included in the original hypothesized hierarchy.

Most of learning hierarchy research has been focused on validation but Beeson (1981) has expressed concern that students often learn intellectual skills in a mechanical rather than meaningful way. This idea has its counterpart in the theory of Ausubel (1963) where he distinguishes between "meaningful learning" and "rote learning". Beeson has suggested that mechanical learning may be a result of teaching the skills in a relatively isolated manner. Thus although mastery of relevant lower skills has occurred, the students may still be unable to combine these to master higher skills. Moreover, some intellectual skills may require more elaboration of verbal information and the student may be unable to recall relevant subordinate skills at the appropriate time. Beeson contends that if the learning of hierarchically related skills occurred within a context of meangingful knowledge about a relevant anchoring idea, meaningful learning would be facilitated. His study included 188 grade ten students divided into three groups. One group was taught the skills in isolation; a second group was provided with additional verbal instructions; and the third was taught the skills in relation to a relevant anchoring idea. All students were initially taught the intellectual skills according to the original validated hierarchy (Beeson, 1977). Two days later the students were tested to determine: (a) long and short-term achievement of the terminal skill, (b) lateral transfer, and (c) subordinate skills. The results showed that the third group, those taught the anchoring idea, did significantly better on the short-term tests for lateral transfer but these results did not persist after seven weeks. However, this group did significantly better on the final task than did the other two, but did not differ significantly on the short-term test. This indicated to Beeson that students tend to learn intellectual skills in the mechanical way he suspected. Where students learn related skills based on hierarchical sequencing and also in the context of an anchoring idea more meaningful learning appears to take place.

**Student Errors Related to Molarity**

The acquisition of new material has always been of prime interest to educators. However, there is a growing recognition that prior information incorrectly or inappropriately applied plays an active interfering role (Simpson & Arnold, 1982). As students attempt to relate new knowledge to existing knowledge wrong connections may be made. Nussbaum (1981) suggests that the development of correct scientific conceptions requires that any misconceptions be identified and the reasons for their occurrence ascertained. Obviously, obtaining this information on an individual basis would be laborious and time consuming. Students will make different errors. Detection and remediation requires individualized attention. It is common practice for teachers to instruct the whole class on the avoidance of particular errors. This investigator feels that it is unsound pedagogically to suggest prior possible misconceptions. Nevertheless, the experimenter has a responsibility to alert a participating teacher if certain errors are characteristic of a particular group.

Chapter 3, the next chapter, discusses the design, instrumentation, and procedures of the study.

# Chapter 3

# DESIGN, INSTRUMENTATION, AND PROCEDURES

## Introduction

The procedure involved in identifying a learning hierarchy follows a general format: (a) hypothesizing the hierarchy, (b) selecting the elements to be included and the desired terminal skill, (c) ascertaining the mode and the timing of instruction, (d) formulating the suitable test questions for each element (e) designing the appropriate testing procedures, (f) selecting a sample for investigation, and (g) analyzing results. This chapter describes the decisions related to the present study and provides a rationale for these decisions.

## Construction of the Hierarchy

The present investigation is underpinned by Gagné's notion that the learner should be able to demonstrate possession of a subskill before a higher skill can be learned. Obviously, the terminal skill of one defined hierarchy can be a subordinate skill of another. Hence, selecting the terminal skill and the lowest skill(s) of a hierarchy is arbitrary but nevertheless the classifications should be reasonable and practical. For example, predicting the formation of precipitates from aqueous solutions requires the ability to perform concentration calculations. The question which arises is: What is the minimum that a student must be able to do in order to make such a prediction? Given appropriate information, the student must be able to recognize the components of a chemical solution, identify the species present before and after dissolution, and demonstrate proficiency in handling appropriate mass, volume and concentration units. The final skill of the proposed hierarchy in the present study is: Given the volume and molarity of solution *a* and the volume and molarity of solution *b*, calculate the molarity of common ion present when the solutions are mixed.

The molarity scale was chosen because it is the concentration unit favoured by the text used by the students and it is also the one most commonly used in the chemical literature. Appropriate information was given in each test item to minimize student errors caused by factors which were not being investigated. For example, the name and the formula of each solute was given and the solutes chosen were strong electrolytes. Hence, the students could assume that these solutes were completely ionized in aqueous solution. This simplification is necessary because the students had not been introduced to the notion of incomplete ionization. The class teachers and the text made the assumption that, on mixing, volumes of aqueous solutions are additive. Characterisitcs such as complexing are likely outside the scope of the students' expertise. The examples used conformed to general solubility rules and no verbal reference was made to the simplifying assumptions discussed above.

The hierarchy was generated by posing the following question for each skill: "What would the individual already have to know how to do in order to learn this new capability, simply by being given verbal instructions?" (Gagné, 1968a, p. 3). Using this method of task analysis the subordinate skills considered necessary for learning the terminal skill were successively determined. Skills that would be required in circumstances thought to be either contrived or artificial were omitted. It was felt that very little information could be gained in the limited time available by testing the ability to manipulate variables in obscure situations. The hierarchy was developed by successively asking Gagné's question for each new skill generated when the terminal skill had been selected. When a reasonable entry level of competence by the participants could be assumed the task analysis ceased.

The proposed hierarchy was scrutinized by a science educator, a chemistry professor, an instructional developer, and the author who is a chemistry lecturer.

All of these people are trained chemists. Reference to texts and course teaching objectives was avoided at this preliminary stage to minimize any bias towards traditional teaching sequences. No alterations to the hypothesized hierarchy were recommended by the scrutineers and none were made but following the pilot study the wording of the test items was modified slightly.

The name of each compound and each ion was given first in the test questions so as to minimize difficulties attributable to nomenclature, for example, sodium chloride, NaCl. However, the concentration of a specific solution was expressed in the usual manner, for example, 0.20 M NaCl rather than 0.20 M sodium chloride.

The task analysis identified 14 skills which are coded A through N. Each skill is specified below with an example:

A. Given the formula of a compound, identify the number of each ion produced from one formula unit.

Example: Zinc chloride, $ZnCl_2$ is dissolved in water. For every $ZnCl_2$ which dissolves, how many chloride ions, $Cl^-$ are present?

B Given the formula of the solute and moles of solute present, calculate the number of moles of specified ion.

Example: How many moles of chloride ion, $Cl^-$, are present in a solution which contains 0.10 moles of cupric chloride, $CuCl_2$?

C Given the molarity and volume of solution, calculate the number of moles of solute.

Example: How many moles of silver nitrate, $AgNO_3$, must be dissolved in water to prepare 2.0 L of 0.30 M $AgNO_3$ solution?

D Given the molarity of solute, calculate the molarity of specified ion.

Example: What is the molarity of chloride ion, $Cl^-$ in a 0.4 M $CaCl_2$, calcium chloride solution?

E Given the volume and molarity of solution, calculate the number of moles of specified ion present.

Example: How many moles of chloride ion, $Cl^-$ are present in 2.0 L of 0.50 M $BaCl_2$, barium chloride solution?

F Given the volume and initial molarity of a solution and volume of diluted solution, calculate the molarity of diluted solution.

Example: Calculate the molarity of sodium chloride, NaCl, when 1.5 L of 0.20 M NaCl is diluted to 3.0 L.

G Given the volume and molarity of solution A and the volume of diluted solution, calculate the molarity of specified ion in the diluted solution.

Example: If 1.5 L of 2 M $BaCl_2$, barium chloride solution were diluted to 6.0 L, what would be the molarity of chloride ion, $Cl^-$ in the resulting solution?

H Given the volume and molarity of solution A and the volume and molarity of solution B, calculate the molarity of common ion present when the solutions are combined.

Example: 2.0 L of 0.30 M KI, potassium iodide, is added to 3.0 L of 0.10 M $MgI_2$, magnesium iodide. What is the molarity of the iodide ion, $I^-$ in the resulting solution?

I Given the number of moles of solute, calculate the mass of solute.

Example: How many grams of magnesium bromide, $MgBr_2$ are in 0.30 moles of $MgBr_2$?

J Given the molarity and volume of solution, calculate the mass of solute.

Example: What mass of sodium nitrate, $NaNO_3$, must be used to prepare 2.0 L of 0.30 M $NaNO_3$ solution?

K Given the number of moles of solute and the volume of solution, calculate the molarity of solute.

Example: Calculate the molarity of potassium chloride, KCl, in a 2.0 L solution in which 0.10 moles 0f KCl have been dissolved.

L Given the mass of solute, calculate the number of moles of solute.

Example: How many moles of ferric chloride, $FeCl_3$ are in 324.6 g of $FeCl_3$?

M Given the mass of solute and volume of solution, calculate the molarity of solute.

Example: 23.8 g of potassium bromide, KBr, is dissolved in water to make 2.0 L of solution. What is the molarity of the KBr in the solution?

N Given the mass of solute and the volume of solution, calculate the molarity of a specified ion.

Example: If a 4.0 L solution contains 26.9 g of cupric chloride, $CuCl_2$, what is the molarity of chloride ion, $Cl^-$ in the solution?

Figure 3 shows the hypothesized hierarchy. Comment on the branching in the hierarchy is appropriate at this juncture. Superficially a reasonable hierarchy showing alternate pathways can be generated by incorporating skills A, B, E, H and A, D, G, H but, this is not the case. Indeed, a closer examination reveals that the route chosen depends on the information given in the problem. A, B, E, H and A, D, G, H are not alternative pathways to Skill H but rather, they comprise two sub-hierarchies which come together at H. Other small discrete hierarchies occur in the study, namely, skills A, D, and N; K, M, and N; L, M, and N; C, E, and H; F, G, and H; I and J; and C and J. Some of the skills in the overall hierarchy are not prerequisite directly or indirectly to the terminal skill. However, they are hypothesized to be related in some fashion to one or more other skills in the hierarchy. As such they are suggested to be part of the overall concept of molarity, and were consequently included in the overall hierarchy.

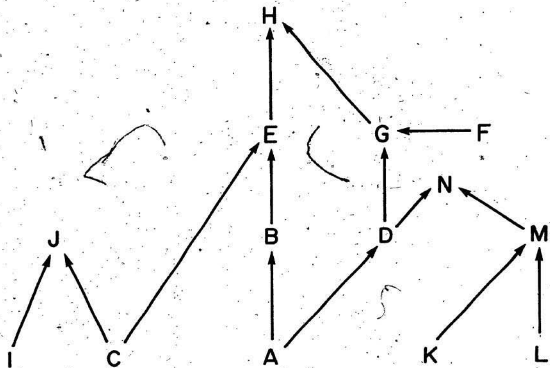



Figure 3. The hypothesized molarity hierarchy.
Note: A through N represent skills of the hierarchy.

Solving chemistry problems involves numerical competence (Denny, 1971; Dence, 1970; Good & Morin, 1978) but Griffiths (1979) argues that emphasis on numerical skills may cloud the ability of the researcher to identify conceptual relationships. Consequently the tests were designed so that the numerical calculations were simple although the students were permitted to use calculators. The students did not have to worry about (a) rounding off, (b) fractional parts, and (c) significant digits. The molar mass of calcium, normally taken to be 40.1 g was given in the table provided with the test as 40.2 g so that the answers are simple integers. The other required molar mass values coincided with those given on the flyleaf of the student text. It is assumed that students made mistakes because their difficulties were with the chemistry rather than the arithmetic. All of the volumes were given in liters (L) although the milliliter (mL) is the familiar unit in practical activities at this level. The ability to convert from one volume unit to another was excluded from the study.

**Sample**

The sample consisted of 144 grade ten students enrolled in introductory chemistry in the St. John's area and all the participants in the study used the same text book (O'Connor, Davis, Haenisch, MacNab, & McClellan, 1977).

**Experimental Design and Procedures**

Figure 4 shows the experimental design of the study. Gagné has suggested that the structure of a learning hierarchy is independent of instruction (Gagné, 1973a, p. 21). Consequently, no steps were taken prior to testing that might influence the teachers to alter their usual instructional practices and this was assumed to be the case. However, the teachers did inform their students that they had been selected to participate in a study and they also distributed the instructional booklets which were prepared for the remedial homework assigned

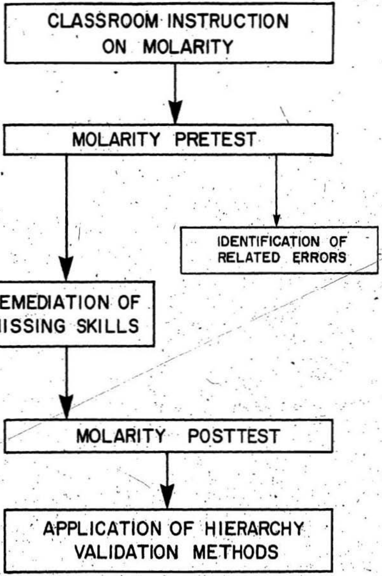



Figure 4. Experimental design of the study.

they had been selected to participate in a study and they also distributed the instructional booklets which were prepared for the remedial homework assigned before the posttest. Discussion with the teachers in different schools indicated that their respective modes of instruction were similar. Instructional practices were conventional, combining classroom exposition with laboratory activities.

All classes were instructed on the topic of molarity at approximately the same time without interference from the investigator. Soon after regular instruction was complete, the subjects were tested on the 14 skills in the hierarchy during class time. The first test was called the "pretest" because it preceded remediation. In one school forty minute periods were available. In this case two single periods on successive days were used for testing. On each day the test included one question for each of the 14 skills, the order of the test items being scrambled. The questions on the second day were equivalent to those of the previous day but were presented in a different sequence. In the other school, because the scheduling provided for two consecutive chemistry periods the pretest was administered in one eighty minute session. The latter students were given a test comprised of identical test items with the same numbering and scrambling as the two period group, the difference being that only one covering page of instructions and molar mass values were given because all 28 test items were handed out when the test commenced.

The pretest was marked by the investigator and returned after two days. At that time each student was given an individualized remedial booklet which was prepared by the investigator. Within the experiment the purpose of the booklet was to provide evidence for transfer of learning between skills. In this booklet skills were arranged in order of the hypothesized hierarchy. Each individual student was directed to areas of incompetence revealed by the pretest. Satisfactory competence for a particular skill on the pretest, required the student to have the two test items representing the skill correct. The students were asked to complete the remedial work by the next test administered three school days later. This second test was similar to the pretest and was called the "posttest".

The number of students who lacked competence on the pretest but showed mastery of these skills on the posttest was used as a measure of learning transfer from a subordinate to a superordinate skill. This testing method was devised by Griffiths (1979, p. 196) and the detailed analysis involves the following steps:

1. The identification of skills in the hypothesized hierarchy which are directly subordinate to any other skill(s) in the hierarchy and each hypothesized subordinate-superordinate connection.
2. Following regular instruction, the identification of those subjects who fail both skills in a particular connection. This group forms a subsample for each connection under test.
3. Following remediation on absent skills revealed by the initial testing, students are retested on all skills.
4. Those participants in each subsample who gain the subordinate skill of the connection under test are identified, as well as those who fail to gain the subordinate skill. These participants are designated as "Gain" or "No Gain", respectively.
5. Participants within the "Gain" and "No Gain" groups are further classified with respect to their performance on the superordinate skill of the connection under test. These subjects are designated either "Pass" or "Fail".
6. The significance of the relationship between Gain/No Gain and Pass/Fail is determined for each connection by application of a chi-

square test with one degree of freedom in each case.

The tests and the instructional booklet designed for remediation are described in the next section. Copies of the pretest, the posttest, and the instructional booklet make up the appendices A, B, and C, respectively.

**Instrumentation**

Two tests were given in this study, namely, the molarity pretest and the molarity posttest. For each skill in the hypothesized hierarchy two equivalent test items were constructed for the pretest and for the posttest. The validity and the reliability of the test items is discussed in Chapter 4.

To maximize consistency of measurement of student responses to the test items used in this study all the tests were marked and scored by one person, the researcher. Because a secondary purpose of this study is to identify errors associated with molarity incorrect responses were scrutinized carefully. The marking was further checked by two competent markers who were extensively briefed and supplied with a detailed answer key. The few discrepancies which occurred were reviewed by the researcher who made the final decisions with respect to scoring the tests.

The test items were of the "open response" type. Enough space was provided on the question paper to enter the answers. Care was taken to make the spacing uniform to avoid any clues as to the relative complexity of the questions. The students were requested to refrain from scribbling out and erasing answers even when they changed their minds. The format allowed detection of strategy changes in answering equivalent questions enhancing the likelihood of identifying the kinds of errors that the students made.

**Instructional Booklet**

The instructional booklet containing 14 units, each corresponding to a particular element of the hypothesized hierarchy was written to ascertain learning transfer. A flow chart of skills is included along with a synopsis of solution chemistry terminology. The worked examples given as models use diagrams in an attempt to make the subject matter easier to understand. The student is then led sequentially through a similar example and the correct answer is given. At the end of each unit, a "Check Yourself" problem is given. The student is directed to the answer key given on the last page of the booklet.

The booklet was designed to encourage the students to work at the assigned remediation but the term "remediation" was avoided lest it have a pejorative connotation. The individualized and prescriptive aspect as well as the language and style of the text material attempts to make the student feel comfortable and special. The returned booklets were not scrutinized to see whether the assigned work was done because the study was not concerned with remediation, but rather to ascertain if learning a lower skill facilitated learning a higher skill. Nevertheless, it was evident that many of the weaker students had conscientiously completed the assigned work.

The construction of the hierarchy and the design of the study have been described in this chapter along with the instruments and procedures that were used. The data collected were used to test the validity of the hypothesized hierarchy and, as a secondary purpose, to identify some errors associated with molarity. The analysis of these data are presented in the next chapter.

# Chapter 4
# RESULTS AND DISCUSSION

## Introduction

An hypothesized learning hierarchy is validated using the responses of the students tested on the individual skills in the hierarchy. The validity and reliability of the tests applied in the present study are discussed. The results of the analyses of the data by specific methods for hierarchical validation are presented and a validated hierarchy is offered. The final section lists and discusses the common errors that the students made in their responses.

The statistical procedures used for the analyses were conducted through the original and revised versions of SPSS 300 statistical package (Nie, Hull, Jenkins, Steinbrenner, & Bent, 1975) and SPSS$^X$.

