

THE EFFECTS OF SCREENCASTING ON THE MASTERY OF HIGH SCHOOL
CHEMISTRY CONCEPTS AND DIFFERENTIATION OF INSTRUCTION

by

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In presenting this professional paper in partial fulfillment of the requirements for a master's degree at Montana State University, I agree that the MSSE Program shall make it available to borrowers under rules of the program.

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July 2014

DEDICATION

I would like to dedicate my work to my students at the Roanoke Valley Governor's School who have supported this project and inspire me to be a better teacher. I hope they have learned as much from me this year as I have learned from them.

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ABSTRACT

The purpose of this study was to examine the effects of using screencasting of video lessons as homework followed by active learning strategies in class, flipping the traditional high school chemistry classroom. The goals of this project were to enhance understanding of chemistry concepts while providing differentiated instruction for gifted and talented students. A comparison was made between two nontreatment units of study, taught with traditional teacher-directed instruction, and three treatment units utilizing the flipped classroom mode of instruction. To determine the effectiveness of this treatment comparison of pretest and posttest scores, interview responses, survey data, and field observations were analyzed. Results of the study did not indicate improvement in the understanding of chemistry concepts, but did provide evidence for the achievement of improved differentiation of instruction.

INTRODUCTION AND BACKGROUND

I have the privilege of teaching high-achieving and highly motivated students at the Roanoke Valley Governor’s School for Science and Technology in Roanoke, Virginia. This regional public school serves 269 gifted and talented students in grades 9 through 12 from 7 area school districts in the study of math, science, and technology. Regional Governor’s Schools in Virginia are public schools supported by tuition paid by participating school districts and the Virginia Department of Education (www.rvgs.k12.va.us). In order to attend this school, students must go through a rigorous application process through their own school district and must maintain a B average in their math and science courses while in attendance.

Roanoke is a city of 97,469 people composed of 61.9% Caucasians, 28.1% African Americans, 5.5% Hispanics, 1.7% Asians, and the remaining 2.7% other races (www.city-data.com). In addition to Roanoke City, the Roanoke Valley Governor’s School serves students from Salem City, Roanoke County, Botetourt County, Craig County, Franklin County, and Bedford County. The populations of these additional areas in the greater Roanoke Valley tend to have less cultural diversity (Table 1).

Table 1
Populations and Racial Percentages of Roanoke Valley Cities/Counties (www.city-data.com)

City/County(Co.)	Population	Percentage of Population		
		Caucasian	African American	Other
Bedford Co.	69,590	90.3	5.7	3.6
Botetourt Co.	33, 154	94.2	3.0	2.5
Craig Co.	5,213	98.3	0.0	0.7
Franklin Co.	56,411	87.4	8.1	4
Roanoke City	97, 469	61.9	28.1	9.9
Roanoke Co.	92,901	88.6	5.0	6.2
Salem City	24,970	87.6	7.1	5.3

There are many rewards associated with teaching the students at my school including a lack of negative classroom behaviors and an eagerness to participate in the process of learning. However, one of the many challenges I have encountered with these students is boredom. I teach several students who do not open their notebooks, do not take notes, and appear to be unengaged in my lessons. At the other end of the learning spectrum are the students who write down every word of my notes without trying to summarize, slowing down the pace of the lesson for the entire class. Through reflection I realized these students might be similarly unengaged in conceptual development since they are focused entirely on note taking rather than processing the information being disseminated. My classroom is homogeneous when considering the students' abilities and motivation to learn, but there are still wide differences in the way these students gather and assimilate concepts. While some of my students are truly gifted, many more of the students are intelligent and highly motivated but do not grasp concepts as quickly as some of their gifted peers. In order to meet the needs of the gifted and talented classroom, I addressed the need for differentiation of instruction in order to help the students to be more engaged and gain a better understanding of the concepts.

Differentiation of instruction is based upon the premise of providing students with learning opportunities that are appropriately challenging and from which they will experience intellectual growth (Tomlinson, 2004). The school at which I teach prides itself upon the ability to provide the differentiation necessary for our student body. In order to meet this goal, I have researched new lesson strategies and methods. Due to a great deal of reflection, research, and personal experience with courses being taught using videos, I decided to attempt to differentiate instruction through the provision of a more

active learning environment through the use of the flipped classroom mode of instruction. Teaching the essential concepts of the lessons using prerecorded videos, or screencasts, that the students watch at home at their own pace, and using classroom time to work on the application and extension of the concepts learned in the videos is an example of the flipped classroom.

My project focus was to investigate the effects of screencasting lessons outside the classroom on the mastery of high school honors chemistry concepts, on differentiation of instruction, and on the students' and the teacher's attitudes and motivation. This project was important at the school district level because another school district in the area had already implemented a flipped classroom mode of instruction for their chemistry program using prerecorded videos purchased from an outside vendor. Our school stresses the importance of differentiation and the use of best practices in gifted education. Therefore, this study provided evidence regarding the value of flipped learning with gifted and talented students.

CONCEPTUAL FRAMEWORK

The use of videos and other forms of technology to aid in effective instruction is a product of the changing relationship between instructional strategies and emerging technologies. The 21st-century classroom is being modified to include these innovations and to better reach students with differing learning styles. Students of all ability levels are responsive to novel teaching techniques that will engage their interest through increased relevance in their lives (de Winter, Winterbottom, & Wilson, 2010). The students of the 21st century are never far from their cell phones, share their most exciting moments on a number of online social networks, and learn how to play the guitar and tie bow ties while

viewing YouTube. The use of videos that may be stopped, rewound, replayed, and fast-forwarded by the viewers gives the students control over their learning, engages their thinking in an active manner, and integrates seamlessly with their everyday technology-saturated existence. In 2007, two chemistry teachers from Colorado started making videos of their lectures and used class time for helping students with problem solving, reviewing difficult concepts, and laboratory work. These educational innovators referred to this instructional strategy as the flipped classroom (Bergmann & Sams, 2012).

The study of chemistry requires learning basic concepts upon which more difficult concepts are learned and applied. For example, students who do not master nomenclature will have great difficulty writing and balancing chemical equations. The basis for improved understanding of chemistry concepts through the use of screencasts is that the time spent in class will be active, engaged learning, tailored to the needs of each student rather than the more passive, teacher-centered approach. In a study of undergraduate organic chemistry students it was determined that students taught with active learning such as cooperative learning, group solving of problems, and warm-up questions based on preparation for class attained higher scores and were less likely to drop the course than those students taught with traditional lectures (Paulson, 1999). Research on undergraduate general chemistry students demonstrated that active learning through simple laboratory activities developed their ability to analyze, synthesize, and evaluate concepts (Worrell, 1992). Using screencasts and strategies of the flipped classroom enables the students to customize their own learning at home and subsequently allows teachers to utilize time with their students actively reconstructing their newly acquired knowledge. The students move from passive vessels of memorized facts to

engaged learners with improved ability to remember and apply concepts (King, 1993).

Active learning encourages the teacher and each student to become collaborators in learning driven by one-on-one interactions. In this way teachers have a clearer picture of the ability and understanding of each of the students (Loo, 2013).