## Validity of the Tests Related to Molarity Skills

Cronbach (1971, p. 447) has argued cogently that tests are not validated but rather the data arising from a procedure are interpreted. Consequently, an instrument can be judged valid in measuring one kind of phenomena but invalid when measuring another. The present study was designed to establish whether each student has mastered or failed to master each skill in the hypothesized hierarchy. Hence, claims about the validity of the molarity skills tests are tempered with Cronbach's caveat. Two tests were given: the molarity pretest and the molarity posttest. For each of the 14 skills in the hypothesized hierarchy two equivalent test questions were constructed for the pretest and for the posttest. Thus, each test is composed of 14 criterion-referenced tests. Good content validity in the construction of criterion-referenced tests has been stressed by Gagné and steps were taken to maximize the content validity of the test items used in the study. They were checked for congruence with the respective behavioral statements of the associated skills with the following people: three chemistry professors with considerable experience in teaching first year university chemistry, one experienced high school chemistry teacher, and two science educators who had taught chemistry at both the high school and first year university level. These consultants rated the questions as appropriate.

A pilot study was conducted with 41 students in two grade ten chemistry classes in the St. John's area. The participants in the pilot study were assumed to be comparable to those in the main testing pool. Ideally, these data from the pilot study should be analysed analogously to that of the main study. Because it was important that the testing be done at an appropriate point after instruction of molarity, time constraints prevented this.

Other kinds of validity often discussed by evaluators are "criterion-related validity" and "construct validity". For the former case, the results must be related to an externally "proven" test and in the latter, to a particular characteristic such as intelligence. Such information was not at the disposal of the researcher. Moreover, this aspect of the investigation is outside the frame of reference of this study.

## Reliability of the Tests Related to Molarity Skills

A necessary characteristic of the testing instrument is "reliability". This is related to the validity of the measuring device because if there is a lack of consistency in measuring what is intended, then the accuracy may be impaired.

There are several reasons why, in practice, a perfect correlation between test items is elusive. There are those which are said to be "instrumented related" or "situational related" (Turney & Robb, 1971, p. 158). Related to instrumentation consistency is the length of the test. The longer the test the more reliable it is thought to be. The students in the pilot study indicated that the length of the tests was appropriate for the available time. It was necessary to administer the tests in single sessions to some classes while it was possible to complete the testing in one session where a double period was available. The single-session groups were likely more susceptible to situational related inconsistency. There are bound to be fluctuations in motivation and attention, health, and emotional feelings from time to time. It is possible that the subjects requiring two sessions might be more affected in this way.

Equivalent test items on molarity are relatively easy to construct. For binary compounds one has only to select elements from the same groups of the Periodic Table. For example, if in one question sodium chloride, NaCl, is used; then the equivalent question would use potassium iodide, KI. Where a polyatomic ion is used, for example, the nitrate ion, $NO_3^-$; the equivalent ion would have the same charge, for example, $OH^-$. The name of the compound used for the solute was given first, followed by the formula, in order to minimize the interference from incompetence with nomenclature and formula writing. Different sequences of test items ensures that these are randomized with respect to the level of difficulty. The test items were randomly sequenced in two sets of 14 items each for the pretest and for the posttest using a computer program. The amount of space provided for the answer was always the same, in order to minimize any inference the student might make about the complexity of the answer to a particular item.

Because only two items tested each skill, little meaning can be attached to conventional reliability statistics. However, a positive correlation between the students' responses on two corresponding test items gives support to the claim that the reliability of the test items is acceptable.

For dichotomous data, when two variables can logically be assumed to be continuous and their joint distribution forms a bivariate normal distribution, the tetrachoric coefficient can be used as a measure of the strength of the relationship between a pair of items (Walker & Lev, 1953, p. 274; Tate, 1955, p. 259). The phi coefficient can also be used as an index of relationship allowing the same assumptions, but Glass and Stanley (1970, p. 165) suggest that this quantity underestimates the relation between the two variables. The extent to which underlying measurements conform to bivariate normal distribution determines whether the interpretation of the tetrachoric coefficient has any useful meaning. However, Carroll (1961, p. 362) holds the view that a good approximation to the normal distribution is likely even when psychological characteristics are not distributed normally because any deviation from central tendancy becomes rarer as a function of the magnitude of the deviation. This appears to be true for most of the skills measured by the test items in this study.

| | | 2nd. test item score on Skill X | |
|---|---|---|---|
| | | Wrong | Right |
| 1st. test item score on Skill X | Wrong | B | D |
| | Right | A | C |

Figure 5. An item matrix for the determination of a tetrachoric correlation coefficient.

Note: A, B, C, and D represent cell frequencies.

The tetrachoric correlation coefficient, therefore, was the index selected to measure the degree of correlation between the two items testing a given skill in the hierarchy. The value of a tetrachoric coefficient is calculated using a modified method devised by Jenkins (1955). The method allows the estimation of tetrachoric $r$'s using the ratios of the cross-products of a fourfold table and applying corrections to allow for assymetric distribution of the scores which was the case in this study. The frequencies of response scores for the two items testing a particular skill are represented in a two by two matrix (Figure 5). The responses are classified as "right" or "wrong" and the frequencies of the four cells represented by the letters A, B, C, and D. The tetrachoric correlation coefficients between each pair of items testing a particular skill in both the pretest and the posttest were calculated using Jenkins' method. The values are shown in Table 1. The significance level represents the level at which the null hypothesis (no correlation between test items) can be rejected and the correlation values can range from -1 to +1. Under ideal conditions, an individual will answer consistently both items testing a particular skill. In practice, however, such consistency is rarely found.

A high degree of correlation was found between the items testing the skills of the hierarchy as indicated by the correlation values shown in Table 1. For 11 of the 14 skills tested on the pretest the correlation coefficient between the test items is 0.85 or greater. For Skill N the coefficient is 0.79, for Skill C the coefficient is 0.69, and for Skill K the coefficient is 0.50. These correlation coefficients are significant at the $< .001$ level. The pairs of test items on the posttest showed a correlation coefficient of 0.9 or greater ($p < .001$). However, if one or more cells in the item matrix have a frequency of zero then the tetrachoric correlation coefficient cannot be determined. This situation occurred in the posttest data for Skills I and K. No student got the first question right and the

Table 1

Tetrachoric Correlation Coefficient $r_{(tet)}$
Between Items Testing Skills of the Hierarchy

| Skill | Corresponding test items | | Sample Size | | $r_{(tet)}$ | | $p$ | |
|---|---|---|---|---|---|---|---|---|
| | Pre- | Post- | Pre- | Post- | Pre- | Post- | Pre- | Post- |
| A | 9, 26 | (7, 19) | 127 | (134) | .87 | (.90) | < .001 | (< .001) |
| B | 11, 27 | (10, 28) | 124 | (131) | .89 | (.91) | < .001 | (< .001) |
| C | 2, 28 | (6, 23) | 124 | (134) | .69 | (.90) | < .001 | (< .001) |
| D | 3, 23 | (2, 21) | 130 | (133) | .90 | (.89) | < .001 | (< .001) |
| E | 5, 16 | (4, 20) | 134 | (133) | .89 | (.76) | < .001 | (< .001) |
| F | 6, 21 | (3, 27) | 131 | (132) | .85 | (.92) | < .001 | (< .001) |
| G | 10, 24 | (8, 22) | 129 | (133) | .93 | (.94) | < .001 | (< .001) |
| H | 14, 20 | (9, 17) | 131 | (135) | .90 | (.95) | < .001 | (< .001) |
| I | 13, 17 | (14, 16) | 134 | (135) | .87 | (*) | < .001 | (-) |
| J | 12, 19 | (5, 18) | 132 | (134) | .90 | (.91) | < .001 | (< .001) |
| K | 4, 25 | (1, 24) | 129 | (134) | .50 | (*) | < .001 | (-) |
| L | 1, 18 | (12, 15) | 132 | (135) | .91 | (.90) | < .001 | (< .001) |
| M | 7, 15 | 13, 26 | 134 | (132) | .90 | (.90) | < .001 | (< .001) |
| N | 8, 22 | (10, 24) | 130 | (134) | .79 | (.82) | < .001 | (< .001) |

Note: $r_{(tet)}$ value (*) not determinable where zero frequency occurs in one cell or more of the data matrix.

Student absences account for the difference in sample size.

second wrong for Skill I. For Skill K the reverse occurred: no student got the first question wrong and the second question right.

### Application of the Ordering-Theoretic Method

The first research question posed was: Does the arrangement of intellectual skills comprising the hypothesized hierarchy represent a learning hierarchy which is valid psychometrically? The Dayton and Macready method formed the major analytical tool for the pretest data, the ordering-theoretic method being applied to the data first as a preliminary sorting technique.

To apply the ordering-theoretic method the student is classified as having mastered or not mastered each skill in the hierarchy. A skill tested by two items is considered mastered if both responses are satisfactory. Students with two incorrect responses are classified as nonmasters. The scores of students who were absent during any one of the testing sessions or who had one of the two test items wrong were not included in the analyses.

Table 2 shows the percentage of exceptions to a hierarchical relationship between each pair of skills, in the hypothesized direction and in the opposite direction. An example is provided to aid in the interpretation of Table 2. Consider Skills C and E. If Skill C is hypothesized to be subordinate to Skill E, ideally no exceptions for this arrangement will occur. That is to say, none of the students tested exhibit possession of Skill E without also exhibiting Skill C. Hence, a hierarchical relationship is implied. The percentage of exceptions of Skill E being superordinate to Skill C using the ordering-theoretic method is 0.0% and the reverse connection of Skill C being superordinate to Skill E shows 55.6% exceptions offering support for the hypothesis that Skill C is subordinate to Skill E. Obviously, this claim depends on the level of exceptions allowed.

Table 2

Ordering-Theoretic Method: Percentage of Exceptions to Hierarchical Connections

| Lower skill | A | B | C | D | E | F | G | H | I | J | K | L | M | N |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Upper skill | | | | | | | | | | | | | |
| A | - | 3.2 | | 1.0 | 0.0 | | 0.9 | 0.0 | | | | | | 0.0 |
| B | 21.[illegible] | - | | | 1.1 | | | 0.0 | | | | | | |
| C | | | - | | 0.0 | | | 0.0 | | 0.0 | | | | |
| D | 24.2 | | | - | | | 0.0 | 0.0 | | | | | | 0.0 |
| E | 42.8 | 17.0 | 55.6 | | - | | | 0.7 | | | | | | |
| F | | | | | | - | 2.0 | 6.6 | | | | | | |
| G | 59.4 | 31.2 | 73.0 | 25.5 | 15.8 | 28.2 | - | 6.8 | | | | | | |
| H | 56.0 | 29.0 | 69.8 | 22.8 | 11.3 | 31.4 | 3.4 | - | | | | | | |
| I | | | | | | | | | - | 0.0 | | | | |
| J | | | 4.8 | | | | | | 8.7 | - | | | | |
| K | | | | | | | | | | | - | | 0.0 | 0.0 |
| L | | | | | | | | | | | | - | 0.0 | 0.0 |
| M | | | | | | | | | | | 5.8 | 7.6 | - | 0.0 |
| N | 51.1 | | | 15.7 | | | | | | | 67.4 | 73.0 | 61.0 | - |

Allowing for 1% exceptions to hierarchical relationship, 20 of the 24 hypothesized hierarchical connections are considered valid. The connection between Skills G and F is valid allowing for 2% exceptions and the connection between B and A is valid allowing for 3% exceptions. The remaining two connections, H being superordinate to G and to F, show 6.6% and 6.8% exceptions, respectively and are not considered valid.

Examination of Skills F and G and the corresponding test items show that these problems involve the dilution of a solution with water. The items related to Skill H involving the mixing of two solutions and determining the molarity of a specified common ion. When the responses were scrutinized to identify the types of errors that the students made, it was discovered that students whose responses failed to support the hypothesized connection had applied the same incorrect relationship. It appears that the students used a strategy learned elsewhere without realizing that it was inappropriate for the problem they were trying to solve. Problems involving dilution require that the student recognize that a "new" solution exists. A sample item testing Skill F is: Calculate the molarity of potassium bromide, KBr when 1.5 L of 0.20 M KBr is diluted with water to 3.0 L. Failure to recognize that the problem involved two solutions prompted some of the participating students to set up an incorrect relationship as follows: 1.5 L is to 0.20 M as 3.0 L is to x, a misapplication of proportion rules learned elsewhere. Using the incorrect relationship gives the incorrect answer of 0.40 M.

The items testing Skill H are more complicated involving more steps and the students are given little flexibility in choosing a strategy. Indeed, they must go back to first principles. If the nonmasters had relied on first principles for Skill F and Skill G they may have answered the related items correctly.

The results obtained from the application of the ordering-theoretic method to the data support the hierarchy presented in Figure 6.

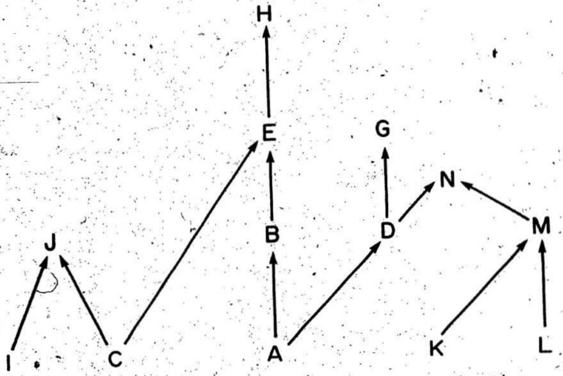



Figure 6. The psychometrically validated molarity hierarchy.
Note: A through N represent skills of the hierarchy.

**Application of the Dayton and Macready Model**

The Dayton and Macready scaling method is considered to be the more valuable of the two psychometric methods presented in this chapter. Decisions about the goodness of fit between the data and the hypothesized hierarchy are determined by a chi-square analysis and the determination of a likelihood ratio.

A likelihood ratio determined using the Dayton and Macready model gives estimates of the misclassification parameters which are needed to provide a fit between the data and the hypothesized hierarchy. Confidence in the hierarchy decreases as these values increase. Consequently, it is imperative that the students be classified correctly as masters or nonmasters of each of the 14 skills of the hierarchy. Only those students who had the two test items for each skill answered correctly were considered as having achieved mastery and hence, included in the analysis.

The computer program for the Dayton and Macready method is limited to hierarchies smaller than the hypothesized hierarchy related to this study. Thus the hypothesized hierarchy was divided into smaller sub-hierarchies and the skills in each of the sub-hierarchies are as follows:

Sub-Hierarchy 1 involving Skills C, E, G, and H
Sub-Hierarchy 2 involving Skills D, F, G, and H
Sub-Hierarchy 3 involving Skills A, B, C, E, and H
Sub-Hierarchy 4 involving Skills F, G, and H
Sub-Hierarchy 5 involving Skills C, D, E, and H
Sub-Hierarchy 6 involving Skills A, D, F, and G
Sub-Hierarchy 7 involving Skills C, I, and J
Sub-Hierarchy 8 involving Skills K, L, M, and N

The null hypothesis being tested is that there is no significant difference between the observed frequencies of response patterns and those consistent with a valid hierarchy. The hierarchy being tested is rejected if the maximum likelihood estimate and/or the misclassification parameters are too high. A significance level less than .05 for the maximum likelihood estimate is considered to indicate inadequate correspondence between the hierarchy and the data. The values for the misclassification parameters and the likelihood estimates for the sub-hierarchies are shown in Table 3. The misclassification parameter, $\alpha$, which allows for guessing is 0.00 for sub-hierarchies 1, 5, 6, 7, and 8; 0.4 for sub-hierarchies 2 and 4; and 0.5 for sub-hierarchy 3. The misclassification parameter, $\beta$, which allows for forgetting is 0.00 for sub-hierarchy 3 and has values ranging from 0.01 and 0.11 for the other seven sub-hierarchies.

Table 3

Dayton and Macready Analysis of Molarity Sub-Hierarchies

| Hierarchy | Guessing Parameter | Forgetting Parameter | Likelihood Function | Degrees of Freedom | Significance |
|---|---|---|---|---|---|
| 1 | 0.00 | 0.11 | 15.21 | 7 | <0.05 |
| 2 | 0.04 | 0.08 | 37.47 | 8 | <0.001 |
| 3 | 0.05 | 0.00 | 8.88 | 22 | 0.99 |
| 4 | 0.04 | 0.09 | 6.89 | 2 | <0.05 |
| 5 | 0.00 | 0.01 | 2.56 | 7 | >0.80 |
| 6 | 0.00 | 0.04 | 4.14 | 73 | >0.30 |
| 7 | Perfect fit, no exceptions | | | | >0.99 |
| 8 | Perfect fit, no exceptions | | | | >0.99 |

Five of the eight sub-hierarchies tested exhibited good fit to the data. The exceptions occurring in sub-hierarchies 1, 2, and 4 again involved Skills F, G, and H. The direct hypothesized connections, Skill G to Skill H and Skill F to Skill G, lacked support as does the indirect relationship, Skill F to Skill H. These findings are consistent with those of the ordering-theoretic application. A suggestion to account for these phenomena was offerred in the discussion of the ordering-theoretic results and also applies here. However, the remaining direct connections (A - B, A - D, B - E, C - E, C - J, D - G, D - N, E - H, I - J, K - M, L - M, and M - N) and the remaining indirect relationships (A - E, A - G, A - H, A - N, B - H, C - H, D - H, K - N, and L - N) are supported. In all, 21 of the 24 hypothesized relationships are substantiated. These are represented in Figure 6.

**Transfer of Learning within the Molarity Hierarchy**

Research question two asks the following question: Is there significant positive transfer between subordinate skill(s) and the related superordinate skill in the hypothesized hierarchy. Chapter 2 describes Gagne's index of Proportion Positive Transfer in addition to other related indices along with the current criticisms. Methods of testing for transfer are described in Chapter 2 with a rationale for the selection of the transfer test which was used in this study, namely, the method devised by Griffiths (1979).