Screencasts viewed at home, on the school bus, or while waiting at the orthodontist's office require a paradigm shift in the nature of instruction. Lessons are delivered to the students as individuals. The screencasts themselves are not the sum of the experience, however. The classroom, where the group of learners gathers, becomes a flowing, collaborative venue with increased interactions between students and between each of the students and the teacher. The teacher's role becomes that of a facilitator, rather than a director, aiding the students through their quest to learn rather than dictating the path (Pedersen & Liu, 2003).

Differentiation of instruction involves mindful, purposeful teaching that addresses the success of each of our students. Differentiation by readiness is the response of the teacher to the individual needs of each student in the classroom so they may experience growth and development in knowledge and skills (Sousa & Tomlinson, 2011). Providing class time for discussion of screencasts viewed at home, working problems, and completing labs supports this differentiation by readiness (Bergman & Sams, 2012). Further support is found in the study performed by de Winter et al. (2010) on five science teachers who were mentors in different secondary schools utilizing technology in the classroom. They found that using podcasts and videos differentiated and personalized learning.

According to Tomlinson (2004), young people need to feel they are moving towards independence and differentiation of instruction helps students become more independent because they must take more responsibility for their own learning. Gifted and talented students demonstrated impatience with other students and complained about boredom in the classroom setting in a qualitative study involving three high school chemistry teachers of gifted students (Park & Oliver, 2009). These teachers used several thematic units completed by the students at their own pace, a variety of teaching strategies and students' products, group strategies, and peer tutoring. Their findings supported the premise that differentiation of instruction helps to reduce impatience, boredom, the tendency to be critical of other students, and negative attitudes toward school. A different study found interventions that increased motivation for gifted students were successful in reducing perceived underachievement for these students (McCoach & Siegle, 2003). The use of the flipped classroom model of instruction provides the gifted learner with more control over the pace and depth of study, reducing boredom, and frustration with routine.

Since the flipped classroom mode of instruction is a recent innovation in education, most of the research has addressed the performance of students and their attitude to this teaching strategy. Rather comprehensive research completed by Pierce and Fox (2012) on 71 pharmacy students yielded statistically significantly improved posttest scores of students taught with the flipped classroom intervention. Attitudes of the students were mostly favorable, and they reported increased learning opportunities. In the current educational climate, where students must be prepared for many standardized tests, increased interaction between each student and the teacher is essential for improved

preparation and learning. All of these factors increase the teaching strategies available to the teacher, and provide an environment in which the attitude and motivation of the teacher will benefit.

Implementing the flipped classroom through screencasting lessons rather than traditional teacher-centered lessons is one way to meet the needs of the 21st-century learner. This teaching strategy is relatively new in educational circles but has garnered a strong following by teachers and education advocates alike. The combination of prerecorded videos, or screencasts, with active learning strategies like cooperative learning and guided inquiry learning engages students in their own learning and creates a student-centered classroom (Pierce & Fox, 2012).

METHODOLOGY

The students who participated in this study were five males and eight females in one section of Honors Introductory Chemistry. One of the students was a junior and 12 of the students were sophomores. This class was composed of 11 white students and 2 black students all of whom were students from Roanoke City. This group of students was chosen for project implementation because it had a broader range of ability levels than my other classes. The research methodology for this project received an exemption by Montana State University's Institutional Review Board and compliance for working with human subjects was maintained (Appendix A).

During the course of this project, a comparison was made between two non-treatment units without the intervention of the flipped classroom and the treatment units that were taught with the intervention. The first unit of study was Chemical Reactions and Stoichiometry, and the second was Gases and Gas Laws, which were taught using

standard teacher-centered instruction using class time to teach the lesson and complete lab work. Practice problems and textbook reading were assigned as homework using the online tool MasteringChemistry[®] or using worksheets and problems from the textbook. The first nontreatment unit was started with the Chemical Quantities Pretest (Appendix B). The focus of lessons, lab work, and practice problems was to develop a solid problem solving process, where students demonstrated their ability to balance chemical equations and use dimensional analysis to solve stoichiometry problems. The Chemical Quantities Posttest was used to evaluate learning of concepts (Appendix C). The Gases Pretest and Gases Posttest were used to obtain quantitative data for the gases unit (Appendices D & E). The posttests for each of the nontreatment units had the pretest questions randomly embedded within the tests. The overall improvements in scores were assessed using scaled percentage change in scores.

The following three units of study on the Model of the Atom and Periodic Trends, Molecular Geometry and Intermolecular Forces, and Solutions, Acids, and Bases were taught with the flipped classroom intervention in order to differentiate instruction by readiness. These units were taught with many of the same techniques used in the nontreatment unit, such as laboratory experiments, readings from the textbook, and the use of MasteringChemistry[®], and each of the units began with a pretest and ended with a posttest similar in design to the Chemical Quantities and Gases tests (Appendices F, G, H, I, J, & K). The intervention of providing videos of the lesson concepts as homework and using class time to work problems and do labs with differentiation by readiness was used with each of the treatment units. The treatment involved the use of video lessons,

prepared by the teacher, incorporating concepts and examples the students viewed as their homework. A sample video can be viewed at the following web address: <http://www.screencast.com/t/8MeNdYxHrsx>. The students had the option to take notes as they watched the videos, completed guided examples, and completed interactive quizzes incorporated into the videos. Class time was utilized to practice solving problems, answer questions regarding the concepts covered in the videos, complete lab work, and extend learning. Differentiated instruction by readiness in order to achieve mastery of concepts was implemented in several ways. Students could view the videos at the speed most appropriate to their own level of understanding, fast-forwarding, rewinding, pausing the videos, or not watching them at all. During class time, they were able to be very focused in their questions regarding the lesson, and they were grouped according to their own perceived level of understanding to work problems. Students with higher ability were able to move through the material faster than the lower ability students. Students who were interested in more challenging problems were able to move on to higher levels of critical thinking and problem solving than the lower ability students. After viewing of the videos, students completed Video Rewind, a Google Document providing the teacher with feedback about their understanding of the material presented and summaries of the topic (Appendix L). Additional qualitative data was collected during Pretreatment and Posttreatment Interviews and Surveys (Appendices M, N, O & P). All students participated in the tests and surveys; only six students participated in the interviews. Interview participants, three girls and three boys, were chosen so that two students were low-achieving, two students were middle-achieving, and two students were high-achieving. The interviews were conducted with each student individually after school.

The surveys were anonymous and the data was collected online. Data collected from the surveys were analyzed using Fisher's Exact Test for Count Data. The statistical findings were supported by qualitative data recorded during interviews.

Three different sources of data collection were used in order to answer the research questions. In this way, triangulation of data was possible enabling greater confidence in the conclusions (Table 1).

Table 2
Data Triangulation Matrix

Research Questions	Data Source 1	Data Source 2	Data Source 3
What are the effects of providing videos of the lesson concepts as homework on the understanding of high school honors chemistry concepts?	Preunit and postunit multiple choice assessments	Pretreatment and posttreatment student interviews	Pretreatment and posttreatment student surveys
What are the effects of providing videos of the lesson concepts as homework on differentiation of instruction?	Instructor field observations	Pretreatment and posttreatment student interviews	Pretreatment and posttreatment student surveys
What are the effects of providing videos of the lesson concepts on students' attitude and motivation?	Instructor field observations	Pretreatment and posttreatment interviews	Pretreatment and posttreatment surveys
What are the effects of providing videos of the lesson concepts on my teaching strategies and on my feelings of professionalism and motivation?	Weekly reflection journal throughout non-treatment and treatment units	Daily teacher attitude survey	Colleague observation

Analysis of the data involved calculating the scaled percent gain in scores from the pretests to the posttests. These scaled percent gains were calculated by finding the difference in pretest and posttest scores and dividing by the possible improvement in scoring from the pretest score to 100 percent. The students' mean scaled percent gains were compared in boxplots and the differences in the medians of the distributions of nontreatment and treatment scaled percent gains were compared using the Wilcoxon Signed-Rank test.

DATA AND ANALYSIS

Out of the 13 students in the class involved in this study only 9 were present for all pretests and posttests. Data from the pretests and posttests were compared using scaled percent gains for each of two units taught with traditional teacher-directed lessons (Nontreatment 1 and Nontreatment 2) and each of three units taught using the screencasting of lessons with active learning strategies in the classroom (Treatment 1, Treatment 2, and Treatment 3). The data revealed major improvements in understanding of chemistry concepts for all five units (Figure 1).

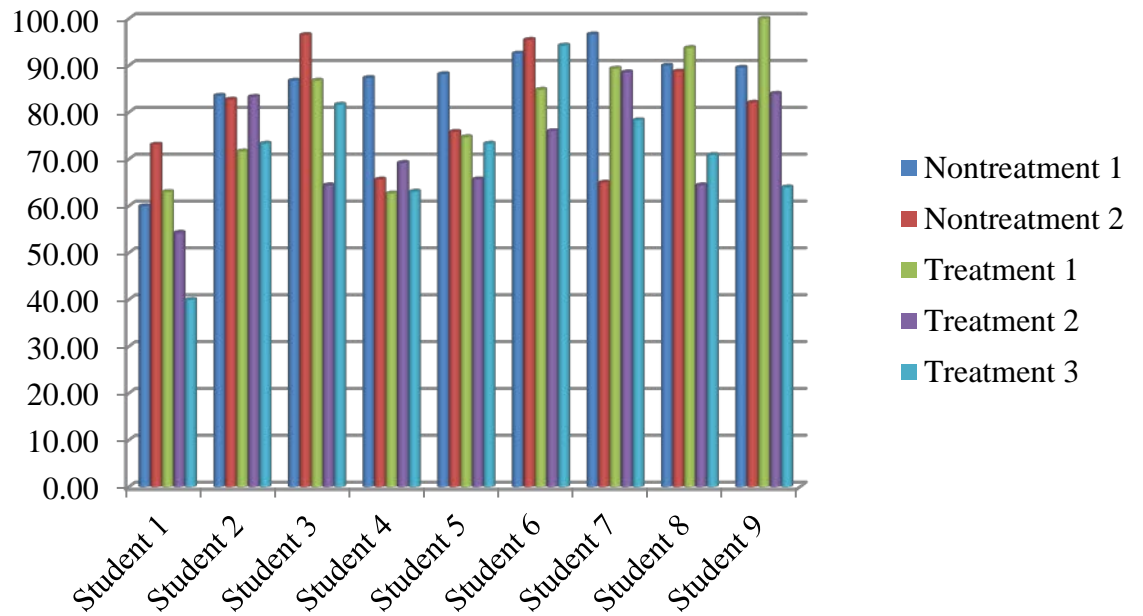


Figure 1. Scaled Percent Gain in Scores from Pretest to Posttest, ($n = 9$).

For each student the mean scaled percent gain score from the two nontreatment units of study was calculated. Similarly, the mean scaled percent gain was calculated from the three treatment units. These data for the nine students present for all pretests and posttests were compared using boxplots. It was demonstrated that the median of the mean scaled percent gain scores in the nontreatment units was higher than the median of the scores attained in the treatment units (Figure 2).

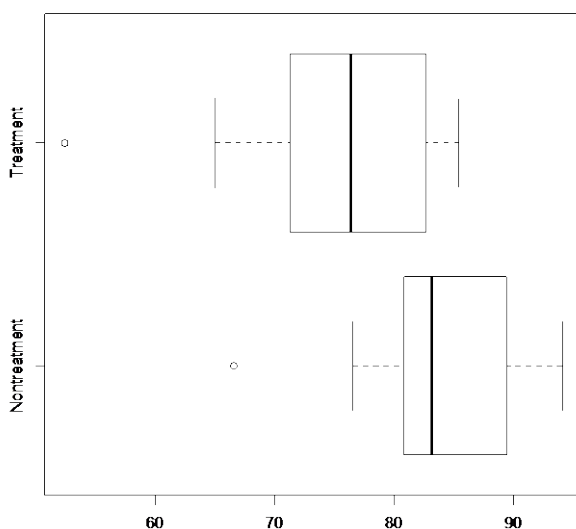


Figure 2. Boxplot of Mean Scaled Percent Change in Scores, ($n = 9$).

The Wilcoxon Signed-Rank nonparametric test established that the medians of these distributions were statistically significantly different ($p = 0.01$). The results indicated the scaled percent gain in scores was reduced during the treatment units when compared with the nontreatment units. Data from the Posttreatment Survey revealed that 18% of students *strongly agreed*, 73% *agreed* and the remaining 9% of students were *neutral* when asked if the videos helped them to learn chemistry concepts. This compares with 27% of respondents who *strongly agreed*, 64% who *agreed*, and 9% *neutral* to the Posttreatment Survey statement that teacher-directed lessons helped them learn chemistry concepts. Analysis of these posttreatment survey responses using Fisher's Exact Test for Count Data yielded a p -value greater than 0.05 ($p = 0.29$) indicating the responses did not demonstrate a statistically significant difference between the contrasting perceptions of the best way to learn chemistry concepts. During posttreatment interviews 100% of

students felt the videos helped them learn chemistry concepts and 100% of respondents to the Posttreatment Survey results *strongly agreed* or *agreed* that the videos were informative and effectively presented. The same survey results revealed 55% of students preferred to have the teacher-directed lessons in order to ask questions immediately and a student commented, “I like in class lessons because I am not good at knowing what questions to ask so I feed off my classmate’s questions.”

Field observations by the instructor determined that students experienced differentiation of instruction, but the differentiation was most effective for the high-ability students who were already more independent in their approach to learning. Some of the students with lower and average ability did not demonstrate growth in their level of independence and did not embrace the opportunity to take more responsibility for their learning. The students with lower ability did not complete the Video Rewind Surveys or demonstrated very superficial understanding of the video through their responses. When several of these students were asked about why they were not completing the surveys one student replied, “It says at the top that it wouldn’t affect my grade.” By comparison, the responses made by the students with higher ability were well considered and often included questions demonstrating synthesis and evaluation of the lesson. Only 55% of students who responded to the Posttreatment Survey felt their role as a student became more independent. However, a lower-achieving student, commenting on the value of the videos with regard to pacing, said she sometimes feels pressured in class but, “at home I can take two hours if I need it.” This student also uncovered the realization that she often asked questions in class without first trying to problem-solve independently. At home she

rewound the video, watched it again, and then figured out her misconception. She concluded that being forced to think about the lesson was a positive experience.