To apply the transfer method the students are first tested on all skills in the hypothesized hierarchy. This is followed by remedial instruction on the missing skills and retesting at an appropriate later period. In this case, remediation took the form of an individualized instructional booklet. A chi-square test is used to show whether those students who gain prerequisite skills between tests are more successful on posttest items which test the superordinate skill than those who do not master the prerequisite skills. The results for seven of these connections are shown in Table 4. Two connections, F $\rightarrow$ G and G $\rightarrow$ H, which were not validated psychometrically showed significant transfer effect ($p < .01$). Four connections which were found to be valid psychometrically also showed significant transfer effect ($p < .01$). The connections are A $\rightarrow$ B, D $\rightarrow$ N, D $\rightarrow$ G, and

E → H. Although the data were consistent, transfer effect is not significant for the seventh connection B → E. For the remaining seven connections (A → D, C → E, C → J, I → J, K → M, L → M, and M → N) the number of students failing both skills of a particular connection in the pretest is too small to be used. Significant transfer of learning effect indicates that learning a lower skill enhances significantly the learning of the related higher skill. Thus, research question 2, is answered in the affirmative for all cases except one for those cases which could be tested.

Table 4

Transfer Test, Molarity Hierarchy

| Connection | Subordinate Not Gained: Superordinate Failed (n) | Subordinate Not Gained: Superordinate Passed (n) | Subordinate Gained: Superordinate Failed (n) | Subordinate Gained: Superordinate Passed (n) | $X^2$ | p |
|---|---|---|---|---|---|---|
| G→H | 26 | 2 | 19 | 18 | 11.01 | <.00 |
| E→H | 18 | 0 | 15 | 15 | 10.87 | <.00 |
| F→G | 13 | 0 | 6 | 19 | 16.83 | <.00 |
| D→G | 9 | 0 | 9 | 19 | 9.98 | <.01 |
| D→N | 8 | 0 | 6 | 17 | 10.28 | <.01 |
| B→E | 3 | 0 | 7 | 15 | 2.67 | NS |
| A→B | 2 | 0 | 0 | 8 | * | <.05 |

Note: Subsamples (n) are those subjects failing both skills of a particular connection in the pretest.

Note: For all other connections, (n) was too small to test.

*Fisher test

Two psychometric techniques and one transfer test were applied to the data of this study. The hierarchy depicted in Figure 7 is offered as the validated molarity hierarchy.

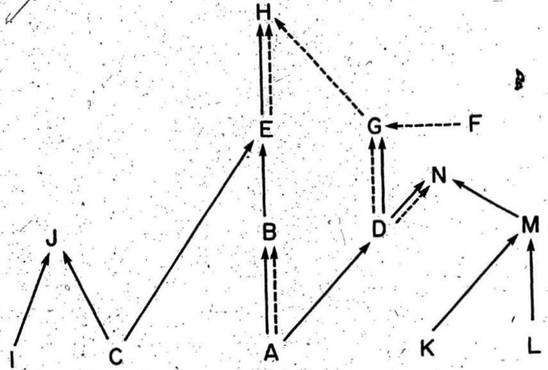



Figure 7. The validated molarity hierarchy.
Note: A through N represent skills of the hierarchy.
---▸ Validated by transfer method. ⟶ Validated psychometrically.

**Student Errors Related to Molarity**

The learning hierarchy model has been shown to be a useful tool in the study and identification of students' misunderstandings. Research Question three dealing with a secondary aspect of this study asks the question, "What student errors about molarity can be identified from the pretest responses?" The task analysis procedure used to generate the molarity hierarchy aids in the detection of the particular errors that students made. The instructional booklet designed for remediation was not intended to address specific individual difficulties although the students were assigned prescriptive homework based on missed skills as shown by the pretest scores. The errors on the posttest are not reported because the purpose of the instructional booklet was to investigate the transfer of learning rather than to evaluate a remediation treatment. Hence, only the errors on the pretest are reported.

The test items follow an "open-response" format and the students were encouraged to show their reasoning and to make their responses legible even if they felt they were wrong. In some cases, students do not get the correct answer because of what teachers often refer to as "carelessness". In this study a judgment was made as to whether errors represented carelessness or misunderstanding. For example, when a molar mass was added up incorrectly and the answer was "wrong" but the reasoning acceptable, the answer was then marked correct. For Skills G and H, no sense could be made of some of the answers and the student was classified as a nonmaster. In other cases, it was suspected that the student had merely manipulated the numerical data given and the term, "numeral shoving" (Holt, 1964), is apt. These students were also classified as nonmasters.

Sometimes the strategies leading to wrong answers are relatively easy to construct, but, even after reasonable diligence, others remain undecipherable. All items answered incorrectly on the tests were scrutinized. Beside each cell of the grid appearing on the cover of the test, the scorer recorded the type of error made. Patterns emerged and the items were coded numerically for different categories. Where a student committed more than one error each was recorded. The coding was assigned after a pattern was recognized in the students' answers rather than beforehand.

Table 5

Summary of Students' Errors Related to the Molarity Concept

| Error | Skills in which the error occurred | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | A | B | C | D | E | F | G | H | I | J | K | L | M | N |
| 1 | - | - | X | X | X | X | X | X | - | X | X | - | X | X |
| 2 | - | X | - | X | X | - | X | X | - | - | - | - | - | X |
| 3 | X | X | - | X | X | - | X | X | - | - | - | - | - | X |
| 4 | - | - | - | - | - | X | X | X | - | - | - | - | - | - |
| 5 | - | - | - | - | - | - | - | - | X | X | - | X | X | X |
| 6 | - | - | X | X | X | X | X | X | - | - | - | - | - | - |

The identification of particular errors that students make in solving molarity problems may be of particular interest to teachers and instructional developers. The errors are described below and the skills where the different errors occurred are shown in Table 5. Five of the error types occurred in Skills G and H, the top skills of the hierarchy. Three error types were identified for Skill F. Skill N which could be considered to be the top skill of a smaller hierarchy showed four error types. Skill J, also the top skill of a small hierarchy shows two error types. The related lower skills to Skill J, namely Skills C and I, show two and one error types respectively. Skills A, K, L, and I which appear as the lowest skills in the hierarchy showed only one error type. It is not surprising that fewer errors occur on less complex skills and that more errors occur on more complex skills. Intermediate skills, D and E showed four error types, and intermediate Skills B and M showed two error types.

The frequency with which the errors occurred must be interpreted with caution. The student who fails to answer a test item at all is reasonably assumed to be incompetent on that skill. However, such a situation provides no information about potential errors. In some cases, students committed more than one error in a particular item. Consequently, the significance of percentage occurence of each error type, their combinations, and their absence becomes marginal. Nevertheless, the percentage occurence of each error type is reported below. The order in which the errors are presented is arbitrary.

ERROR 1: Incorrect application of the formula for molarity.

Of the total errors identified from the responses of the pretest, 14.9% indicated that the concepts of mole and molarity had been confused, the values when substituted into the formula having been interchanged. In four cases, unnecessary calculation of molar mass was performed.

ERROR 2: Incorrect use of the ratio of ions present.

When the solute is a type like barium chloride, $BaCl_2$, many students failed to make allowance for the presence of twice as many chloride ions as barium ions. The reasons for this error are unknown. Occasionally, the relevant ion concentration was halved rather than doubled. The reason for this is also obscure. Of the total errors identified 51.7 % were errors of this type.

ERROR 3: Incorrect use of the formula for a given compound.

Some students have a wrong notion about the ratio of ions present. For the purpose of illustration, consider a solution of 0.4 M $BaCl_2$. Students making incorrect use of the formula of the solute assumed a total ion concentration of

0.4 M with 1/3 being barium ion and 2/3 chloride ion. They calculated the molar concentration of barium ion and of chloride ion to be 0.133 M and 0.266 M, respectively. The incidence of errors of this type was 11.8%.

ERROR 4: Incorrect determination of final volume.

Failure to use the correct final volume may be a problem associated with the idea of dilution and the recognition that two solutions are involved. This error type occurred in 10.2% of the total errors identified. Mistaking a dilution problem for one involving ratio and proportion was discussed in considerable detail above in the section describing the results of the ordering-theoretic method involving the Skills F, G, and H and the relevent connections between them. The occurence of this student error suggests that instructors should emphasize that students return to the fundamental relationship between moles and volume when solving molarity problems even when the problem appears simple.

ERROR 5: Failure to recognize correctly the relationship between the mass of substance and the number of moles.

Incidence of errors of this type was 6.8%. Students failing this skill used the formula, moles = mass x molar mass.

ERROR 6: Inappropriate addition of volumes and/or molarities

A sample problem where this kind of error was observed is the following: "2.0 L of 0.30 M KI, potassium iodide is added to 3.0 L of 0.10 M $MgI_2$, magnesium iodide. What is the molarity of the iodide ion, $I^-$, in the resulting solution?" It is suspected that these students merely manipulated the values given with little thought to the concept. Of the total errors identified, 4.6% were in this category.

## Summary

The research questions posed in this present study are addressed in this chapter and a validated hierarchy for molarity presented. The identification of transfer between related skills is impossible when students master the lower skills of the hierarchy. However, those connections where positive transfer occurred provide additional support for the validation results determined psychometrically. Finally, several errors identified from the student responses related to the concept of molarity are reported and discussed. Chapter 5 offers recommendations for further research on the molarity concept.

# Chapter 5
# SUMMARY AND RECOMMENDATIONS

## Summary of the Study

The main purpose of the present study is to identify a learning hierarchy for the molarity concept. This concept is central to elementary chemistry because a large body of quantitative chemistry is carried out in solutions. Many students find the concept difficult. The prospective science student who fails to master this concept is seriously handicapped because such a student cannot hope to understand some other important concepts which depend on a correct use of molarity.

A learning hierarchy for the molarity concept was developed by a "common sense" approach based on the Gagné method of task analysis. A review of the literature on learning hierarchies including criticisms of some earlier validation techniques is presented. The latter were helpful in choosing the validation methods used in this study. Three methods were selected: two of these are psychometric in character and the other relates to learning transfer. The two approaches to the data are rated as equally significant.

The identification of errors related to elementary science is an interesting topic. Although this aspect of the study is secondary, the author found it fascinating to try and decipher the salient characteristics of the errors that the students made in the tests administered.

When the molarity hierarchy had been constructed using the Gagnéan method, the corresponding test and remedial material were designed and then evaluated by experienced teachers. After preliminary field testing no substantial modification to the the tests was required. The testing pool for the study came from five local Grade 10 chemistry classes and each of these classes was tested shortly after the students had been taught molarity by their class teacher. Following the pretest, each student was given an individualized instructional booklet designed by the investigator. Voluntary homework was then assigned for the particular skills evidently requiring remediation. Two days later a posttest was administered to detect if there were any gain in mastery of skills.

The test data were analyzed using the ordering-theoretic method of for learning hierarchy validation. This method was used to sift the data so that a second psychometric test, the Dayton and Macready method, could be more easily applied. The Griffiths' test for transfer was also applied to the data and significant transfer of learning was apparent for a number of the hypothesized connections. The study also shows that the learning hierarchy model provides a useful tool for probing student misconceptions about molarity. The analyses also show that learning subordinate skills enhances the learning of superordinate skills. This is a significant observation for curriculum designers and classroom teachers. The Griffiths' transfer test has a major disadvantage, namely, that the sample selected for the transfer investigation consists of nonmasters and this set of participants is frequently too small to yield meaningful results. This situation can arise if either the original testing pool is small or if a large proportion of the students master the subordinate skill for the pair under test. The selection of the subordinate skills is arbitrary because any set of skills is, in principle, the subset of a larger set. Nevertheless, showing that learning transfer takes place between skills is a valuable exercise and promises a better route to improved methods of instruction. Thus the present study offers definite evidence that learning can be enhanced if the intellectual skills which define a selected area of knowledge are carefully sequenced. Additionally, missing skills can be identified and this information can be used as a basis of new instructional materials and tactics. Learning hierarchies are also useful in detecting student weaknesses and difficulties so that effective remediation is possible. Finally, the errors revealed by the present study represent important information because teachers cannot help students master new ideas unless areas of ignorance and misunderstanding are clearly defined. A hierarchical model provides a possible tool to identify areas of difficulty and remediation based on such information may be less painful for the students.

**Suggestions for Further Research**

1. Further application of the learning hierarchy model to other concepts in chemistry, for example, $K_a$, $K_{sp}$, elementary electrochemistry.
2. Application of the learning hierarchy model to practical skills in chemistry to learn further aspects of the molarity concept, for example, making up standard solutions.
3. Application of the learning hierarchy model to instructional development and the use of different media for teaching molarity, for example, a slide-tape presentation on preparing a standard solution including the calculation of the concentration of specified species.
4. Application of the learning hierarchy model to concepts in other sciences.
5. Extension of the Dayton and Macready model to allow for testing of larger hierarchies.
6. Development of a more probing method of testing for transfer of learning.
7. Further investigation, using the hierarchical model, of students' errors in other chemical concepts.

# REFERENCES

AAAS (1967). *Science-- a process approach*. American Association for the Advancement of Science.

Aikenhead, G. S. (1980). *Science in social issues: implications for teaching*. Ottawa: Science Council of Canada.

Airasian, P. W. & Bart, W. M. (1975). Validating a priori instructional hierarchies. *Journal of Educational Measurement, 12(3)*, 163-173.

Ausubel, D. P. (1963). *The psychology of meaningful verbal learning*. New York: Grune & Stratton.

BSCS (1970). *Biological Sciences Curriculum Study (BSCS), Biological Science: Patterns and Processes (Teachers Edition)*. Toronto: Holt, Rinehart, and Winston.

Bart, W. M. & Krus, D. J. (1973). An ordering-theoretic method to determine hierarchies among items. *Education and Psychological Measurement, 33*, 291-300.

Beeson, G. W. (1977). Hierarchical learning in electrical science. *Journal of Research in Science Teaching, 14(2)*, 117-127.

Beeson, G. W. (1981). Influence of knowledge content on the learning of intellectual skills. *American Educational Research Journal, 18(3)*, 363-379.

Bergan, J. R. & Jeska, P. (1980). An examination of prerequisite relations, positive transfer among learning tasks, and variations in instruction for a seriation hierarchy. *Contemporary Educational Psychology, 5(3)*, 203-215.

Bergan, J. R. (1980). The structural analysis of behavior: An alternative to the learning-hierarchical model. *Review of Educational Research, 50(4)*, 625-646.

Block, J. H. (1971). *Mastery learning: theory and practice*. New York: Holt, Rinehart, and Winston.

Bloom, B. S. (1968). Learning for mastery. *Evaluation Comment, 1*, 2.

Bloom, B. S., Hastings, J. T. & Madaus, G. F. (1971). *Handbook on Formative and Summative Evaluation of Student Learning*. New York: McGraw-Hill, Inc.

Boblick, J. M. (1971). Applying the systems approach to curriculum development in the science classroom. *Science Education, 55(1)*, 102-113.

Briggs, L. J. (1968). Sequencing of instruction in relation to hierarchies of competence. AIR G3 10/G7FR. Pittsburg: American Institute for Research in Behavioral Sciences.

Bruner, J. S. (1960). *The process of education*. Cambridge, Massachusetts: Harvard University Press.

Bruner, J. S. (1966). *Toward a theory of instruction*. Cambridge: Harvard University Press.

Capie, W. & Jones, W. S. (1971). An assessment of hierarchy validation techniques. *Journal Of Research in Science Teaching, 8*, 137-147.

Carroll, J. B. (1961). The nature of the data, or how to choose a correlation coefficient.

*Psychometrika, 26(4)*, 347-372.

Carroll, J. B. (1973). Hierarchies in children's learning. *Instructional Science, 2*, 311-362.

Cotton, J. W., Gallagher, J. P. & Marshall, S. P. (1977). The identification and decomposition of hierarchical tasks. *American Educational Research Journal, 14(3)*, 189-212.

Cronbach, L. J. (1971). Test Validation . In R. L. Thorndike (Ed.), *Educational Measurement* . Washington: American Council on Education: 443-507.

Dayton, C. M. & Macready, G. B. (1976a). A probabilistic model for behavioral hierarchies. *Psychometrica, 41(2)*, 189-204.

Dayton, C. M. & Macready, G. B. (1976b). *Computer programs for probabilistic models*: University of Maryland.

Dayton, C. M. & Macready, G. B. (1980). A scaling model with response errors and intrinsically unscalable respondents. *Psychometrica, 45(3)*, 343-356.

Denne, J. B. (1970). The mathematics needed in freshman chemistry. *Science Education*, 287-290.

Denny, R. T. (1971). The mathematics skills test (MAST) for chemistry. *Journal of Chemical Education, 12*, 845-846.

Dewey, J. (1916). *Democracy and Education*. New York: Macmillan.

Doll, R. C. (1978). *Curriculum improvement: decision-making and process*. Boston: Allyn & Bacon.

Driver, R. & Easley, J. (1978). Pupils and paradigms: a review of literature related to concept development in adolescent science students. *Studies in Science Education, 5*, 61-84.

Fiel, R. L. & Okey, J. R. (1975). The effects of formative evaluation and remediation on mastery of intellectual skills. *Journal of Educational Research, 68*, 253-255.

Gagné, R. M. (1973b). *Learning and instructional sequence*. Itasca, Illinois: F. E. Peacock.

Gagné, R. M. & Paradise, M. E. (1961). Abilities and learning sets in knowledge acquisition. *Psychological Monographs (Whole Number 518), 75(14)*.

Gagné, R. M., Mayor, J. R., Garstens, H. L. & Paradise, N. E. (1962). Factors in acquiring knowledge of a mathematical task. *Psychological Monographs (Whole Number 526), 76(7)*.

Gagné, R. M. (1962). The acquisition of knowledge. *Psychological Review, 69(4)*, 355-365.

Gagné, R. M. (1965). *The Conditions of Learning (1st Ed. )*. New York: Holt, Rinehart, and Winston.

Gagné, R. M. (1968). Contributions of learning to human development. *Psychological Review, 75(3)*, 177-191.

Gagné, R. M. (1970). *The Conditions of Learning (2nd Ed. )*. New York: Holt, Rinehart, and

Winston.

Gagné, R. M. (1972). Domains of learning. *Interchange, 3(1)*, 1-8.

Gagné, R. M. (1974). *Essentials of learning for instruction.* Hinsdale, Illinois: The Dryden Press.

Gagné, R. M. (1977). *The Conditions of Learning (3rd Ed. ).* New York: Holt, Rinehart, and Winston.

Gagné, R. M. (1968a). Learning hierarchies. *Education, 6(1)*, 1-9.

Glass, G. V. & Stanley, J. C. (1970). *Statistical methods in education and psychology.* Englewood Cliffs, New Jersey: Prentice-Hall.