Comparison of the Pretreatment and Posttreatment Surveys showed slight decreases in positive attitudes and motivation after the flipped classroom model of instruction was implemented. The students' replies indicated they preferred practicing problems at home and were more inclined to take notes in traditional, teacher-directed lessons (Figures 3 and 4).

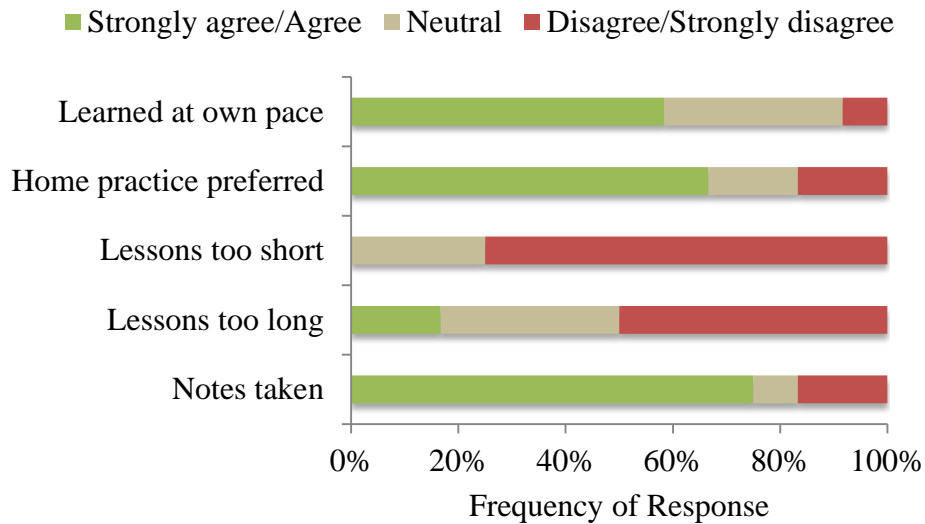


Figure 3. Attitude and Motivation Responses from the Pretreatment Survey, ($n = 12$).

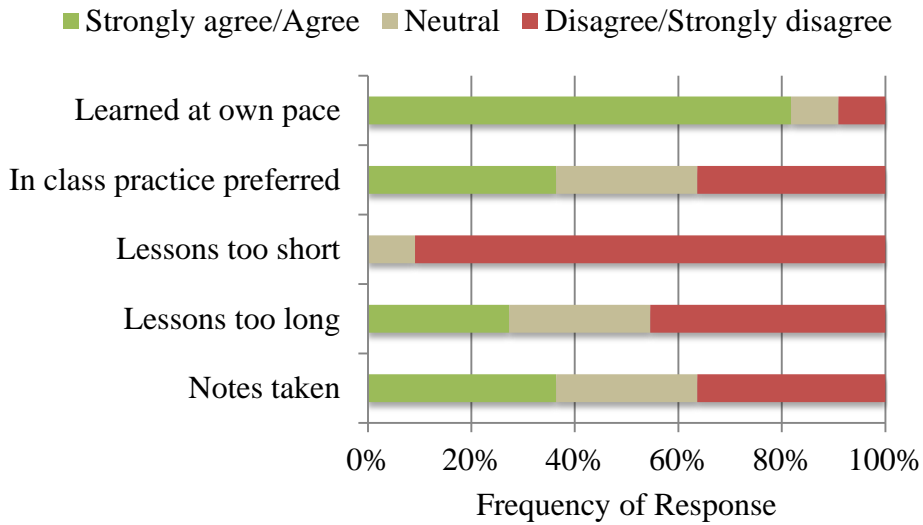


Figure 4. Attitude and Motivation Responses from the Posttreatment Survey, (n = 11).

The attitude and motivation of the teacher stayed consistent during both the nontreatment and treatment units of study. Implementation of the active learning aspect of the flipped classroom was compromised due to a reduction in the percentage of school days with a full complement of students during the treatment units of study. Increased absences occurred as a result of cancelled school days for weather events and excessive absences for extra-curricular activities such as orchestra travel trips and sports competitions (Figure 5).

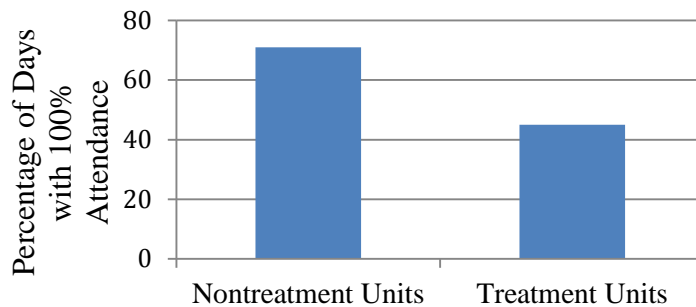


Figure 5. Comparison of Percentage of School Days with Full Attendance, (N = 13).

In light of the excessive school cancellations and absences, the use of video lessons enabled the instructor to complete the delivery of all lesson content in alignment with the pacing guidelines necessary to prepare all students for the Virginia Standards of Learning end of course exam. Students achieved a success rate of 100% on the 2014 test, the same as a similar group of students taught last year, but the percentage of pass/advanced ratings improved (Figure 6).

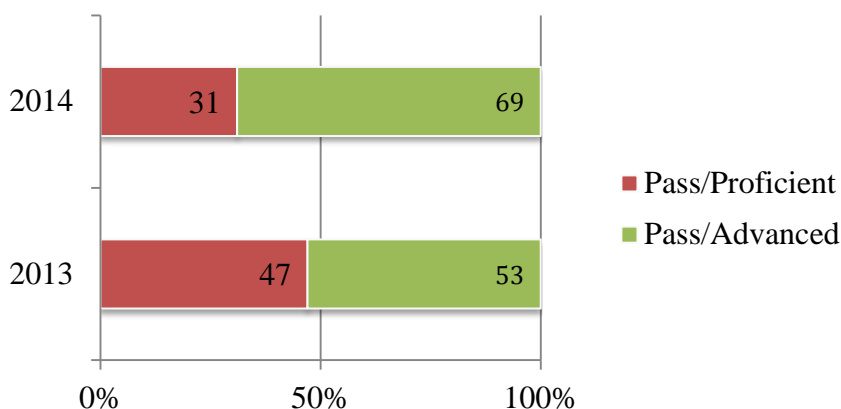


Figure 6. Percentage of Pass/Proficient vs. Pass/Advanced Standing in 2013, ($N = 15$), and 2014, ($N = 13$).

It was noted by the instructor that the use of the flipped classroom model of instruction enabled students who were traveling to return to class with all of their notes complete and MasteringChemistry[®] assignments turned in electronically. There were five students who were absent for five class periods and although they missed the active learning in the classroom they returned to school in step with the rest of the class. All students were absent for many snow days during the treatment units of study but since they were able to access the lessons online learning continued with the aid of screencasting of lessons. Without the flipped classroom delivery of course content would have been compromised.