Good, R. & Morris, G. (1978). Mathematical and logical skills exhibited by college freshman chemistry students. A paper presented to NARST, Toronto.

Goodman, L. A. (1975). A new model for scaling response patterns: An application of the quasi-independence concept. *Journal of the American Statistical Association, 70*, 755-768.

Gower, D. M., Daniels, D. J. & Lloyd, G. (1977). Hierarchies among the concepts which underlie the mole. *School Science Review, 59*, 285-299.

Grant, B. A. C. (1983). The food web concept: identification of a learning hierarchy and related misconceptions. Unpublished M. Ed. thesis, Memorial University of Newfoundland.

Griffiths, A. K. (1979). The mole concept: investigation of an hierarchical model. Unpublished Doctoral dissertation, University of Alberta.

Griffiths, A. K. (1982). Applications of the learning hierarchy model to acquisition of three science concepts. A paper presented at CSSE, Ottawa.

Guttman, L. (1944). A basis for scaling qualitative data. *American Sociological Review, 9*, 139-150.

Hedges, W. D. (1966). *Testing and evaluation for the secondary school.* Belmont, California: Wadsworth.

Herron, J. D. (1975). Piaget for chemists. *Journal of Chemical Education, 52(3)*, 146-150.

Holt, J. (1964). *How Children Fail.* New York: Dell.

Hopkins, K. D. & Stanley, J. C. (1981). *Educational and psychological measurement and evaluation.* Englewood Cliffs, New Jersey: Prentice-Hall.

Ingle, R. B., & Shayer, M. (1971). Conceptual demands in Nuffield 'O' level chemistry. *Education in Chemistry, 8*, 182-183.

Jenkins, W. L. (1955). An improved method for tetrachoric r. *Psychometrika, 20(3)*, 253-258.

Jones, H. J. & Russell, J. M. (1979). Hierarchical learning paradigm. *Journal of Research in Science Teaching, 16(6)*, 489-499.

Kolb, J. R. (1967). Effects of relating mathematics to science instruction on the acquisition of quantitative science behaviors. *Journal of Research in Science Teaching, 5*, 174-182.

Lawson, A. E. & Renner, J. W. (1975). Relationships of science subject matter and developmental levels of learners. *Journal of Research in Science Teaching, 12(4)*, 347-358.

Linke, R. D. (1975). Replicative studies in hierarchical learning of graphical interpretation skills. *British Journal of Educational Psychology, 45*, 39-46.

Merrill, M. D. (1965). Correction and review on successive parts in learning a hierarchical task. *Journal of Educational Psychology, 56*, 225-234.

Nie, N. H., Hull, C. H., Jenkins, J. G., Steinbrenner, K. & Bent, D. H. (1975). *Statistical package for the social sciences.* New York: McGraw-Hill.

Nussbaum, J. (1981). Towards the diagnosis by science teachers of pupils's misconceptions: an exercise with student teachers. *European Journal of Science Education, 3(2)*, 159-169.

O'Connor, P. R., Davis, J. E., Haenisch, E. L., MacNab, K. & McLellan, A. L. (1977). *Chemistry: experiments and principles.* Lexington, Massachusetts: D. C. Heath and Company.

Okey, J. R. & Gagné, R. M. (1970). Revision of a science topic using evidence of performance on subordinate skills. *Journal of Research in Science Teaching, 7*, 321-325.

Orlosky, D. E. & Smith, B. O. (1978). *Curriculum Development: Issues and Insights.* Chicago: Rand McNally Publishing Co.

Page, J. (1980). *A canadian context for science education.* Ottawa: Science Council of Canada.

Phillips, D. C. & Kelley, M. E. (1975). Hierarchical theories of development in education and psychology. *Harvard Educational Review, 45*, 351-375.

Piaget, J. (1964). Cognitive development in children. *Journal of Research in Science Teaching, 2*, 170-186.

Posner, G. J. & Strike, K. A. (1976). A categorization scheme for principles of sequencing content. *Review of Educational Research, 46(4)*, 665-690.

Pottle, J. W. (1982). A study investigating a hierarchical model relating to the concept of conservation of mechanical energy. Unpublished M. Ed. thesis, Memorial University of Newfoundland.

Proctor, C. H. (1970). A probabilistic formulation and statistical analysis for Guttman scaling. *Psychometrica, 35*, 73-78.

Raven, R. J. (1972). The development of the concept of acceleration in elementary school children. *Journal of Research in Science Teaching, 9(3)*, 201-206.

Resnick, L. B. & Wang, M. C. (1969). Approaches to the validation of learning hierarchies , *Education Testing Service* .

Resnick, L. B. (1973). Hierarchies in children's learning: a symposium. *Instructional Science, 2*, 311-362.

Schwab, J. J. (1964). In S. Elam (Ed.), *Education and the structure of knowledge*. Chicago: Rand McNally.

Seddon, G. M. (1974). A comparison of three different measures for predicting achievement in chemistry in the age range 15 to 18 plus. *Research in Education, 12*, 63-70.

Simpson, M. & Arnold, B. (1982). The inappropriate use of subsumers in biology learning. *European Journal of Science Education, 4(2)*, 205-221.

Stake, R. E. (1967). The countenance of educational evaluation. *Teachers College Record, 68(7)*.

Taba, H. (1962). *Curriculum Development; theory and practice*. New York: Harcourt Brace Janovich, Inc.

Tate, M. W. (1955). *Statistics in education*. New York: The Macmillan Company.

Trembath, R. J. & White, R. T. (1979). Mastery achievement of intellectual skills. *Journal of Experimental Education, 47(3)*, 247-252.

Turney, B. & Robb, G. (1971). *Research in education: an introduction*. Hindsdale, Illinois: The Dryden Press Inc.

Tyler, R. W. (1950). *Basic principles of curriculum and instruction*. Chicago: University of Chicago Press.

Uprichard, A. E. (1970). The effect of sequence in the acquisition of three set relations: an experiment with preschoolers. *Arithmetic Teacher, 17(7)*, 597-604.

Walbesser, H. H. & Eisenberg, T. A. (1972). A review of research on behavioral objectives and learning hierarchies.

Walker, H. M. & Lev, J. (1953). *Statistical inference*. New York: Holt, Rhinehart, and Winston.

Whelan, P. J. (1982). A study investigating a hierarchical model relating to stoichiometric calculations. Unpublished M. Ed. thesis, Memorial University of Newfoundland.

White, R. T. (1974a). Indexes used in testing the validity of learning hierarchies. *Journal of Research in Science Teaching, 11(1)*, 61-66.

White, R. T. (1974b). A model for validation of learning hierarchies. *Journal of Research in Science Teaching, 11(1)*, 1-3.

White, R. T. (1974c). The validation of a learning hierarchy. *American Educational Research Journal, 11(2)*, 121-136.

White, R. T. & Clarke, R. C. (1973). A test of inclusion which allows errors of measurement. *Psychometrica, 38*, 77-86.

White, R. T. (1973). Research into learning hierarchies. *Review of Educational Research, 43(3)*, 361-375.

White, R. T. & Gagné, R. M. (1974). Past and future research on learning hierarchies. *Educational Psychologist, 11(1)*, 19-28.

White, R. T. & Gagné, R. M. (1978). Formative evaluation applied to a learning hierarchy. *Contemporary Educational Psychology, 3*, 87-94.

Wiegand, V. K. (1973). A study of subordinate skills in science problem solving. In L. B. Resnick (Ed.), *Instructional Science* Vol. 2: 311-362.

Wood, W. A. (1975). A significance test for ordering theory (Doctoral dissertation, Boston College, 1974). *Dissertation Abstracts International, 35*, 7145A.

# APPENDIX A

## MOLARITY PRETEST

NAME: ______________________

SCHOOL: ______________________

DATE: ______________________

STUDENT INSTRUCTIONS

This is a closed book test. You are asked to answer all of the questions in the space provided on this paper. Please do not use scrap paper.

It is important to show each step you use in arriving at your answer. If you make a mistake, just put a line through it.

Do not spend too long on any one question. If you are having difficulty, leave the question and go on to the next.

Try as many questions as you can.

| Molar Mass | |
|---|---|
| Barium, Ba | 137.3 |
| Bromine, Br | 79.9 |
| Calcium, Ca | 40.2 |
| Chlorine, Cℓ | 35.5 |
| Copper, Cu | 63.5 |
| Fluorine, F | 19.0 |
| Hydrogen, H | 1.0 |
| Iodine, I | 126.9 |
| Iron, Fe | 55.8 |
| Magnesium, Mg | 24.3 |
| Manganese, Mn | 54.9 |
| Nickel, Ni | 58.7 |
| Nitrogen, N | 14.0 |
| Oxygen, O | 16.0 |
| Potassium, K | 39.1 |
| Silver, Ag | 107.9 |
| Sodium, Na | 23.0 |

1. How many moles of ferric chloride, $FeCl_3$ are in 324.6 g of $FeCl_3$?

2. How many moles of silver nitrate, $AgNO_3$, must be dissolved in water to prepare 2.0 L of 0.30 M $AgNO_3$ solution?

3. What is the molarity of chloride ion, $Cl^-$, in a 0.4 M $CaCl_2$ solution?

4. Calculate the molarity of potassium chloride, $KC\ell$, in a 2.0 L solution in which 0.10 moles of $KC\ell$ have been dissolved.

5. How many moles of chloride ion, $C\ell^-$ are present in 2.0 L of 0.50 M $BaC\ell_2$?

6. Calculate the molarity of sodium chloride, $NaC\ell$ when 1.5 L of 0.20 M $NaC\ell$ is diluted to 3.0 L.

7. 23.8 g of potassium bromide, KBr, is dissolved in water to make 2.0 L of solution. What is the molarity of the KBr in the solution?

8. If a 4.0 L solution contains 26.9 g of cupric chloride, $CuCl_2$, what is the molarity of chloride ion, $Cl^-$ in the solution?

9. Zinc chloride, $ZnCl_2$ is dissolved in water. For every $ZnCl_2$ which dissolves, how many chloride ions, $Cl^-$ are present?

10. If 1.5 L of 2M $BaCl_2$, barium chloride solution were diluted to 6.0 L, what would be the molarity of chloride ion, $Cl^-$ in the resulting solution?

11. How many moles of chloride ion, $Cl^-$, are present in a solution which contains 0.10 moles of cupric chloride, $CuCl_2$?

12. What mass of sodium nitrate, $NaNO_3$, must be used to prepare 2.0 L of 0.30 M $NaNO_3$ solution?

13. How many grams of magnesium bromide, $MgBr_2$ are in 0.30 moles of $MgBr_2$?

14. 2.0 L of 0.30 M KI, potassium iodide, is added to 3.0 L of 0.10 M $MgI_2$, magnesium iodide. What is the molarity of the iodide ion, $I^-$, in the resulting solution?

15. Suppose that 11.7 g of sodium chloride, NaCℓ is dissolved in water to make 2.0 L of solution. What is the molarity of the NaCℓ in the solution?

16. How many moles of bromide ion, $Br^-$ are present in 5.0 L of 0.20 M $MgBr_2$?

17. How many grams of barium chloride, $BaCℓ_2$ are in 0.20 moles of $BaCℓ_2$?

18. Determine the number of moles of nickel bromide, $NiBr_2$ in 437.0 g of $NiBr_2$.

19. What mass of potassium permanganate, $KMnO_4$ must be used to prepare 3.0 L of 0.20 M $KMnO_4$ solution?

20. 3.0 L of 0.20M NaCℓ is mixed with 2.0 L of 0.20M $BaCℓ_2$. What is the molarity of $Cℓ^-$, chloride ion, in the resulting solution?

21. Calculate the molarity of potassium bromide, KBr when 2.5 L of 0.20 M KBr is diluted to 5.0 L.

22. If a 4.0 L solution contains 40.0 g of calcium bromide, $CaBr_2$, what is the molarity of bromide ion, $Br^-$ in the solution?

23. Calculate the molarity of bromide ion, $Br^-$ in a 0.3 M $BaBr_2$ solution.

24. If 2.0 L of 0.30 M $MgBr_2$, magnesium bromide, solution were diluted to 8.0 L, what would be the molarity of bromide ion, $Br^-$ in the resulting solution?

25. Calculate the molarity of sodium bromide, NaBr, in a 4.0 L solution in which 0.20 moles of NaBr were dissolved.

26. Cupric iodide, $CuI_2$ is dissolved in water. For every $CuI_2$ which dissolves, how many iodide ions, $I^-$ are present?

27. How many moles of chloride ion, $C\ell^-$ are present in a solution which contains 0.20 moles of barium chloride, $BaC\ell_2$?

28. How many moles of ammonium bromide, $NH_4Br$ must be dissolved in water to prepare 3.0 L of 0.20 M $NH_4Br$ solution?

# APPENDIX B

## MOLARITY POSTTEST

NAME: ____________________

SCHOOL: ____________________

DATE: ____________________

STUDENT INSTRUCTIONS

This is a closed book test. You are asked to answer all of the questions in the space provided on this paper. Please do not use scrap paper.

It is important to show each step you use in arriving at your answer. If you make a mistake, just put a line through it.

Do not spend too long on any one question. If you are having difficulty, leave the question and go on to the next.

Try as many questions as you can.

Molar Mass

| | |
|---|---|
| Barium, Ba | 137.3 |
| Bromine, Br | 79.9 |
| Calcium, Ca | 40.2 |
| Chlorine, Cℓ | 35.5 |
| Copper, Cu | 63.5 |
| Fluorine, F | 19.0 |
| Hydrogen, H | 1.0 |
| Iodine, I | 126.9 |
| Iron, Fe | 55.8 |
| Magnesium, Mg | 24.3 |
| Manganese, Mn | 54.9 |
| Nickel, Ni | 58.7 |
| Nitrogen, N | 14.0 |
| Oxygen, O | 16.0 |
| Potassium, K | 39.1 |
| Silver, Ag | 107.9 |
| Sodium, Na | 23.0 |

1. Calculate the molarity of sodium bromide, NaBr in a 2.0 L solution in which 0.10 moles of NaBr have been dissolved.

2. What is the molarity of iodide ion, $I^-$ in a 0.4 M $MgI_2$ solution?

3. Calculate the molarity of potassium bromide, KBr when 1.5 L of 0.20 M KBr is diluted to 3.0 L.

4. How many moles of chloride ion, $Cl^-$ are present in 4.0 L of 0.30 M $MgCl_2$?

5. What mass of potassium nitrate, $KNO_3$ must be used to prepare 2.0 L of 0.30 M $KNO_3$ solution?

6. How many moles of ammonium bromide, $NH_4Br$ must be dissolved in water to prepare 2.0 L of 0.20 M $NH_4Br$ solution?

7. Ferric chloride, $FeCl_3$ is dissolved in water. For every $FeCl_3$ which dissolves, how many chloride ions, $Cl^-$ are present?

8. If 2.0 L of 0.30 M $BaCl_2$, barium chloride solution were diluted to 6.0 L, what would be the molarity of chloride ion, $Cl^-$ in the resulting solution?

9. 3.0 L of 0.20 M KI, potassium iodide, is added to 2.0 L of 0.10 M $MgI_2$, magnesium iodide. What is the molarity of the iodide ion, $I^-$ in the resulting solution?

10. How many moles of chloride ion, $C\ell^-$ are present in a solution which contains 0.20 moles of nickel chloride, $NiC\ell_2$?

11. If a 4.0 L solution contains 53.8 g of cupric chloride, $CuC\ell_2$ what is the molarity of chloride ion, $C\ell^-$ in the solution?

12. How many moles of zinc chloride, $ZnC\ell_2$ are in 272.8 g of $ZnC\ell_2$?

13. 47.6 g of potassium bromide, KBr is dissolved in water to make 2.0 L of solution. What is the molarity of the KBr in the solution?

14. How many grams of magnesium chloride, $MgC\ell_2$ are in 0.30 moles of $MgC\ell_2$?

15. Determine the number of moles of nickel bromide, $NiBr_2$ in 874.0 g of $NiBr_2$.

16. How many grams of strontium chloride, $SrCl_2$ are in 0.30 moles of $SrCl_2$?

17. 2.0 L of 0.30 M NaCl, sodium chloride is mixed with 3.0 L of 0.20 M $BaCl_2$, barium chloride. What is the molarity of chloride ion, $Cl^-$ in the resulting solution?

18. What mass of potassium permanganate, $KMnO_4$ must be used to prepare 2.0 L of 0.40 M $KMnO_4$ solution?

19. Cupric chloride, $CuCl_2$ is dissolved in water. For every $CuCl_2$ which dissolves, how many chloride ions, $Cl^-$ are present?

20. How many moles of bromide ion, $Br^-$ are present in 3.0 L of 0.40 M $MgBr_2$?

21. Calculate the molarity of chloride ion, $Cl^-$ in a 0.30 M $BaCl_2$ solution.

22. If 2.0 L of 0.30 M $MgCl_2$, magnesium chloride solution were diluted to 8.0 L, what would be the molarity of chloride ion, $Cl^-$ in the resulting solution?

23. How many moles of silver nitrate, $AgNO_3$ must be dissolved in water to prepare 3.0 L of 0.20 M $AgNO_3$ solution?

24. Calculate the molarity of potassium chloride, KCℓ in a 4.0 L solution in which 0.20 moles of KCℓ, were dissolved.

25. If a 4.0 L solution contains 60.0 g of calcium bromide, $CaBr_2$ what is the molarity of bromide ion, $Br^-$ in the solution?

26. Suppose that 23.4 g of sodium chloride, NaCℓ is dissolved in water to make 2.0 L of solution. What is the molarity of the NaCℓ in the solution?

27. Calculate the molarity of sodium chloride, NaCℓ when 2.5 L of 0.20 M NaCℓ is diluted to 5.0 L.

28. How many moles of chloride ion, $Cℓ^-$ are present in a solution which contains 0.30 moles of strontium chloride, $SrCℓ_2$?

APPENDIX C

INSTRUCTIONAL BOOKLET

AUTHOR'S NOTE: The enclosed Instructional Booklet (Appendix C) appears in this thesis in the exact form that the participating students received from the researcher.