INTERPRETATION AND CONCLUSION

The results of this study were inconclusive in determining if there was an improvement in the understanding of chemistry concepts through the use of screencasting videos of lessons. This mode of instruction did provide students with differentiation by readiness and students who demonstrated high ability and independence voiced positive attitudes towards the use of screencasting to learn at their own pace. Students of high ability and motivation are often overlooked in a multi-level classroom because they can be counted on to learn the material and achieve mastery. Teachers often need to focus energy on the lower and average ability students. The flipped classroom helped to alleviate boredom and frustration in students who learn quickly and efficiently. In order to encourage all levels of students to move towards independence, as described by Tomlinson (2004), increased oversight and accountability may be needed with students who are demonstrating lower levels of motivation.

Students did not indicate a clear preference for the flipped classroom mode of instruction but the study was impacted by excessive school cancellations and student absences during the treatment units of study. This impact was offset by the ability to continue with content delivery, but the active learning strategies and opportunities for reinforcement in the classroom were greatly reduced. Instead of a true flipped classroom, some aspects of the treatment units unavoidably became online learning. The results of the study were also limited by small sample size and the influence of variability in the difficulty of material studied. The experimental design made it difficult to account for the influence of conceptual difficulty on the change in scaled percent gain in scores from pretests to posttests. In many ways, however, these are the daily challenges of the teacher

in any classroom, whether traditional or technology driven. The teaching strategies were successful and effective, they helped to meet the learning needs of more students, and end of course test results indicated that mastery was attained in the face of many procedural challenges.

From an instructional perspective, the use of screencasting and active learning strategies required the use of unfamiliar technology, hardware, and software, and it necessitated moving away from modes of instruction that had become comfortable to new and uncharted territory. The flipped classroom requires a teacher to shift their personal paradigm of teaching and learning, encouraging growth in the teacher and student alike. Throughout time it has been demonstrated that every scientific revolution required a paradigm shift, often of colossal, groundbreaking proportions. Screencasting lessons is a valuable adjunct to traditional teacher-directed lessons.

This study has revealed that the use of the flipped classroom may help teachers to deliver content when classroom time is compromised, but students still have a need and desire for the structure and guidance provided by teacher-directed delivery of lessons. The use of this teaching strategy with independent, gifted students was completely successful and aided in differentiating instruction for these students. It provided an opportunity for students to decide on their own course pacing and enabled students to move towards independence. As a tool for the teacher of 21st century, overcommitted, technology savvy learners it was critical for the continuity of teaching and learning.

VALUE

I originally heard about the flipped classroom model of instruction several years ago. My initial reaction was negative. I felt that teaching this way would essentially make

the classroom teacher obsolete and also take away the important social interchange that is an integral part of our education system. I began to question these initial reactions about a year later when I participated in a class with a screencasting component. I found that I enjoyed the videos and used them repeatedly to improve my understanding of the content being taught. I also found that I could ask very specific questions based on the lessons being viewed. My change in attitude to this mode of instructional delivery led me to my capstone project. I wondered if my students would benefit from the ability to tailor their learning through the use of screencasts of my lessons. It was a reminder of one of the basic premises of teaching – there are many effective methods for accomplishing the learning objectives of any given course of study.

Although my students are motivated, highly achieving, computer literate youth of the 21st century, this project based on the action research model demonstrated to me that many of these young people appreciate the ability to interact with an expert in their field of study. Perhaps it is an aspect of their need for instant gratification, or youthful impatience, but they indicated a preference for a more traditional classroom. It is encouraging to know that the role of the classroom teacher is not yet obsolete.

From a practical perspective, using videos enabled the class to continue learning when weather caused school cancellations, when they were competing at a national swim meet, performing at a concert hall in Chicago, or playing second base on the junior varsity baseball team. They came back from a week of absence from class without the need to ask for anybody's class notes. They were able to view the lessons on their smartphones and the time needed for these students to catch up was markedly reduced.

As a teacher, the action research process was valuable in a number of ways. Producing videos of one's lessons is both enlightening and humbling as a teacher. It gave me the opportunity to be my own critical friend, with the ability to script, edit, and often completely revise my work. I became aware of speech mannerisms that were distracting and tried to avoid inciting boredom in my viewers. My preparation was more exacting and the presentation of the lesson more thoughtfully considered. Essentially, the creation of video lessons raised my own standards of professionalism. This increased awareness extended into all of my teaching venues and, more generally, into all verbal interactions with students and colleagues alike. One of the hallmarks of the Roanoke Valley Governor's School is the emphasis on research science. The completion of this study has elevated my ability to advise students as they move through their own research.

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APPENDICES

APPENDIX A
INSTITUTIONAL REVIEW BOARD EXEMPTION



INSTITUTIONAL REVIEW BOARD
For the Protection of Human Subjects
FWA 00000165

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 c/o Immunology & Infectious Diseases
 Montana State University
 Bozeman, MT 59718
 Telephone: 406-994-6783
 FAX: 406-994-4303
 E-mail: cherylj@montana.edu

Chair: Mark Quinn
 406-994-5721
 mquinn@montana.edu
Administrator:
 Cheryl Johnson
 406-994-6783
 cherylj@montana.edu

MEMORANDUM

TO: Sherry Otruba and John Graves
FROM: Mark Quinn, Chair *Mark Quinn et al.*
DATE: November 12, 2013
RE: "The Effects of Screencasting on the Mastery of High School Chemistry Concepts and Differentiation of Instruction" [SO111213-EX]

The above research, described in your submission of November 12, 2013, is exempt from the requirement of review by the Institutional Review Board in accordance with the Code of Federal regulations, Part 46, section 101. The specific paragraph which applies to your research is:

- (b) (1) Research conducted in established or commonly accepted educational settings, involving normal educational practices such as (i) research on regular and special education instructional strategies, or (ii) research on the effectiveness of or the comparison among instructional techniques, curricula, or classroom management methods.
- (b) (2) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior, unless: (i) information obtained is recorded in such a manner that human subjects can be identified, directly or through identifiers linked to the subjects; and (ii) any disclosure of the human subjects' responses outside the research could reasonably place the subjects at risk of criminal or civil liability, or be damaging to the subjects' financial standing, employability, or reputation.
- (b) (3) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior that is not exempt under paragraph (b)(2) of this section, if: (i) the human subjects are elected or appointed public officials or candidates for public office; or (ii) federal statute(s) without exception that the confidentiality of the personally identifiable information will be maintained throughout the research and thereafter.
- (b) (4) Research involving the collection or study of existing data, documents, records, pathological specimens, or diagnostic specimens, if these sources are publicly available, or if the information is recorded by the investigator in such a manner that the subjects cannot be identified, directly or through identifiers linked to the subjects.
- (b) (5) Research and demonstration projects, which are conducted by or subject to the approval of department or agency heads, and which are designed to study, evaluate, or otherwise examine: (i) public benefit or service programs; (ii) procedures for obtaining benefits or services under those programs; (iii) possible changes in or alternatives to those programs or procedures; or (iv) possible changes in methods or levels of payment for benefits or services under those programs.
- (b) (6) Taste and food quality evaluation and consumer acceptance studies, (i) if wholesome foods without additives are consumed, or (ii) if a food is consumed that contains a food ingredient at or below the level and for a use found to be safe, or agricultural chemical or environmental contaminant at or below the level found to be safe, by the FDA, or approved by the EPA, or the Food Safety and Inspection Service of the USDA.

Although review by the Institutional Review Board is not required for the above research, the Committee will be glad to review it. If you wish a review and committee approval, please submit 3 copies of the usual application form and it will be processed by expedited review.

APPENDIX B
CHEMICAL QUANTITIES PRETEST

Chemical Quantities Pretest

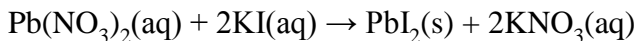
Name _____

MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question.

- 1) A reaction which forms a solid product is an example of a(n)_____.
- combustion reaction
 - oxidation-reduction reaction
 - gas evolution reaction
 - precipitation reaction
 - none of the above
- 2) Which of the following statements about balancing reactions is FALSE?
- Coefficients are added to compounds to ensure both sides of the reaction have equal numbers of each atom.
 - If there is no coefficient or subscript, a one is implied.
 - When coefficients are added the type of compounds is changed in the chemical reaction.
 - Subscripts are multiplied by the coefficients to determine the number of atoms in a compound.
 - All of the above statements are true.
- 3) What are the coefficients for the following reaction when it is properly balanced?
- $$\underline{\quad} \text{HCl} + \underline{\quad} \text{Mg} \rightarrow \underline{\quad} \text{MgCl}_2 + \underline{\quad} \text{H}_2$$
- 1, 2, 1/2, 1
 - 2, 1, 1, 1
 - 2, 1, 2, 2
 - 1, 1, 1, 2
 - none of the above
- 4) Sodium metal reacts with water to form aqueous sodium hydroxide and hydrogen gas. Which equation below best describes the balanced equation for this reaction?
- $2\text{Na} + 2\text{H}_2\text{O} \rightarrow 2\text{NaOH} (\text{aq}) + \text{H}_2 (\text{g})$
 - $\text{Na} + \text{H}_2\text{O} \rightarrow \text{NaOH} (\text{aq}) + \text{H} (\text{g})$
 - $2\text{Na} + \text{H}_2\text{O} \rightarrow \text{Na}_2\text{OH} (\text{aq}) + \text{H} (\text{g})$
 - $\text{S} + \text{H}_2\text{O} \rightarrow \text{SOH} (\text{aq}) + \text{H} (\text{g})$
 - $\text{Na} + \text{H}_2\text{O} \rightarrow \text{NaOH} (\text{aq}) + \text{H}_2 (\text{g})$
- 5) The compound sodium sulfate is soluble in water. When this compound dissolves in water, which ion listed below would be present in solution?
- Na_2^{2+}
 - S^{2-}
 - SO_4^{2-}

- D) O^{2-}
 E) none of the above

6) Considering the following precipitation reaction:



Which ion(s) would NOT be spectator ions?

- A) NO_3^- , Pb^{2+}
 B) K^+ , I^-
 C) Pb^{2+} , NO_3^-
 D) Pb^{2+} , I^-
 E) All the above ions are in the net ionic equation.

7) Identify the double displacement reactions among the following:

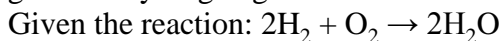
1. $KCl(aq) + AgNO_3(aq) \rightarrow AgCl(s) + KNO_3(aq)$
2. $Na_2SO_4(aq) + BaCl_2(aq) \rightarrow BaSO_4(s) + 2NaCl(aq)$
3. $H_2SO_4(aq) + 2NaOH(aq) \rightarrow Na_2SO_4(aq) + 2H_2O(l)$

- A) 1 and 3 only
 B) 1 and 2 only
 C) 2 and 3 only
 D) All of 1, 2, and 3
 E) None of 1, 2, and 3

8) Which of the following is TRUE?

- A) Stoichiometry allows prediction of how much of the reactants are necessary to form a given amount of product.
 B) Stoichiometry allows prediction of the amounts of products that form in a chemical reaction based on the amounts of reactants.
 C) Stoichiometry shows the numerical relationship between chemical quantities in a balanced chemical equation.
 D) All of the above are true.
 E) None of the above are true.

9) How many moles of water are made from complete reaction of 2.2 moles of oxygen gas with hydrogen gas?



- A) 1.1
 B) 4.4
 C) 2.2
 D) 3.3
 E) not enough information

10) How many moles of chlorine gas are needed to make 0.6 moles of sodium chloride?

Given the reaction: $2\text{Na} + \text{Cl}_2 \rightarrow 2\text{NaCl}$

- A) 3.6
- B) 0.3
- C) 0.6
- D) 1.2
- E) not enough information

11) How many grams of chlorine gas are needed to make 117 grams of sodium chloride?

Given the reaction: $2\text{Na} + \text{Cl}_2 \rightarrow 2\text{NaCl}$

- A) 71.0
- B) 35.5
- C) 142
- D) 48.2
- E) not enough information

12) Given the balanced equation $\text{CO}_2 + \text{Si} \rightarrow \text{SiO}_2 + \text{C}$, if you were to react 1 mole of CO_2 with 1 mole of Si, which statement is TRUE?

- A) The CO_2 is the limiting reactant.
- B) The SiO_2 is the limiting reactant.
- C) You have equal stoichiometric amounts of reactants.
- D) The Si is the limiting reactant.
- E) none of the above

13) If the theoretical yield of a reaction is 42.0 grams of product and the percent yield is 75%. How many grams were actually produced?

- A) 5400
- B) 1.8
- C) 56
- D) 32
- E) none of the above

14) What is the limiting reactant for the following reaction given we have 3.4 moles of $\text{Ca}(\text{NO}_3)_2$ and 2.4 moles of Li_3PO_4 ?

Reaction: $3\text{Ca}(\text{NO}_3)_2 + 2\text{Li}_3\text{PO}_4 \rightarrow 6\text{LiNO}_3 + \text{Ca}_3(\text{PO}_4)_2$

- A) LiNO_3
- B) $\text{Ca}_3(\text{PO}_4)_2$
- C) $\text{Ca}(\text{NO}_3)_2$
- D) Li_3PO_4
- E) not enough information

15) What is the limiting reactant for the reaction below given that you start with 2.50 grams C and 2.50 grams SiO_2 ?

Reaction: $\text{C} + \text{SiO}_2 \rightarrow \text{SiC} + \text{O}_2$

- A) SiO_2
- B) C
- C) SiC
- D) O_2
- E) There is no limiting reactant.

APPENDIX C
CHEMICAL QUANTITIES POSTTEST

Chemical Quantities Posttest

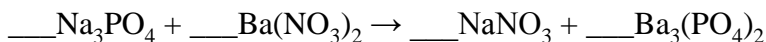
Name _____

MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question.