# Molarity: Instructional Booklet


Prepared especially for

Name: ________________

School: ________________

# MOLAR MASSES



| NAME | SYMBOL | MOLAR MASS | NAME | SYMBOL | MOLAR MASS |
|---|---|---|---|---|---|
| Actinium | Ac | (227) | Mercury | Hg | 200.6 |
| Aluminum | Al | 27.0 | Molybdenum | Mo | 95.9 |
| Americium | Am | (243) | Neodymium | Nd | 144.2 |
| Antimony | Sb | 121.8 | Neon | Ne | 20.2 |
| Argon | Ar | 39.9 | Neptunium | Np | (237) |
| Arsenic | As | 74.9 | Nickel | Ni | 58.7 |
| Astatine | At | (210) | Niobium | Nb | 92.9 |
| Barium | Ba | 137.3 | Nitrogen | N | 14.01 |
| Berkelium | Bk | (247) | Nobelium | No | (255) |
| Beryllium | Be | 9.01 | Osmium | Os | 190.2 |
| Bismuth | Bi | 209.0 | Oxygen | O | 16.00 |
| Boron | B | 10.8 | Palladium | Pd | 106.4 |
| Bromine | Br | 79.9 | Phosphorus | P | 31.0 |
| Cadmium | Cd | 112.4 | Platinum | Pt | 195.1 |
| Calcium | Ca | 40.1 | Plutonium | Pu | (244) |
| Californium | Cf | (251) | Polonium | Po | 210 |
| Carbon | C | 12.01 | Potassium | K | 39.1 |
| Cerium | Ce | 140.1 | Praseodymium | Pr | 140.9 |
| Cesium | Cs | 132.9 | Promethium | Pm | (145) |
| Chlorine | Cl | 35.5 | Protactinium | Pa | (231) |
| Chromium | Cr | 52.0 | Radium | Ra | (226) |
| Cobalt | Co | 58.9 | Radon | Rn | (222) |
| Copper | Cu | 63.5 | Rhenium | Re | 186.2 |
| Curium | Cm | (247) | Rhodium | Rh | 102.9 |
| Dysprosium | Dy | 162.5 | Rubidium | Rb | 85.5 |
| Einsteinium | Es | (254) | Ruthenium | Ru | 101.1 |
| Erbium | Er | 167.3 | Samarium | Sm | 150.4 |
| Europium | Eu | 152.0 | Scandium | Sc | 45.0 |
| Fermium | Fm | (257) | Selenium | Se | 79.0 |
| Fluorine | F | 19.0 | Silicon | Si | 28.1 |
| Francium | Fr | (223) | Silver | Ag | 107.9 |
| Gadolinium | Gd | 157.2 | Sodium | Na | 23.0 |
| Gallium | Ga | 69.7 | Strontium | Sr | 87.6 |
| Germanium | Ge | 72.6 | Sulfur | S | 32.1 |
| Gold | Au | 197.0 | Tantalum | Ta | 180.9 |
| Hafnium | Hf | 178.5 | Technetium | Tc | (97) |
| Helium | He | 4.00 | Tellurium | Te | 127.6 |
| Holmium | Ho | 164.9 | Terbium | Tb | 158.9 |
| Hydrogen | H | 1.008 | Thallium | Tl | 204.4 |
| Indium | In | 114.8 | Thorium | Th | 232.0 |
| Iodine | I | 126.9 | Thulium | Tm | 168.9 |
| Iridium | Ir | 192.2 | Tin | Sn | 118.7 |
| Iron | Fe | 55.8 | Titanium | Ti | 47.9 |
| Krypton | Kr | 83.8 | Tungsten | W | 183.9 |
| Lanthanum | La | 138.9 | Uranium | U | 238.0 |
| Lawrencium | Lr | (260) | Vanadium | V | 50.9 |
| Lead | Pb | 207.2 | Xenon | Xe | 131.3 |
| Lithium | Li | 6.94 | Ytterbium | Yb | 173.0 |
| Lutetium | Lu | 175.0 | Yttrium | Y | 88.9 |
| Magnesium | Mg | 24.3 | Zinc | Zn | 65.4 |
| Manganese | Mn | 54.9 | Zirconium | Zr | 91.2 |
| Mendelevium | Md | (258) | (unnamed)* | ? | (261) |

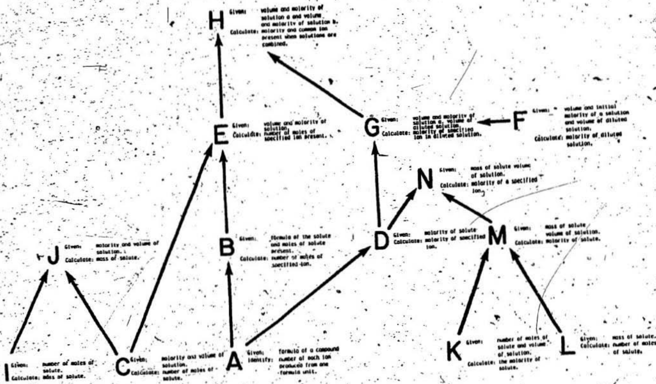
As you continue in Chemistry you will soon see that MOLARITY is a concept that comes up again and again. Therefore, it is very important that any difficulties be overcome now.

The test that you wrote recently showed that you are having difficulty with some items. The Flow Chart on the next page shows how the skills are related to each other. We believe that working through this booklet as directed will help you clear up any difficulties by showing you where you went wrong and providing extra practice.

You need do ONLY THE SKILLS INDICATED on Page 3.

OFF WE GO!!!

# FLOW CHART OF SKILLS



These directions are prepared especially for you. Work through the items in the order given. Follow through the examples carefully. The first example takes you step by step. In the following examples, work through the question by following the model of example 1. Don't skip any! Check yourself by answering the PROBLEM given. When you are quite satisfied that you have mastered the skill place a ✓ beside that skill and proceed to the next.

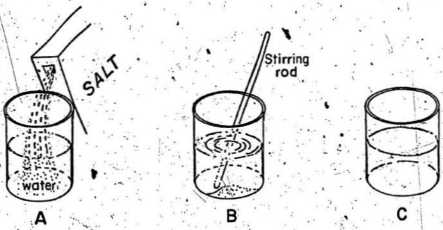
1. Read Introduction on page 4.
2.

| ORDER | SKILL | PAGE | CHECK | ORDER | SKILL | PAGE | CHECK |
|---|---|---|---|---|---|---|---|
| | Intro. | 4 | | | H | 31 | |
| | A | 6 | | | I | 35 | |
| | B | 10 | | | J | 38 | |
| | C | 13 | | | K | 41 | |
| | D | 16 | | | L | 43 | |
| | E | 19 | | | M | 46 | |
| | F | 24 | | | N | 49 | |
| | G | 27 | | | | | |

You can see how the skills are related on the opposite page.
You will find a table of molar masses on the inside cover.

## Introduction

The process whereby a solid substance is distributed throughout a liquid is called dissolving and the resulting mixture a solution.




1. Usually, the solid is called the solute.
   What is the solute in the above diagram? Answer: ____________
2. The liquid is usually called the solvent.
   What is the solvent here? Answer: ____________
3. Which diagram above shows that the solute (salt) has dissolved in the water (solvent)? Answer: ____________

4. You were quite correct in rocognizing that diagram C showed that the salt had indeed dissolved in the water. The resulting mixture is called a <u>solution</u>. (You probably recognized that $NaC\ell$ is the formula for common table salt and that its chemical name is sodium chlordie.)

5. When $NaC\ell$ is dissolved in water, the resulting solution contains ions: sodium ions, $Na^+$ and chloride ions, $C\ell^-$. This can be represented as:

$$NaC\ell \longrightarrow Na^+ + C\ell^-$$

We say that the substance has <u>dissociated</u>. The ions that are present in the solid crystal structure have become separated from each other. Such substances are called electrolytes because in water they conduct electricity.

<u>CAUTION</u>: Not all solids that dissolve in water form ions. e.g. sugar dissolves in water but it does <u>not</u> conduct electricity. Solutions like this that do not conduct electricity are called non-electrolytes.

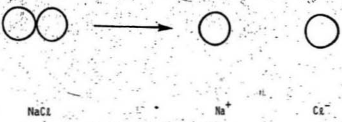
<u>N.B.</u> In working through this booklet you may assume that all the substances that have been selected as solutes <u>will</u> form ions in solution.

6. The relationship between the amount of solute and the volume of the solution is referred to as the <u>concentration</u> of the solution.

<u>Molarity</u> is one way of expressing the concentration of a solution.


| | |
|---|---|
| *GIVEN:* | *formula of a compound* |
| *IDENTIFY:* | *number of each ion produced from one formula unit* |

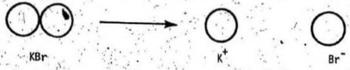
When one formula unit of sodium chloride, NaCℓ is dissolved in water, the resulting solution contains ions: sodium ions, $Na^+$ and chloride ions, $C\ell^-$. We might show this by a diagram:



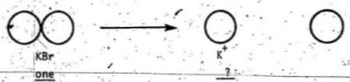

[N.B. The diagram is used to show the dissociation of NaCℓ into its ions. We are interested in the relative <u>numbers</u> and not the relative <u>sizes</u>. The diagram is not drawn to scale.]

**EXAMPLE 1:** If one formula unit of potassium bromide, KBr is dissolved, how many potassium ions, $K^+$ are present?

STEP 1: What are you looking for? A good way to begin is to draw a diagram to show what is given and what is required. From the formula you can see that each KBr will give one $K^+$ ion and one $Br^-$ ion. The diagram for this is:




Next fill in on the diagram the amounts given in the problem. You are told you have one formula unit of KBr. Put a question by what is required. You want to know <u>how many</u> $K^+$ ions.




STEP 2: Work out the answer. In this case you already have it! The answer is <u>one</u> $K^+$ ion because <u>one</u> KBr gives <u>one</u> $K^+$ ion and <u>one</u> $Br^-$.

Answer: <u>1 $K^+$</u>

EXAMPLE 2: For every formula unit of silver nitrate, $AgNO_3$ which dissolves, how many nitrate ions, $NO_3^-$ would be present?

STEP 1: Draw the diagram to show what you want to know and what you are given.

Notice that the word "every" in this particular examples means "one".

STEP 2: Work out the answer. Here again you have it. It is one $NO_3^-$.

Answer: $1\ NO_3^-$

EXAMPLE 3: If one formula unit of potassium dichromate, $K_2Cr_2O_7$, how many potassium ions, $K^+$ are there?

STEP 1:

STEP 2:

Answer: $2\ K^+$

✓ CHECK YOURSELF.

PROBLEM A1: If one formula unit of nickel hydroxide, $Ni(OH)_2$ is dissolved, how many hydroxide ions, $OH^-$ are present?

STEP 1: Draw the diagram.

STEP 2: Give the answer.

Answer: ________

See Page 53

PROBLEM A2: How many iodide ions, $I^-$ are present in one formula unit of lead iodide, $PbI_2$?

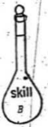
Answer: ________

See Page 53

PROBLEM A3: How many silver ions, $Ag^+$ are present in one formula unit of silver chloride, $AgC\ell$?

Answer: ________

See Page 53




*GIVEN:* *formula of the solute and moles of solute present*

*CALCULATE:* *number of moles of specified ion*

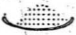
You are already aware that the unit which chemists use to talk about <u>amount</u> of substance is the <u>mole</u>. From the formula you know that one mole of sodium chloride, $NaC\ell$ will give one <u>mole</u> of sodium ion $Na^+$ and one <u>mole</u> of chloride ion $C\ell^-$.

1 mole $NaC\ell$

1 mole $Na^{+1}$
1 mole $C\ell^-$

Similarly, the formula for calcium bromide, $CaBr_2$ tells you that one mole of $CaBr_2$ will give one mole of $Ca^{2+}$ ion and two moles of $Br^-$ ion.

1 mole $CaBr_2$



1 mole $Ca^{2+}$
2 moles $Br^-$

EXAMPLE 1: 3.0 moles of sodium chloride, NaCℓ are dissolved in water to make a solution. How many moles of sodium ion, $Na^+$ are there?

STEP 1: What are you looking for? You want to know moles of $Na^+$. To find this you must know the number of moles of NaCℓ because that is where the ions are coming from. Write down an expression which shows what one mole of NaCℓ gives:

1 mole NaCℓ ⟶ 1 mole of $Na^+$

STEP 2: Work out the answer. One mole of NaCℓ gives 1 mole of $Na^+$ ion.
∴ 3 moles of NaCℓ gives 3 x 1 = 3 moles $Na^+$ ion.

Answer: 3 moles $Na^+$

EXAMPLE 2: Suppose that 2 moles of magnesium bromide, $MgBr_2$ are dissolved in water. How many moles of bromide ion, $Br^-$ are present?

STEP 1: What you want to know? You want to know moles of $Br^-$. Where is the $Br^-$ coming from? From $MgBr_2$. Write down an expression to show what one mole of $MgBr_2$ gives.

STEP 2: Work out the answer.

Answer: 4 moles $Br^-$

Now you try one. Use the previous example as a model and work out the answer step by step. Don't skip any!

EXAMPLE 3: How many moles of silver ions, $Ag^+$ are present in 2.5 moles of silver chromate, $Ag_2CrO_4$?

STEP 1:

STEP 2:

Answer: 5.0 moles $Ag^+$

✓ CHECK YOURSELF.

PROBLEM B1: Suppose that 2 moles of strontium chloride, $SrC\ell_2$ are dissolved in water to make 10 L of solution. How many moles of chloride ions, $C\ell^-$ would be present?

STEP 1:

STEP 2:

Answer: ______

See Page 53


*GIVEN:* *molarity and volume of solution*

*CALCULATE:* *number of moles of solute*

<u>EXAMPLE 1</u>: How many moles of sodium carbonate, $Na_2CO_3$ are present in 7.5 L of 2.0 M $Na_2CO_3$ solution?

STEP 1: What do you want to know? To help you think about this, draw a diagram showing what you are given and what you are required to find.

GIVEN REQUIRED

2.0 M $Na_2CO_3$ in 7.5 L

? moles $Na_2CO_3$ in 7.5 L

STEP 2: You want to convert (M) molarity to moles. How do you do this? Write down the relationship to express molarity.

$$\text{molarity} = \frac{\text{moles}}{\text{liters}}$$

STEP 3: Rearrange the relationship so that the unknown quantity is on the left hand side.

$$\text{moles} = \text{molarity} \times \text{liters}$$

STEP 4: Substitute the given values and calculate your answer.

$$\text{moles} = 2.0 \times 7.5$$
$$= 15$$

Answer: <u>15 moles $Na_2CO_3$</u>

EXAMPLE 2: A solution of 2.0 M $Ca(NO_3)_2$ calcium nitrate, has a volume of 6.0 L. How many moles of $Ca(NO_3)_2$ does the solution contain?

You try this one.

STEP 1: Draw a diagram showing what you are given and what you want to find.

STEP 2: Write the relationship to express molarity.

STEP 3: Rearrange the relationship so that the unknown quantity is on the left hand side.

STEP 4: Substitute the given values and calculate your answer.

Answer: 12 moles $Ca(NO_3)_2$

CHECK YOURSELF.

**PROBLEM C1:** How many moles of lithium bromide, LiBr are present in 0.50 L of 2.5 M LiBr.

STEP 1:

STEP 2:

STEP 3:

STEP 4:

Answer: ____________

See Page 53


*GIVEN:* *molarity of solute*

*CALCULATE:* *molarity of specified ion*

EXAMPLE 1: What is the molarity of bromide ion, $Br^-$ in a solution of 2 M $SrBr_2$, strontium bromide?

STEP 1: What do you want to know? To help you think about this, draw a diagram to show what you are given and what you are required to find.


STEP 2: What is the relationship between the molarity of $SrBr_2$ and the molarity of $Br^-$?

From the formula you can see that

one $SrBr_2$ $\longrightarrow$ two $Br^-$

$\therefore$ one mole $SrBr_2$ $\longrightarrow$ two moles $Br^-$

$\therefore$ 1 mole/L $SrBr_2$ $\longrightarrow$ 2 moles/L $Br^-$

or 1 M $SrBr_2$ $\longrightarrow$ 2 M $Br^-$

STEP 3: Use the relationship to calculate your answer,

1 M $SrBr_2$ $\longrightarrow$ 2 M $Br^-$

$\therefore$ 2 M $SrBr_2$ $\longrightarrow$ $2 \times 2 = 4$ M $Br^-$

Answer: 4 M $Br^-$

EXAMPLE 2: Calculate the molarity of the nitrate ion, $NO_3^-$ in 5 L of 3 M $Ca(NO_3)_2$, calcium nitrate solution.

STEP 1: Draw a diagram to show what you are given and what you are required to find:

STEP 2: What is the relationship between molarity of $Ca(NO_3)_2$ and $NO_3^-$?

STEP 3: Use the relationship to calculate your answer.

[N.B. You did not need to know the volume of the solution in this case.]

Answer: 6 M $NO_3^-$

CHECK YOURSELF.

PROBLEM D1: Suppose you have 6.0 L of 0.1 M NaF, sodium fluoride solution. What is the molarity of the fluoride ion, $F^-$?

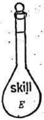
Answer: ________

See Page 53

PROBLEM D2: What is the molarity of potassium ion, $K^+$ in 3 L of solution which is 3 M $K_2SO_4$, potassium sulfate?

Answer: ________

See Page 53




| | |
|---|---|
| *GIVEN:* | *volume and molarity of solution* |
| *CALCULATE:* | *number of moles of specified ion present* |

**EXAMPLE 1:** How many moles of sodium ion, $Na^+$ are present in 3.0 L of 2 M $Na_2SO_4$, sodium sulfate solution?

STEP 1: What do you want to know? To help you think about this, draw a diagram to show what you are given and what you are required to find:

GIVEN | REQUIRED

2 M $Na_2SO_4$ in 3 L | ? moles $Na^+$ in 3 L

STEP 2: You can see from the diagram that you have to convert from molarity to number of moles. Write down the relationship to express molarity.

$$\text{molarity} = \frac{\text{moles}}{\text{liters}}$$

STEP 3: Rearrange the relationship so that the unknown quantity is on the left hand side.

$$\text{moles} = \text{molarity} \times \text{liters}$$

STEP 4: Substitute the given values and calculate the number of moles of $Na_2SO_4$.

$$\begin{aligned}\text{moles} &= \text{molarity} \times \text{liters}\\ &= 2 \times 3\\ &= 6 \text{ moles}\end{aligned}$$

STEP 5: What is the relationship between moles of $Na_2SO_4$ and moles of $Na^+$? From the formula you can see that

$$1 \text{ mole } Na_2SO_4 \longrightarrow 2 \text{ moles } Na^+$$

STEP 6: Use the relationship to calculate your answer.

$$6 \text{ moles } Na_2SO_4 = 6 \times 2 = 12 \text{ moles } Na^+$$

Answer: <u>12 moles $Na^+$</u>

Now you try one. Use the previous example as a model and work out the answer step by step. Don't skip any!