- 1) A reaction which forms a solid product is an example of a(n)_____.
- A) oxidation-reduction reaction
 - B) precipitation reaction
 - C) gas evolution reaction
 - D) combustion reaction
 - E) none of the above
- 2) When water is heated, bubbles form in the water. Is this evidence of a chemical reaction? Why?
- A) No, the formation of gas bubbles is a secondary chemical reaction which is ignored.
 - B) Yes, the formation of a gas is evidence of a chemical reaction.
 - C) No, boiling water is a physical change.
 - D) Yes, the formation of a gas is proof a new compound has been made.
 - E) none of the above
- 3) Which of the following statements about balancing reactions is FALSE?
- A) Subscripts are multiplied by the coefficients to determine the number of atoms in a compound.
 - B) If there is no coefficient or subscript, a one is implied.
 - C) Coefficients are added to compounds to ensure both sides of the reaction have equal numbers of each atom.
 - D) When coefficients are added the type of compounds is changed in the chemical reaction.
 - E) All of the above statements are true.
- 4) When the equation, $__ \text{O}_2 + __ \text{C}_5\text{H}_{12} \rightarrow __ \text{CO}_2 + __ \text{H}_2\text{O}$ is balanced, the coefficient of O_2 is:
- A) 5
 - B) 3
 - C) 4
 - D) 8
 - E) none of the above
- 5) What are the coefficients for the following reaction when it is properly balanced?
- $$__ \text{HCl} + __ \text{Mg} \rightarrow __ \text{MgCl}_2 + __ \text{H}_2$$
- A) 2, 1, 1, 1
 - B) 1, 2, 1/2, 1
 - C) 2, 1, 2, 2
 - D) 1, 1, 1, 2

E) none of the above

6) What are the coefficients for the following reaction when it is properly balanced?



A) 2, 3, 1, 6

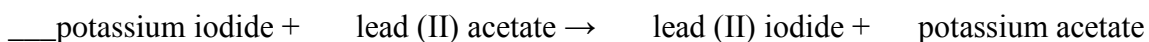
B) 2, 3, 6, 1

C) 2, 1, 1, 3

D) 6, 1, 3, 2

E) none of the above

7) What are the coefficients for the following reaction when it is properly balanced?



A) 2, 1, 1, 2

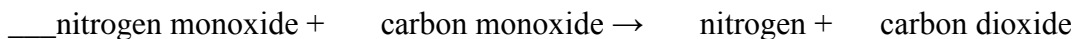
B) 3, 2, 2, 1

C) 2, 1, 1, 1

D) 1, 1, 2, 2

E) none of the above

8) What are the coefficients for the following reaction when it is properly balanced?



A) 1, 1, 2, 2

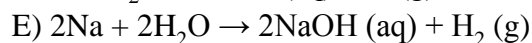
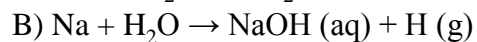
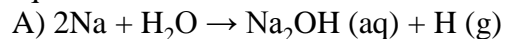
B) 2, 1, 1, 2

C) 2, 2, 2, 1

D) 2, 2, 1, 2

E) none of the above

9) Sodium metal reacts with water to form aqueous sodium hydroxide and hydrogen gas. Which equation below best describes the balanced equation for this reaction?



10) Which of the following compounds is INSOLUBLE?

A) lithium carbonate

B) magnesium bromide

C) aluminum sulfide

D) potassium acetate

E) none of the above

11) Which of the following compounds is SOLUBLE?

A) copper carbonate

- B) calcium carbonate
- C) strontium carbonate
- D) potassium carbonate
- E) none of the above

12) The compound sodium sulfate is soluble in water. When this compound dissolves in water, which ion listed below would be present in solution?

- A) O^{2-}
- B) Na_2^{2+}
- C) S^{2-}
- D) SO_4^{2-}
- E) none of the above

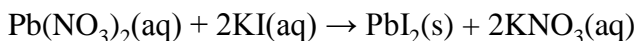
13) In writing the chemical equation for a precipitation reaction, what abbreviation of the physical state must appear with one of the products?

- A) (g)
- B) (w)
- C) (s)
- D) (l)
- E) none of the above

14) What type of a reaction occurs when a potassium nitrate solution is mixed with a barium acetate solution?

- A) gas evolution
- B) oxidation-reduction
- C) acid-base neutralization
- D) precipitation
- E) no reaction

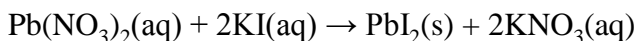
15) Considering the following precipitation reaction:



Which ion(s) would NOT be spectator ions?

- A) Pb^{2+} , I^-
- B) K^+ , I^-
- C) NO_3^- , Pb^{2+}
- D) Pb^{2+} , NO_3^-
- E) All the above ions are in the net ionic equation.

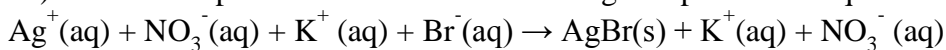
16) Considering the following precipitation reaction:



What is the correct net ionic equation?

- A) $2\text{NO}_3^- + 2\text{K}^+ \rightarrow 2\text{KNO}_3$
 B) $\text{Pb}^{2+} + 2\text{NO}_3^- + 2\text{K}^+ + 2\text{I}^- \rightarrow \text{PbI}_2(\text{s}) + 2\text{K}^+ + 2\text{NO}_3^-$
 C) $\text{Pb}^{2+} + 2\text{I}^- \rightarrow \text{PbI}_2(\text{s})$
 D) $\text{Pb}^{2+} + \text{I}_2^- \rightarrow \text{PbI}_2(\text{s})$
 E) none of the above

17) Which is a spectator ion from the following complete ionic equation:



- A) AgBr
 B) Br⁻
 C) Ag⁺
 D) K⁺
 E) none of the above

18) What is the complete ionic equation for the reaction of hydrochloric acid with potassium hydroxide?

- A) $\text{H}^+ + \text{Cl}^- + \text{K}^+ + \text{OH}^- \rightarrow \text{H}_2\text{O} + \text{K}^+ + \text{Cl}^-$
 B) $2\text{H}^+ + 2\text{Cl}^- + \text{K}^{2+} + 2\text{OH}^- \rightarrow \text{H}_2\text{O} + \text{K}^{2+} + 2\text{Cl}^-$
 C) $\text{H}^+ + \text{Cl}^- + \text{K}^+ + \text{OH}^- \rightarrow 2\text{H}^+ + \text{O}^{2-} + \text{K}^+ + \text{Cl}^-$
 D) $\text{H}^+ + \text{OH}^- \rightarrow \text{H}_2\text{O}$
 E) none of the above

19) What type of a reaction occurs when potassium metal reacts with fluorine gas?