EXAMPLE 2: A solution of cupric chloride, $CuCl_2$ has a molarity of 3.0 M. The volume is 6.0 L. How many moles of chloride ion, $Cl^-$ are there?

STEP 1: Draw a diagram to show what you are given and what you are required to find:

STEP 2:

STEP 3:

STEP 4:

STEP 5:

STEP 6:

Answer: 36 moles $Cl^-$ ions

✓ CHECK YOURSELF.

PROBLEM E1: 4.0 L of 0.2 M NaI solution, sodium iodide contains how many moles of iodide ion, $I^-$?

Answer: ______________

See Page 53

PROBLEM E2: How many moles of chloride ion, $C\ell^-$ ion are present in a solution of 3 M $PbC\ell_2$, lead chloride. The volume is 7.0 L.

Answer: ___________

See Page 53


| | |
|---|---|
| *GIVEN:* | *volume and initial molarity of solution and volume of diluted solution* |
| *CALCULATE:* | *molarity of diluted solution* |



The molarity of a solution can be changed by adding more solvent to it. This process is called <u>dilution</u>. As the solution becomes more dilute, the molarity decreases.

<u>EXAMPLE 1:</u> What is the molarity of sodium chloride NaCℓ, when 6 L of 3 M NaCℓ is diluted with water to a volume of 10 L?

STEP 1: To help you think about what you want to find, draw a diagram to show what you are given and what is required.

GIVEN | REQUIRED

3 M NaCℓ in 6 L | ? M NaCℓ in 10 L

To make the dilute solution, water was added. Therefore, the number of moles of NaCℓ is the same in the "old" and "new" solution.

STEP 2: To relate the "old" molarity to the "new" molarity you need to calculate the number of <u>moles</u> of NaCℓ present. How are moles and molarity related? The relationship is given by:

$$\text{molarity} = \frac{\text{moles}}{\text{liters}}$$

STEP 3: Rearrange the relationship so that the unknown quantity is on the left hand side.

$$\text{moles} = \text{molarity} \times \text{liters}$$

STEP 4: Substitute the given values and calculate the number of moles of NaC;

$$\text{moles} = \text{molarity} \times \text{liters}$$
$$= 3 \times 6$$
$$= 18 \text{ moles NaC}\ell$$

STEP 5: What are you looking for? __?__ M NaCℓ in the "new" (dilute) solution. Write down the relationship for molarity

$$\text{molarity} = \frac{\text{moles}}{\text{liters}}$$

STEP 6: Substitute the given values and calculate your answer.

$$\text{molarity} = \frac{\text{moles}}{\text{liters}}$$

$$= \frac{18}{10}$$

$$= 1.8$$

Answer: __1.8 M NaCℓ__

__EXAMPLE 2:__ Water is added to 4 L of 3 M KCℓ, potassium chloride to give 6 L of diluted solution. What is the molarity of KCℓ in the diluted solution?

STEP 1: Draw a diagram to show what you are given and what is required.

STEP 2:

STEP 3:

STEP 4:

STEP 5:

STEP 6:

Answer: __2 M KCℓ__

CHECK YOURSELF

PROBLEM F1: Water is added to 3.5 L of 2 M $H_2SO_4$, sulfuric acid to make 5.0 L of dilute solution. What is the molarity of the $H_2SO_4$ in the dilute solution?

Answer: ________

See Page 53


| | |
|---|---|
| *GIVEN:* | *volume and molarity of solution A*<br>*volume of diluted solution* |
| *CALCULATE:* | *molarity of specified ion in diluted solution* |

The molarity of a solution can be changed by adding more solvent to it. This process is called <u>dilution</u>. As the solution becomes more dilute, the molarity decreases.

<u>EXAMPLE 1:</u> What is the molarity of the potassium ion, $K^+$ in a solution of potassium chromate, $K_2CrO_4$, where water is added to 3 L of 0.4 M $K_2CrO_4$ make 7 L of dilute solution?

STEP 1: What do you want to know? To help you think about this, draw a diagram to show what you are given and what is required.

GIVEN REQUIRED

0.4 M $K_2CrO_4$ in 3 L     <u>?</u> M $K^+$ in 7 L

STEP 2: <u>Because the volume is changed the molarity of the $K_2CrO_4$ changes, but not the number of moles.</u> The water which was added did not change the number of moles present since it contained no $K_2CrO_4$. Determine the moles of $K_2CrO_4$ present. Write down the relationship for molarity.

$$\text{molarity} = \frac{\text{moles}}{\text{liters}}$$

STEP 3: Rearrange the relationship so that the unknown quantity is on the left hand side.

$$\text{molarity} = \frac{\text{moles}}{\text{liters}}$$

STEP 4: Substitute the given values and calculate the answer.

moles of $K_2CrO_4$ in original solution = molarity x liters

= 0.4 x 3 = 1.2

∴ moles of $K_2CrO_4$ in diluted solution = 1.2

STEP 5: Now calculate the molarity of $K_2CrO_4$ in the dilute solution.

$$\text{molarity} = \frac{\text{moles}}{\text{liters}}$$

$$= \frac{1.2}{7}$$

$$= 0.17\ M$$

STEP 6: You're almost there! Look back at the diagram.

What are you looking for? The molarity of $K^+$. To convert 0.17 M $K_2CrO_4$ (the "new" molarity) to ? M $K^+$ you need to recall the following:

The formula $K_2CrO_4$ tells you that

one $K_2CrO_4$ ⟶ 2 $K^+$

one mole $K_2CrO_4$ ⟶ 2 moles $K^+$

one mole/L $K_2CrO_4$ ⟶ 2 moles/L $K^+$

or 1 M $K_2CrO_4$ ⟶ 2 M $K^+$

STEP 7: Use the relationship to calculate your answer.

M of $K^+$ = 2 x M of $K_2CrO_4$ (step 4)

= 2 x .17

= 0.34

Answer: <u>0.34 M $K^+$</u>

Now you try one. Use the previous example as a model and work out the answer step by step. Don't skip any!

EXAMPLE 2: Suppose that 4.0 L of 0.2 M $AgNO_3$, silver nitrate is diluted with water to make 5.0 L of solution. What is the molarity of the silver ion, $Ag^+$ in the dilute solution?

STEP 1: Draw a diagram to show what you are given and what is required.

STEP 2:

STEP 3:

STEP 4:

STEP 5:

STEP 6:

STEP 7:

Answer: .16 M $Ag^+$

CHECK YOURSELF.

PROBLEM G): A solution of sodium phosphate, $Na_3PO_4$ is prepared by diluting 3.5 L of .30 M $Na_3PO_4$ to a volume of 5.0 L. Calculate the molarity of the sodium ion, $Na^+$.

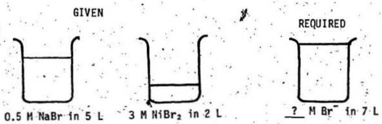
Answer: ____________

See Page 53


| | |
|---|---|
| *GIVEN:* | *volume and molarity of solution A and volume and molarity of solution B* |
| *CALCULATE:* | *molarity of common ion present when solutions are combined* |

EXAMPLE 1: Suppose that 2 L of 3 M $NiBr_2$, nickel bromide is added to 5L of 0.5M NaBr, sodium bromide, what is the molarity of the bromide ion, $Br^-$ in the resulting solution?

STEP 1: What do you want to know? To help you think about this, draw a diagram to show what you are given and what is reouired.




STEP 2: Since you want to know the molarity of $Br^-$ in the resulting solution a good route to go is to determine the total number of moles of $Br^-$ ion present from each solution. How many moles of $Br^-$ ion does $NiBr_2$ provide? Write down the relationship for molarity.

$$\text{molarity} = \frac{\text{moles}}{\text{liters}}$$

Rearrange the relationship so that the unknown quantity is on the left hand side.

$$\text{moles} = \text{molarity} \times \text{liters}$$

STEP 3: What is the relationship between moles of $NiBr_2$ and moles of $Br^-$? From the formula you can see that

one $NiBr_2$ ⟶ 2 $Br^-$

one mole $NiBr_2$ ⟶ two moles $Br^-$

∴ 6 moles of $NiBr_2$ (step 2) gives 6 x 2 = 12 moles $Br^-$.

STEP 4: How many moles of $Br^-$ does the NaBr solution provide? Write down the relationship for molarity.

$$\text{molarity} = \frac{\text{moles}}{\text{liters}}$$

Rearrange the relationship so that the unknown quantity is on the left hand side.

$$\text{moles} = \text{molarity} \times \text{liters}$$

Substitute the given values and calculate number of moles of NaBr.

$$\text{moles of NaBr} = \text{molarity} \times \text{liters}$$
$$= 0.5 \times 5$$
$$= 2.5$$

STEP 5: What is the relationship between moles of NaBr and moles of $Br^-$.

From the formula you can see that

one NaBr ⟶ one $Br^-$

one mole NaBr ⟶ one mole $Br^-$

∴ 2.5 moles NaBr (step 5) give 2.5 moles $Br^-$.

STEP 6: Determine the total $Br^-$ in the final solution. 12 moles $Br^-$ from $NiBr_2$ added to 2.5 moles $Br^-$ from NaBr.

$$\text{Total } Br^- = 12 + 2.5$$
$$= 14.5$$

STEP 7: To calculate the molarity of $Br^-$ in the final solution, write down the relationship for molarity.

$$\text{molarity} = \frac{\text{moles}}{\text{liters}}$$

Substitute the values and calculate your answer. The total number of liters is

$$2\text{ L} + 5\text{ L} = 7\text{ L}$$

$$\text{molarity} = \frac{14.5}{7}$$
$$= 2.2$$

Answer: 2.2 M $Br^-$

Now you try one. Use the previous example as a model and work out the answer step by step. Don't skip any!

EXAMPLE 2: What is the molarity of hydroxide ion, $OH^-$ in the resulting solution when 2.0 L of 0.3 M NaOH, sodium hydroxide is mixed with 5.0 L of 0.1 M $Ba(OH)_2$, barium hydroxide?

STEP 1: Draw a diagram to show what you are given and what is required.

STEP 2:

STEP 3:

STEP 4:

STEP 5:

STEP 6:

STEP 7:

Answer: .23 M $OH^-$

CHECK YOURSELF.

PROBLEM H1: Suppose that 5.0 L of 2 M NaCℓ, sodium chloride is mixed with 3.0 L of 1.5 M $SrCℓ_2$, strontium chloride. What is the molarity of chloride ion, $Cℓ^-$ in the resulting solution?

Answer: ________

See Page 53


*GIVEN:* *number of moles of solute*

*CALCULATE:* *mass of solute*

EXAMPLE 1: How many grams of potassium iodide, KI are present in 2.0 moles of KI?

STEP 1: Make a diagram to show what you are given and what you are required to find.


STEP 2: Write down the relationship between grams and moles.

$$\text{molarity} = \frac{\text{mass (g)}}{\text{molar mass}}$$

STEP 3: Rearrange the relationship so that the unknown quantity mass, g is on the left hand side.

$$\text{mass} = \text{moles} \times \text{molar mass}$$

STEP 4: Check to see if you know all the values you need. You have the moles. It is 2.0 moles. You need to determine the molar mass. The molar mass table is located on the inside cover of the booklet.

$$\text{molar mass of KI} = 39.1 + 126.9$$
$$= 166.0$$

STEP 5: Now you can calculate your answer.

$$\text{mass} = \text{moles} \times \text{molar mass}$$
$$= 2.0 \times 166.0$$
$$= 332 \text{ g}$$

Answer: 332 g KI

Now you try one. Use the previous example as a model and work out the answer step by step. Don't skip any!

<u>EXAMPLE 2:</u> Suppose you required 0.30 moles of iron(III) bromide, $FeBr_3$ to prepare a 0.4 M $FeBr_3$ solution. How many grams would you have to weigh out?

STEP 1: Make a diagram to show what you are given and what you are required to find.

STEP 2:

STEP 3:

STEP 4:

STEP 5:

Answer: <u>89 g $FeBr_3$</u>

[Did you notice that you did not need to use the molarity of $FeBr_3$?]

✓ CHECK YOURSELF.

PROBLEM I1: How many grams of sodium carbonate, $Na_2CO_3$ are present in 0.25 moles of $Na_2CO_3$?

Answer: ________

See Page 53

PROBLEM I2: If you wished to prepare 6.0 L of copper(II) sulfate, $CuSO_4$ and required 0.3 moles of $CuSO_4$. How many grams of $CuSO_4$ would you have to weigh out?

Answer: ________

See Page 53


*GIVEN:* *molarity and volume of solution*

*CALCULATE:* *mass of solute*

EXAMPLE 1: How many grams of cupric chloride, $CuC\ell_2$ must be dissolved to make 6.0 L of 0.20 M $CuC\ell_2$ solution?

STEP 1: Draw a diagram to show what is given and what is required.

GIVEN

0.20 M $CuC\ell_2$
6.0 L

REQUIRED

? g $CuC\ell_2$

STEP 2: There is not a direct link between molarity and mass. To calculate the mass of $CuC\ell_2$, first you need to determine the number of moles. Write down the relationship for molarity.

$$\text{molarity} = \frac{\text{moles}}{\text{liters}}$$

Rearrange the relationship so that the unknown quantity, moles is on the left hand side and calculate the answer.

$$\text{moles} = \text{molarity} \times \text{liters}$$
$$= 0.20 \times 6$$
$$= 1.2 \text{ moles } CuC\ell_2$$

STEP 3: To convert from moles to grams, the relationship needed is:

$$\text{moles} = \frac{\text{mass (g)}}{\text{molar mass}}$$

Rearrange the relationship so that the unknown quantity mass (g) is on the left hand side.

$$\text{mass} = \text{moles} \times \text{molar mass}$$

To calculate your answer you need to work out the molar mass of $CuCl_2$

The molar mass table is located on the inside cover of this booklet.

$$\text{molar mass of } CuCl_2 = 63.5 + 2(35.5)$$
$$= 134.5$$

STEP 4: Make the final calculation.

$$\text{mass} = \text{moles} \times \text{molar mass}$$
$$= 1.2 \times 134.5$$
$$= 161.4 \text{ g}$$

Now you try one. Use the previous example as a model and work out the answer step by step. Don't skip any!

EXAMPLE 2: A student has prepared 5.0 L of 0.3 M NaCl, sodium chloride solution. How much of the solute, NaCl would he have to weigh out?

STEP 1: Draw a diagram to show what is given and what is required.

STEP 2:

STEP 3:

STEP 4:

Answer: 87.8 g NaCl

√ CHECK YOURSELF.

PROBLEM 11: How many grams of barium bromide, $BaBr_2$ are present in 3.0 L of 0.2 M $BaBr_2$?

Answer: ________

See Page 53


*GIVEN:* *number of moles of solute and volume of solution*

*CALCULATE:* *molarity of solute*

The relationship between the amount of solute and the volume of solution is referred to as the <u>concentration</u>. When the amount of solute is expressed in <u>moles</u> and the volume is expressed in liters this relationship is called MOLARITY and sometimes shortened to M.

$$\text{molarity} = \frac{\text{moles}}{\text{liters}}$$

<u>EXAMPLE 1</u>: 3.5 moles of sodium chloride, NaCℓ, is dissolved in water to give 7.0 L of solution. What is the molarity of the NaCℓ?

STEP 1: What do you want to know? To help you to think about this, draw a diagram showing what you are given and what you are required to find.

GIVEN REQUIRED

3.5 moles NaCℓ in 7.0 L — <u>?</u> M NaCℓ

STEP 2: Write a relationship for molarity.

$$\text{molarity} = \frac{\text{moles}}{\text{liters}}$$

STEP 3: Substitute the values and calculate the answer.

$$\text{molarity} = \frac{\text{moles}}{\text{liters}}$$

$$= \frac{3.5}{7}$$

$$= 0.5$$

Answer: <u>0.5 M NaCℓ</u>

Now you try one. Use the previous example as a model and work out the answer step by step. Don't skip any!

EXAMPLE 2: A solution of lead nitrate, $Pb(NO_3)_2$ was prepared by dissolving 0.20 moles of $Pb(NO_3)_2$ in water to give 5.0 L of solution. Calculate the molarity of the $Pb(NO_3)_2$.

STEP 1: Draw a diagram showing what you are given and what you are required to find.

STEP 2:

STEP 3:

Answer: .040 M $Pb(NO_3)_2$

CHECK YOURSELF

PROBLEM K1: Suppose that 0.50 moles of sodium hydroxide, NaOH is present in 10.0 L of solution. What is the molarity of the NaOH?

Answer: ______

See Page 53


*GIVEN:* *mass of solute*

*CALCULATE:* *number of moles of solute*

EXAMPLE 1: How many moles of sodium chloride, NaCℓ are present in 90.0 g of NaCℓ?

STEP 1: Make a diagram to show what you are given and what you are required to find.

GIVEN

90.0 g NaCℓ

REQUIRED

? moles NaCℓ

STEP 2: Write down the relationship between grams and moles.

$$\text{moles} = \frac{\text{mass (g)}}{\text{molar mass}}$$

STEP 3: Do you have all the values to substitute? You have the mass. It is 90.0 g. You need to determine the molar mass. Look up molar mass values on the inside cover of this booklet.

$$\text{molar mass of NaC}\ell = 23.0 + 35.5$$
$$= 58.5$$

STEP 4: Now you can calculate your answer.

$$\text{moles} = \frac{\text{mass}}{\text{molar mass}}$$
$$= \frac{90.0}{58.5}$$
$$= 1.53$$

Answer: 1.53 moles NaCℓ

Now you try one. Use the previous example as a model and work out the answer step by step. Don't skip any!

EXAMPLE 2: Suppose you weighed out 296 g of iron(III) bromide, $FeBr_3$ to prepare a 3 M solution. How many moles of $FeC\ell_3$ would you have?

STEP 1: Make a diagram to show what you are given and what you are required to find.

STEP 2:

STEP 3:

STEP 4:

Answer: 1.00 moles $FeBr_3$

[N.B. You did not need to use the molarity.]

CHECK YOURSELF.

PROBLEM L1: How many moles of sodium phosphate, $Na_3PO_4$ are present in 16.4 g of $Na_3PO_4$?

Answer: ____________

See Page 53

PROBLEM L2: If you wished to prepare 5.0 L of cupric sulfate, $CuSO_4$, and were instructed to weigh out 15.96 g of $CuSO_4$, how many moles of $CuSO_4$ would you have?

Answer: ____________

See Page 53


*GIVEN:* *mass of solute and volume of solution*

*CALCULATE:* *molarity of solute*

EXAMPLE 1: If 5.00 L of a solution of silver nitrate, $AgNO_3$ contains 17.0 grams of $AgNO_3$, what is the molarity of the solution with respect to $AgNO_3$?

STEP 1: What do you want to know? To help you think about this, draw a diagram to show what you are given and what you are required to find.

GIVEN | REQUIRED

17.0 g $AgNO_3$ in 5.00 L | ? M $AgNO_3$

STEP 2: You want to find the molarity of $AgNO_3$. Write the relationship for molarity.

$$\text{molarity} = \frac{\text{moles}}{\text{liters}}$$

You can see that you need to find the moles of $AgNO_3$. How can you find this? Look at the diagram. You have 17.0 g of $AgNO_3$. Write the relationship for grams to moles.

$$\text{moles} = \frac{\text{mass (g)}}{\text{molar mass}}$$

Determine the molar mass of $AgNO_3$. A molar mass table is on the inside cover of this booklet.

$$\text{molar mass of } AgNO_3 = 107.8 + 14.0 + 3(16.0)$$
$$= 169.8 \text{ g}$$

Now you can substitute in the answers.

$$\text{moles } AgNO_3 = \frac{17.0}{169.8}$$
$$= 0.100 \text{ moles}$$

STEP 3: What are you trying to find? The molarity of $AgNO_3$. Write down the relationship for molarity.

$$\text{molarity} = \frac{\text{moles}}{\text{liters}}$$

Substitute in the values and calculate your answer.

$$\text{molarity} = \frac{0.100}{5.00}$$

$$= 0.0200$$

Answer: 0.0200 M $AgNO_3$

Now you try one. Use the previous example as a model and work out the answer step by step. Don't skip any!

EXAMPLE 2: If 234 g of sodium chloride, NaCℓ is dissolved in water to make 4.0 L of solution, what is the molarity of the NaCℓ?

STEP 1: Draw a diagram to show what you are given and what you are required to find.

STEP 2:

STEP 3:

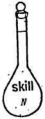
Answer: 1.0 M NaCℓ

CHECK YOURSELF.

PROBLEM M1: If 26.9 grams of cupric chloride, $CuC\ell_2$ is dissolved in water to make 10.0 L of solution, what is the molarity of the $CuC\ell_2$?

Answer: __________

See Page 53




*GIVEN:* *mass of solute and volume of solution*

*CALCULATE:* *molarity of a specified ion*

<u>EXAMPLE 1:</u> What is the molarity of chloride ion, $C\ell^-$ in a solution where 20.8 grams of barium chloride, $BaC\ell_2$ is dissolved to make a solution. The volume of the solution is 3.0 L.

STEP 1: What do you want to find? To help you think about this, draw a diagram showing what you are given and what you are required to find.

GIVEN REQUIRED

20.8 g $BaC\ell_2$ in 3.0 L ? M $C\ell^-$

STEP 2: You want to find the molarity of $C\ell^-$ ion. What is the relationship for molarity?

$$\text{molarity} = \frac{\text{moles}}{\text{liters}}$$

You need therefore to find the number of moles of $C\ell^-$ ion.

STEP 3: Where does the $Cl^-$ ion come from? From the $BaCl_2$ which dissolved. Find the number of moles of $BaCl_2$. Write down the relationship for grams to moles.

$$\text{moles} = \frac{\text{mass (g)}}{\text{molar mass}}$$

You need to find the molar mass of $BaCl_2$ to calculate this. A molar mass table is found on the inside cover of this booklet.

molar mass of $BaCl_2$ = 137.3 + 2(35.5) = 208.3 g

Now calculate the moles of $BaCl_2$

$$\text{moles} = \frac{\text{mass}}{\text{molar mass}} = \frac{20.8}{208} = 0.100$$

STEP 4: Calculate the molarity of $BaCl_2$.

$$\text{molarity} = \frac{\text{moles}}{\text{liters}}$$

$$= \frac{0.100}{3.0}$$

$$= 0.033\ M$$

STEP 5: What is the relationship between molarity of $BaCl_2$ and molarity of $Cl^-$ ion? From the formula you can see that

one $BaCl_2$ ⟶ 2 $Cl^-$

one mole $BaCl_2$ ⟶ two mole $Cl^-$

∴ one mole/L $BaCl_2$ ⟶ two moles/L $Cl^-$

or 1 M $BaCl_2$ ⟶ 2 M $Cl^-$

STEP 6: Calculate your answer. You worked out in step 4 the molarity of $BaCl_2$. It was 0.033 M.

molarity of $Cl^-$ = 2 x molarity of $BaCl_2$

= 2 x 0.033

= 0.066

Answer: .066 M $BaCl_2$

Now you try one. Use the previous example as a model and work out the answer step by step. Don't skip any!

EXAMPLE 2: 5.0 L of cesium chloride, CsCℓ solution was prepared by dissolving 16.84 grams of CsCℓ in water. What is the molarity of the chloride ion, $C\ell^-$ in the solution?

STEP 1: Make a diagram showing what you are required to find and what you are given.

STEP 2:

STEP 3:

STEP 4:

STEP 5:

STEP 6:

Answer: .02 M CsCℓ

CHECK YOURSELF.

PROBLEM N1: Suppose that 32.4 grams of sodium chromate, $Na_2CrO_4$ are dissolved in water to make up 5.0 L of solution. What is the molarity of the sodium ion, $Na^+$?

Answer: __________

See Page 53

CHECK YOURSELF.

PROBLEM ANSWERS

| | |
|---|---|
| A1 | 2 $OH^-$ |
| A2 | 2 $I^-$ |
| A3 | 1 $Ag^+$ |
| B1 | 4 moles $C\ell^-$ (volume not required) |
| C1 | 1.25 moles |
| D1 | 0.1 M |
| D2 | 6 M |
| E1 | 0.8 moles |
| E2 | 42 moles |
| F1 | 1.4 M |
| G1 | 0.63 M |
| H1 | 2.4 M |
| I1 | 26.5 g |
| I2 | 47.9 g (volume not required) |
| J1 | 178.3 G |
| K1 | .05 M NaOH |
| L1 | 0.10 moles |
| L2 | 0.10 moles |
| M1 | 0.020 M |
| N1 | 0.08 M |

# APPENDIX D
## TEST SCORES ON THE PRETEST

APPENDIX D: Test Scores on the PRETEST

(1 = correct response; 0 = incorrect response; 9 = missing information)

| Skills | L | | C | | D | | K | | E | | F | | M | | N | | A | | G | | B | | J | | I | | H | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Items | 9 | 26 | 11 | 27 | 2 | 28 | 3 | 23 | 5 | 16 | 6 | 21 | 10 | 24 | 14 | 20 | 13 | 17 | 12 | 19 | 4 | 25 | 1 | 18 | 7 | 15 | 8 | 22 |
| ID # | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 4 | 1 | 1 | 1 | 9 | 1 | 9 | 1 | 9 | 0 | 1 | 0 | 9 | 1 | 1 | 1 | 9 | 1 | 9 | 0 | 9 | 1 | 9 | 1 | 1 | 1 | 1 | 1 | 9 |
| 5 | 1 | 1 | 1 | 9 | 1 | 9 | 1 | 9 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 9 | 1 | 9 | 1 | 9 | 1 | 9 | 1 | 1 | 1 | 1 | 0 | 0 |
| 6 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 7 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 |
| 8 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 9 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 10 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 11 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 |
| 12 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 13 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| 14 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 15 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

APPENDIX D: Test Scores on the PRETEST

(1 = correct response; 0 = incorrect response; 9 = missing information)

| Skills | L | | C | | D | | K | | E | | F | | M | | N | | A | | G | | B | | J | | I | | H | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Items | 9 | 26 | 11 | 27 | 2 | 28 | 3 | 23 | 5 | 16 | 6 | 21 | 10 | 24 | 14 | 20 | 13 | 17 | 12 | 19 | 4 | 25 | 1 | 18 | 7 | 15 | 8 | 22 |
| ID # | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 16 | 1 | 9 | 1 | 9 | 1 | 9 | 1 | 9 | 1 | 9 | 1 | 9 | 0 | 9 | 0 | 9 | 1 | 9 | 1 | 9 | 1 | 9 | 0 | 9 | 0 | 9 | 0 | 9 |
| 17 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 18 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 |
| 19 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 20 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 21 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 |
| 22 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| 23 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 |
| 24 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 25 | 1 | 1 | 1 | 9 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 9 | 0 | 0 | 1 | 9 | 0 | 1 | 1 | 1 | 0 | 0 |
| 26 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 27 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | 0 |
| 28 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 29 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| 30 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

APPENDIX D: Test Scores on the PRETEST

*(1 = correct response; 0 = incorrect response; 9 = missing information)

| Skills | L | | C | | D | | K | | E | | F | | M | | N | | A | | G | | B | | J | | I | | H | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Items | 9 | 26 | 11 | 27 | 2 | 28 | 3 | 23 | 5 | 16 | 6 | 21 | 10 | 24 | 14 | 20 | 13 | 17 | 12 | 19 | 4 | 25 | 1 | 18 | 7 | 15 | 8 | 22 |
| ID # | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 31 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 32 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 33 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 34 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | [illegible] | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| 35 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 36 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 |
| 37 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 38 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 |
| 39 | 1 | 1 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 |
| 40 | 1 | 1 | 0 | 9 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 9 | 0 | 0 | 0 | 1 | 0 | 0 |
| 41 | 1 | 1 | 1 | 9 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 9 | 0 | 0 | 1 | 1 | 0 | 0 |
| 42 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| 43 | 1 | 1 | 1 | 9 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 1 | 9 | 0 | 0 | 1 | 9 | 1 | 1 | 1 | 1 | 1 | 1 |
| 44 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 |
| 45 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |

APPENDIX D: Test Scores on the PRETEST *

(1 = correct response; 0 = incorrect response; 9 = missing information)

| Skills | L | | C | | D | | K | | E | | F | | M | | N | | A | | G | | B | | J | | I | | H | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Items | 9 | 26 | 11 | 27 | 2 | 28 | 3 | 23 | 5 | 16 | 6 | 21 | 10 | 24 | 14 | 20 | 13 | 17 | 12 | 19 | 4 | 25 | 1 | 18 | 7 | 15 | 8 | 22 |
| ID # | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 46 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| 47 | 0 | 9 | 0 | 9 | 0 | 9 | 0 | 9 | 0 | 0 | 0 | 9 | 0 | 0 | 0 | 9 | 0 | 9 | 0 | 9 | 0 | 9 | 0 | 9 | 0 | 0 | 0 | 9 |
| 48 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 49 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 50 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| 51 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 |
| 52 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| 53 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 |
| 54 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 0 |
| 55 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 56 | 1 | 1 | 1 | 9 | 0 | 9 | 1 | 9 | 0 | 0 | 0 | 9 | 0 | 0 | 0 | 9 | 1 | 9 | 0 | 9 | 0 | 9 | 0 | 9 | 1 | 0 | 0 | 9 |
| 57 | 1 | 1 | 1 | 9 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 9 | 0 | 0 | 1 | 1 | 0 | 0 |
| 58 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 59 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| 60 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 |

APPENDIX D: Test Scores on the PRETEST

(1 = correct response; 0 = incorrect response; 9 = missing information)

| Skills | L | | C | | D | | K | | E | | F | | M | | N' | | A | | G | | B | | J | | I | | H | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Items | 9 | 26 | 11 | 27 | 2 | 28 | 3 | 23 | 5 | 16 | 6 | 21 | 10 | 24 | 14 | 20 | 13 | 17 | 12 | 19 | 4 | 25 | 1 | 18 | 7 | 15 | 8 | 22 |
| ID # | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 61 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 |
| 62 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 |
| 63 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 |
| 64 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| 65 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 |
| 66 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| 67 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | 0 |
| 68 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | 0 |
| 69 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| 70 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 71 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 |
| 72 | 1 | 1 | 0 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 |
| 73 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | 0 |
| 74 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 75 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |

APPENDIX D: Test Scores on the PRETEST

(1 = correct response; 0 = incorrect response; 9 = missing information)

| Skills | L | | C | | D | | K | | E | | F | | M | | N | | A | | G | | B | | J | | I | | H | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Items | 9 | 26 | 11 | 27 | 2 | 28 | 3 | 23 | 5 | 16 | 6 | 21 | 10 | 24 | 14 | 20 | 13 | 17 | 12 | 19 | 4 | 25 | 1 | 18 | 7 | 15 | 8 | 22 |
| ID # | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 76 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 |
| 77 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | 0 |
| 78 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| 79 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 0 |
| 80 | 1 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 0 |
| 81 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | 0 |
| 82 | 1 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 0 |
| 83 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| 84 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 |
| 85 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 |
| 86 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 |
| 87 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 0 |
| 88 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 0 |
| 89 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 |
| 90 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |

APPENDIX D: Test Scores on the PRETEST

(1 = correct response; 0 = incorrect response; 9 = missing information)

| Skills | L | | C | | D | | K | | E | | F | | M | | N | | A | | G | | B | | J | | I | | H | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Items | 9 | 26 | 11 | 27 | 2 | 28 | 3 | 23 | 5 | 16 | 6 | 21 | 10 | 24 | 14 | 20 | 13 | 17 | 12 | 19 | 4 | 25 | 1 | 18 | 7 | 15 | 8 | 22 |
| ID # | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 91 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| 92 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| 93 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 |
| 94 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 |
| 95 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| 96 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 |
| 97 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 |
| 98 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 |
| 99 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 |
| 100 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 |
| 101 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 |
| 102 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 |
| 103 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| 104 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 |
| 105 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |

APPENDIX D: Test Scores on the PRETEST

(1 = correct response; 0 = incorrect response; 9 = missing information)

| Skills | L | | C | | D | | K | | E | | F | | M | | N | | A | | G | | B | | J | | I | | H | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Items | 9 | 26 | 11 | 27 | 2 | 28 | 3 | 23 | 5 | 16 | 6 | 21 | 10 | 24 | 14 | 20 | 13 | 17 | 12 | 19 | 4 | 25 | 1 | 18 | 7 | 15 | 8 | 22 |
| ID # | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 106 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 107 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 |
| 108 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| 109 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 |
| 110 | 1 | 9 | 1 | 9 | 0 | 9 | 1 | 9 | 0 | 9 | 1 | 9 | 1 | 9 | 1 | 9 | 0 | 9 | 0 | 9 | 0 | 9 | 1 | 9 | 1 | 9 | 0 | 9 |
| 111 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 112 | 1 | 9 | 1 | 9 | 1 | 9 | 1 | 9 | 1 | 9 | 1 | 9 | 1 | 9 | 1 | 9 | 1 | 9 | 1 | 9 | 1 | 9 | 1 | 9 | 1 | 9 | 0 | 9 |
| 113 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 |
| 114 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 |
| 115 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| 116 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 0 |
| 117 | 1 | 9 | 0 | 9 | 0 | 9 | 1 | 9 | 0 | 9 | 1 | 9 | 1 | 9 | 1 | 9 | 1 | 9 | 1 | 9 | 0 | 9 | 0 | 9 | 1 | 9 | 0 | 9 |
| 118 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 0 |
| 119 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 |
| 120 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 0 |

APPENDIX D: Test Scores on the PRETEST

(1 = correct response; 0 = incorrect response; 9 = missing information)

| Skills | L | | C | | D | | K | | E | | F | | M | | N | | A | | G | | B | | J | | I | | H | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Items | 9 | 26 | 11 | 27 | 2 | 28 | 3 | 23 | 5 | 16 | 6 | 21 | 10 | 24 | 14 | 20 | 13 | 17 | 12 | 19 | 4 | 25 | 1 | 18 | 7 | 15 | 8 | 22 |
| ID # | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 121 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 122 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 0 |
| 123 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 |
| 124 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 |
| 125 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 |
| 126 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 |
| 127 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| 128 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 |
| 129 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 |
| 130 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 |
| 131 | 1 | 9 | 1 | 9 | 0 | 0 | 1 | 9 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 9 | 0 | 9 | 1 | 9 | 1 | 1 | 1 | 1 | 0 | 0 |
| 132 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| 133 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| 134 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| 135 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |

APPENDIX D: Test Scores on the PRETEST

(1 = correct response; O = incorrect response; 9 = missing information)

| Skills | L | | C | | D | | K | | E | | F | | M | | N | | A | | G | | B | | J | | I | | H | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Items | 9 | 26 | 11 | 27 | 2 | 28 | 3 | 23 | 5 | 16 | 6 | 21 | 10 | 24 | 14 | 20 | 13 | 17 | 12 | 19 | 4 | 25 | 1 | 18 | 7 | 15 | 8 | 22 |
| ID # | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 136 | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| 137 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| 138 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 139 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 |
| 140 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 0 |
| 141 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 0 |
| 142 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| 143 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| 144 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| 145 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 146 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 147 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 148 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 149 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 150 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

APPENDIX D: Test Scores on the PRETEST

(1 = correct response; 0 = incorrect response; 9 = missing information)

| Skills | L | | C | | D | | K | | E | | F | | M | | N | | A | | G | | B | | J | | I | | H | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Items | 9 | 26 | 11 | 27 | 2 | 28 | 3 | 23 | 5 | 16 | 6 | 21 | 10 | 24 | 14 | 20 | 13 | 17 | 12 | 19 | 4 | 25 | 1 | 18 | 7 | 15 | 8 | 22 |
| ID # | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 151 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 |
| 152 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 153 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| 154 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 155 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 |
| 156 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 157 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 158 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 159 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 160 | 1 | 9 | 1 | 9 | 1 | 1 | 1 | 9 | 1 | 9 | 1 | 9 | 1 | 9 | 1 | 9 | 1 | 9 | 0 | 9 | 1 | 9 | 1 | 9 | 1 | 9 | 1 | 9 |
| 161 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 162 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 |
| 163 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 164 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 165 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