- A) acid-base neutralization
 B) oxidation-reduction
 C) gas evolution
 D) precipitation
 E) no reaction

20) Identify the oxidation-reduction reactions among the following:

- $\text{Zn}(\text{s}) + \text{Cu}^{2+}(\text{aq}) \rightarrow \text{Zn}^{2+}(\text{aq}) + \text{Cu}(\text{s})$
- $2\text{Na}(\text{s}) + \text{Cl}_2(\text{aq}) \rightarrow 2\text{NaCl}(\text{s})$
- $2\text{Mg}(\text{s}) + \text{O}_2(\text{g}) \rightarrow 2\text{MgO}$

- A) 1 and 3 only
 B) 1 and 2 only
 C) 2 and 3 only
 D) All of 1, 2, and 3
 E) None of 1, 2, and 3

21) Methane gas (CH₄), on complete combustion in air, produces:

- CO₂
- H₂
- H₂O

- A) 2 and 3 only
B) 1 and 3 only
C) 1 and 2 only
D) All of 1 and 2 only
E) None of
- 22) What type of reaction is the generic equation $AB \rightarrow A + B$?
A) single displacement
B) decomposition
C) double-displacement
D) synthesis/combination
E) none of the above
- 23) What type of reaction is the generic equation $A + BC \rightarrow AC + B$?
A) decomposition
B) single displacement
C) synthesis/combination
D) double-displacement
E) none of the above
- 24) Identify the double displacement reactions among the following:
1. $KCl(aq) + AgNO_3(aq) \rightarrow AgCl(s) + KNO_3(aq)$
2. $Na_2SO_4(aq) + BaCl_2(aq) \rightarrow BaSO_4(s) + 2NaCl(aq)$
3. $H_2SO_4(aq) + 2NaOH(aq) \rightarrow Na_2SO_4(aq) + 2H_2O(l)$
A) 1 and 3 only
B) 2 and 3 only
C) 1 and 2 only
D) All of 1, 2, and 3
E) None of 1, 2, and 3
- 25) The reaction $CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g)$ is
A) a redox reaction.
B) a combustion reaction.
C) an exothermic reaction.
D) all of the above
E) none of the above
- 26) Which of the following is TRUE?
A) Stoichiometry allows prediction of the amounts of products that form in a chemical reaction based on the amounts of reactants.
B) Stoichiometry allows prediction of how much of the reactants are necessary to form a given amount of product.
C) Stoichiometry shows the numerical relationship between chemical quantities in a balanced chemical equation.
D) All of the above are true.
E) None of the above are true.

27) How many waffles can be made from 1 dozen eggs, assuming you have enough of all other ingredients?

Given: 2 cups flour + 3 eggs + 1 tbs oil \rightarrow 4 waffles

- A) 4
- B) 16
- C) 12
- D) 48
- E) not enough information

28) How many moles of water are made from complete reaction of 2.2 moles of oxygen gas with hydrogen gas?

Given the reaction: $2\text{H}_2 + \text{O}_2 \rightarrow 2\text{H}_2\text{O}$

- A) 2.2
- B) 1.1
- C) 4.4
- D) 3.3
- E) not enough information

29) How many moles of chlorine gas are needed to make 0.6 moles of sodium chloride?

Given the reaction: $2\text{Na} + \text{Cl}_2 \rightarrow 2\text{NaCl}$

- A) 3.6
- B) 0.6
- C) 0.3
- D) 1.2
- E) not enough information

30) How many moles of aluminum are needed to make 9 moles of molecular hydrogen?

Given the reaction: $2\text{Al} + 6\text{HCl} \rightarrow 2\text{AlCl}_3 + 3\text{H}_2$

- A) 3 moles
- B) 2 moles
- C) 6 moles
- D) 4 moles
- E) none of the above

31) How many grams of water are made from the reaction of 16.0 grams of oxygen gas?

Given the reaction: $2\text{H}_2 + \text{O}_2 \rightarrow 2\text{H}_2\text{O}$

- A) 16
- B) 36
- C) 18
- D) 9
- E) not enough information

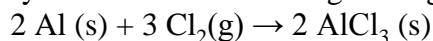
32) How many grams of chlorine gas are needed to make 117 grams of sodium chloride?

Given the reaction: $2\text{Na} + \text{Cl}_2 \rightarrow 2\text{NaCl}$

- A) 142

- B) 35.5
- C) 48.2
- D) 71.0
- E) not enough information

33) Many metals react with halogens to give metal halides. For example,



If you begin with 13.5 g of aluminum,

- A) you will need 26.6 g Cl_2 for complete reaction and will produce 49.0 g of AlCl_3 .
- B) you will need 11.8 g Cl_2 for complete reaction and will produce 49.0 g of AlCl_3 .
- C) you will need 53.2 g Cl_2 for complete reaction and will produce 66.7 g of AlCl_3 .
- D) you will need 23.6 g Cl_2 for complete reaction and will produce 66.7 g of AlCl_3 .
- E) none of the above

34) What is the theoretical yield of waffles if you have 5 cups of flour, 9 eggs and 3 tbs of oil?

Given: 2 cups flour + 3 eggs + 1 tbs oil \rightarrow 4 waffles

- A) 12
- B) 10
- C) 6
- D) 4
- E) not enough information

35) Consider the following generic chemical equation: $2\text{W} + 3\text{X} \rightarrow 3\text{Y} + \text{Z}$

When 5 units of W and 6 units of X are allowed to react, the limiting reactant would be:

- A) X
- B) Y
- C) Z
- D) W
- E) There is no limiting reactant in this situation.

36) Given the balanced equation $\text{CO}_2 + \text{Si} \rightarrow \text{SiO}_2 + \text{C}$, if you were to react 1 mole of CO_2 with 1 mole of Si, which statement is TRUE?

- A) The CO_2 is the limiting reactant.
- B) You have equal stoichiometric amounts of reactants.
- C) The SiO_2 is the limiting reactant.
- D) The Si is the limiting reactant.
- E) none of the above

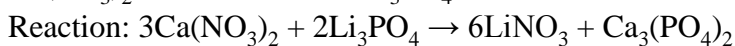
37) If the theoretical yield of a reaction is 42.0 grams of product and the percent yield is 75%. How many grams were actually produced?

- A) 5400
- B) 1.8
- C) 56
- D) 32
- E) none of the above

38) The theoretical yield of a reaction is 75.0 grams of product and the actual yield is 42.0g. What is the percent yield?

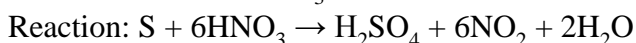
- A) 178
- B) 75.0
- C) 31.5
- D) 56.0
- E) none of the above

39) What is the limiting reactant for the following reaction given we have 3.4 moles of $\text{Ca}(\text{NO}_3)_2$ and 2.4 moles of Li_3PO_4 ?



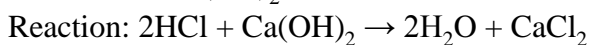
- A) LiNO_3
- B) $\text{Ca}(\text{NO}_3)_2$
- C) $\text{Ca}_3(\text{PO}_4)_2$
- D) Li_3PO_4
- E) not enough information

40) How many grams of NO_2 are theoretically produced if we start with 1.20 moles of S and 9.90 moles of HNO_3 ?



- A) 331
- B) 786
- C) 7.20
- D) 455
- E) not enough information

41) What is the excess reactant for the following reaction given we have 2.6 moles of HCl and of $\text{Ca}(\text{OH})_2$?



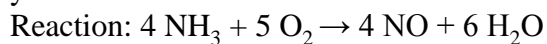
- A) CaCl_2
- B) HCl
- C) $\text{Ca}(\text{OH})_2$
- D) H_2O
- E) not enough information

42) What is the limiting reactant for the reaction below given that you start with 2.50 grams C and 2.50 grams SiO_2 ?



- A) C