APPENDIX D: Test Scores on the PRETEST

(1 = correct response; 0 = incorrect response; 9 = missing information)

| Skills | L | | C | | D | | K | | E | | F | | M | | N | | A | | G | | B | | J | | I | | H | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Items | 9 | 26 | 11 | 27 | 2 | 28 | 3 | 23 | 5 | 16 | 6 | 21 | 10 | 24 | 14 | 20 | 13 | 17 | 12 | 19 | 4 | 25 | 1 | 18 | 7 | 15 | 8 | 22 |
| ID # | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 166 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 167 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 168 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 169 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 170 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 171 | 1 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 0 |
| 172 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| 173 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 0 |
| 174 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 0 |
| 175 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 |
| 176 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 |
| 177 | 1 | 1 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 0 |
| 178 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 0 |
| 179 | 1 | 1 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 |
| 180 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 |

APPENDIX D: Test Scores on the PRETEST

(1 = correct response; 0 = incorrect response; 9 = missing information)

| Skills | L | | C | | D | | K | | E | | F | | M | | N | | A | | G | | B | | J | | I | | H | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Items | 9 | 26 | 11 | 27 | 2 | 28 | 3 | 23 | 5 | 16 | 6 | 21 | 10 | 24 | 14 | 20 | 13 | 17 | 12 | 19 | 4 | 25 | 1 | 18 | 7 | 15 | 8 | 22 |
| ID # | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 181 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 |
| 182 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 183 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 184 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 185 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 186 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 187 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 188 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 |
| 189 | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 190 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 |
| 191 | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 |
| 192 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 |
| 193 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 1 | 1 | 0 | 0 |
| 194 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 |
| 195 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 |

APPENDIX D: Test Scores on the PRETEST

(1 = correct response; 0 = incorrect response; 9 = missing information)

| Skills | L | | C | | D- | | K | | E | | F | | M | | N | | A | | G | | B | | J | | I | | H | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Items | 9 | 26 | 11 | 27 | 2 | 28 | 3 | 23 | 5 | 16 | 6 | 21 | 10 | 24 | 14 | 20 | 13 | 17 | 12 | 19 | 4 | 25 | 1 | 18 | 7 | 15 | 8 | 22 |
| ID # | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 196 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 197 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 |
| 198 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 199 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| 200 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| 201 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 |
| 202 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| 203 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 204 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| 205 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| 206 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 207 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 |
| 208 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| 209 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 0 |
| 210 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |

APPENDIX D: Test Scores on the PRETEST

(1 = correct response; 0 = incorrect response; 9 = missing information)

| Skills | L | | C | | D | | K | | E | | F | | M | | N | | A | | G | | B | | J | | I | | H | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Items | 9 | 26 | 11 | 27 | 2 | 28 | 3 | 23 | 5 | 16 | 6 | 21 | 10 | 24 | 14 | 20 | 13 | 17 | 12 | 19 | 4 | 25 | 1 | 18 | 7 | 15 | 8 | 22 |
| ID # | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 211 | [illegible] | [illegible] | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| 212 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 |
| 213 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 |
| 214 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| 215 | 9 | 0 | 9 | 0 | 9 | 0 | 9 | 0 | 9 | 0 | 9 | 0 | 9 | 0 | 9 | 0 | 9 | 1 | 9 | 0 | 9 | 0 | 9 | 0 | 9 | 0 | 9 | 0 |
| 216 | 0 | 9 | 0 | 9 | 0 | 9 | 0 | 9 | 0 | 9 | 0 | 9 | 0 | 9 | 0 | 9 | 0 | 9 | 0 | 9 | 0 | 9 | 0 | 9 | 0 | 9 | 0 | 9 |
| 217 | 9 | 0 | 9 | 0 | 9 | 0 | 9 | 0 | 9 | 0 | 9 | 0 | 9 | 0 | 9 | 0 | 9 | 0 | 9 | 0 | 9 | 0 | 9 | 0 | 9 | 0 | 9 | 0 |
| 218 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 |
| 219 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 |
| 220 | 1 | 1 | 0 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 0 |
| 221 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| 222 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| 223 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 |
| 224 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| 225 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

APPENDIX E

TEST SCORES ON THE POSTTEST

APPENDIX E: Test Scores on the POSTTEST

(1 = correct response; 0 = incorrect response; 9 = missing information)

| Skills | L | | C | | D | | K | | E | | F | | M | | N | | A | | G | | B | | J | | I | | H | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Items | 7 | 19 | 10 | 28 | 6 | 23 | 2 | 21 | 4 | 20 | 3 | 27 | 8 | 22 | 9 | 17 | 14 | 16 | 5 | 18 | 1 | 24 | 12 | 15 | 13 | 26 | 10 | 24 |
| ID # | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 |
| 3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 4 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 5 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 6 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 7 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | [illegible] | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 8 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 9 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 10 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 11 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 12 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 13 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 0 |
| 14 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 15 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

APPENDIX E: Test Scores on the POSTTEST

(1 = correct response; 0 = incorrect response; 9 = missing information)

| Skills | L | | C | | D | | K | | E | | F | | M | | N | | A | | G | | B | | J | | I | | H | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Items | 7 | 19 | 10 | 28 | 6 | 23 | 2 | 21 | 4 | 20 | 3 | 27 | 8 | 22 | 9 | 17 | 14 | 16 | 5 | 18 | 1 | [illegible] | 12 | 15 | 13 | 26 | [illegible] | 24 |
| ID # | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 16 | 1 | 9 | 1 | 9 | 1 | 9 | 1 | 9 | 1 | 9 | 1 | 9 | 1 | 9 | 0 | 9 | 1 | 9 | 1 | 9 | 1 | 9 | 0 | 9 | 0 | 9 | 0 | 9 |
| 17 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 18 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 |
| 19 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 20 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 21 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 22 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 |
| 23 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 |
| 24 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 25 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| 26 | 1 | 1 | 1 | 9 | 1 | 9 | 1 | 9 | 1 | 9 | 1 | 9 | 1 | 9 | 1 | 9 | 1 | 9 | 0 | 9 | 1 | 9 | 1 | 9 | 1 | 1 | 1 | 1 |
| 27 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 28 | 1 | 1 | 1 | 1 | 1 | [illegible] | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 29 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 30 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

APPENDIX E: Test Scores on the POSTTEST

(1 = correct response; 0 = incorrect response; 9 = missing information)

| Skills | L | | C | | D | | K | | E | | F | | M | | N | | A | | G | | B | | J | | I | | H | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Items | 7 | 19 | 10 | 28 | 6 | 23 | 2 | 21 | 4 | 20 | 3 | 27 | 8 | 22 | 9 | 17 | 14 | 16 | 5 | 18 | 1 | 24 | 12 | 15 | 13 | 26 | 10 | 24 |
| ID # | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 31 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 32 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 33 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 34 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| 35 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 36 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 37 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 |
| 38 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 9 | 0 | 0 | 1 | 1 | 0 | 0 |
| 39 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 |
| 40 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 9 | 1 | 9 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 9 | 1 | 1 | 1 | 1 | 0 | 0 |
| 41 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 0 |
| 42 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 43 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 44 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 |
| 45 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |

APPENDIX E: Test Scores on the POSTTEST

(1 = correct response; 0 = incorrect response; 9 = missing information)

| Skills | L | | C | | D | | K | | E | | F | | M | | N | | A | | G | | B | | J | | I | | H | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Items | 7 | 19 | 10 | 28 | 6 | 23 | 2 | 21 | 4 | 20 | 3 | 27 | 8 | 22 | 9 | 17 | 14 | 16 | 5 | 18 | 1 | 24 | 12 | 15 | 13 | 26 | 10 | 24 |
| ID # | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 46 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 47 | 0 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 0 |
| 48 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 49 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 |
| 50 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 |
| 51 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 0 |
| 52 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| 53 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| 54 | 1 | 1 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 |
| 55 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 |
| 56 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| 57 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| 58 | 1 | 1 | [illegible] | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 59 | 1 | 1 | [illegible] | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 9 | 1 | 9 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 9 | 1 | 1 | 1 | 1 | 0 | 0 |
| 60 | 0 | 0 | 0 | 0 | 0 | 9 | 1 | 0 | 0 | 9 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 9 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

APPENDIX E: Test Scores on the POSTTEST

(1 = correct response; 0 = incorrect response; 9 = missing information)

| Skills | L | | C | | D | | K | | E | | F | | M | | N | | A | | G | | B | | J | | I | | H | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Items | 7 | 19 | 10 | 28 | 6 | 23 | 2 | 21 | 4 | 20 | 3 | 27 | 8 | 22 | 9 | 17 | 14 | 16 | 5 | 18 | 1 | 24 | 12 | 15 | 13 | 26 | 10 | 24 |
| ID # | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 61 | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 62 | 9 | 1 | 9 | 1 | 9 | 1 | 9 | 1 | 9 | 1 | 9 | 1 | 9 | 1 | 9 | 1 | 9 | 1 | 9 | 1 | 9 | 1 | 9 | 1 | 9 | 1 | 9 | 1 |
| 63 | 0 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 0 |
| 64 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 |
| 65 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 |
| 66 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 |
| 67 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| 68 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| 69 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 70 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 71 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| 72 | 1 | 9 | 1 | 9 | 1 | 9 | 1 | 9 | 0 | 9 | 1 | 9 | 1 | 9 | 0 | 9 | 1 | 9 | 1 | 9 | 1 | 9 | 0 | 9 | 1 | 9 | 0 | 9 |
| 73 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 |
| 74 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 |
| 75 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 |

APPENDIX E: Test Scores on the POSTTEST

(1 = correct response; 0 = incorrect response; 9 = missing information)

| Skills | L | | C | | D | | K | | E | | F | | M | | N | | A | | G | | B | | J | | I | | H | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Items | 7 | 19 | 10 | 28 | 6 | 23 | 2 | 21 | 4 | 20 | 3 | 27 | 8 | 22 | 9 | 17 | 14 | 16 | 5 | 18 | 1 | 24 | 12 | 15 | 13 | 26 | 10 | 24 |
| ID # | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 76 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 77 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 |
| 78 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 79 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 0 |
| 80 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| 81 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 82 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 |
| 83 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| 84 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| 85 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 |
| 86 | 1 | 9 | 1 | 9 | 1 | 9 | 1 | 9 | 0 | 9 | 0 | 9 | 1 | 9 | 0 | 9 | 1 | 9 | 0 | 9 | 0 | 9 | 1 | 9 | 1 | 9 | 0 | 9 |
| 87 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| 88 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| 89 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| 90 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

APPENDIX E: Test Scores on the POSTTEST

(1 = correct response; 0 = incorrect response; 9 = missing information)

| Skills | L | | C | | D | | K | | E | | F | | M | | N | | A | | G | | B | | J | | I | | H | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Items | 7 | 19 | 10 | 28 | 6 | 23 | 2 | 21 | 4 | 20 | 3 | 27 | 8 | 22 | 9 | 17 | 14 | 16 | 5 | 18 | 1 | 24 | 12 | 15 | 13 | 26 | 10 | 24 |
| ID # | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 91 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 |
| 92 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| 93 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| 94 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| 95 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 96 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| 97 | 1 | 9 | 1 | 9 | 1 | 9 | 1 | 9 | 1 | 9 | 1 | 9 | 1 | 9 | 1 | 9 | 1 | 9 | 1 | 9 | 1 | 9 | 1 | 9 | 1 | 9 | 1 | 9 |
| 98 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 99 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| 100 | 9 | 1 | 9 | 1 | 9 | 1 | 9 | 1 | 9 | 1 | 9 | 1 | 9 | 1 | 9 | 1 | 9 | 1 | 9 | 1 | 9 | 1 | 9 | 1 | 9 | 1 | 9 | 1 |
| 101 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 102 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 0 | 1 | 0 | 0 |
| 103 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 |
| 104 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 105 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | [illegible] | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

APPENDIX E: Test Scores on the POSTTEST

(1 = correct response; 0 = incorrect response; 9 = missing information)

| Skills | L | | C | | D | | K | | E | | F | | M | | N | | A | | G | | B | | J | | I | | H | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Items | 7 | 19 | 10 | 28 | 6 | 23 | 2 | 21 | 4 | 20 | 3 | 27 | 8 | 22 | 9 | 17 | 14 | 16 | 5 | 18 | 1 | 24 | 12 | 15 | 13 | 26 | 10 | 24 |
| ID # | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 106 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 107 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| 108 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 109 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 110 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| 111 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 112 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 113 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| 114 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| 115 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 116 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 1 |
| 117 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| 118 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 119 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 120 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

APPENDIX E: Test Scores on the POSTTEST

(1 = correct response; 0 = incorrect response; 9 = missing information)

| Skills | L | | C | | D | | K | | E | | F | | M. | | N | | A. | | G | | B | | J | | I | | H | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Items | 7 | 19 | 10 | 28 | 6 | 23 | 2 | 21 | 4 | 20 | 3 | 27 | 8 | 22 | 9 | 17 | 14 | 16 | 5 | 18 | 1 | 24 | 12 | 15 | 13 | 26 | 10 | 24 |
| ID # | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 121 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 122 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 123 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 124 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| 125 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | [illegible] | 0 | 0 |
| 126 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| 127 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 |
| 128 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 |
| 129 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| 130 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| 131 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 132 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| 133 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| 134 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| 135 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

APPENDIX E: Test Scores on the POSTTEST

(1 = correct response; 0 = incorrect response; 9 = missing information)

| Skills | L | | C | | D | | K | | E | | F | | M | | N | | A | | G | | B | | J | | I | | H | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Items | 7 | 19 | 10 | 28 | 6 | 23 | 2 | 21 | 4 | 20 | 3 | 27 | 8 | 22 | 9 | 17 | 14 | 16 | 5 | 18 | 1 | 24 | 12 | 15 | 13 | 26 | 10 | 24 |
| ID # | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 136 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| 137 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| 138 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| 139 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 140 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| 141 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| 142 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| 143 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| 144 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 145 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 |
| 146 | 1 | [illegible] | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 1 |
| 147 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| 148 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 |
| 149 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 150 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 0 |

APPENDIX E: Test Scores on the POSTTEST

(1 = correct response; 0 = incorrect response; 9 = missing information)

| Skills | L | | C | | D | | K | | E | | F | | M | | N | | A | | G | | B | | J | | I | | H | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Items | 7 | 19 | 10 | 28 | 6 | 23 | 2 | 21 | 4 | 20 | 3 | 27 | 8 | 22 | 9 | 17 | 14 | 16 | 5 | 18 | 1 | 24 | 12 | 15 | 13 | 26 | 10 | 24 |
| ID # | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 151 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| 152 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 1 |
| 153 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 |
| 154 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 155 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 156 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 157 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| 158 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 159 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| 160 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 161 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 162 | 1 | 1 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 1 | 1 | 0 | 0 |
| 163 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 164 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | [illegible] | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 0 |
| 165 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 1 |

APPENDIX E: Test Scores on the POSTTEST

(1 = correct response; 0 = incorrect response; 9 = missing information)

| Skills | L | | C | | D | | K | | E | | F | | M | | N | | A | | G | | B | | J | | I | | H | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Items. | 7 | 19 | 10 | 28 | 6 | 23 | 2 | 21 | 4 | 20 | 3 | 27 | 8 | 22 | 9 | 17 | 14 | 16 | 5 | 18 | 1 | 24 | 12 | 15 | 13 | 26 | 10 | 24 |
| ID # | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 166 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 167 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 0 |
| 168 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| 169 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 170 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 1 |
| 171 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 172 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| 173 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 174 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 175 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 176 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 177 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 |
| 178 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 |
| 179 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 180 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

APPENDIX E: Test Scores on the POSTTEST

(1 = correct response; 0 = incorrect response; 9 = missing information)

| Skills | L | | C | | D | | K | | E | | F | | M | | N | | A | | G | | B | | J | | I | | H | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Items | 7 | 19 | 10 | 28 | 6 | 23 | 2 | 21 | 4 | 20 | 3 | 27 | 8 | 22 | 9 | 17 | 14 | 16 | 5 | 18 | 1 | 24 | 12 | 15 | 13 | 26 | 10 | 24 |
| ID # | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 181 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 182 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 0 |
| 183 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| 184 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 185 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 186 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 187 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 1 | 1 | 0 | 1 |
| 188 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 |
| 189 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 190 | 1 | 1 | 1 | 0 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 0 |
| 191 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| 192 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 0 |
| 193 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 |
| 194 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 195 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

APPENDIX E: Test Scores on the POSTTEST

(1 = correct response; 0 = incorrect response; 9 = missing information)

| Skills | L | | C | | D | | K | | E | | F | | M | | N | | A | | G | | B | | J | | I | | H | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Items | 7 | 19 | 10 | 28 | 6 | 23 | 2 | 21 | 4 | 20 | 3 | 27 | 8 | 22 | 9 | 17 | 14 | 16 | 5 | 18 | 1 | 24 | 12 | 15 | 13 | 26 | 10 | 24 |
| ID # | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 196 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 0 |
| 197 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 198 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 |
| 199 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 |
| 200 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | [illegible] | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| 201 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 202 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| 203 | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 204 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 205 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| 206 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 0 |
| 207 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 |
| 208 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 |
| 209 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 |
| 210 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

APPENDIX E: Test Scores on the POSTTEST

(1 = correct response; 0 = incorrect response; 9 = missing information)

| Skills | L | | C | | D | | K | | E | | F | | M | | N | | A | | G | | B | | J | | I | | H | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Items | 7 | 19 | 10 | 28 | 6 | 23 | 2 | 21 | 4 | 20 | 3 | 27 | 8 | 22 | 9 | 17 | 14 | 16 | 5 | 18 | 1 | 24 | 12 | 15 | 13 | 26 | 10 | 24 |
| ID # | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 211 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 |
| 212 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 213 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 214 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| 215 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 |
| 216 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 |
| 217 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 1 | 1 | 0 | 0 |
| 218 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 219 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 220 | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 221 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 |
| 222 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 223 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| 224 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 225 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |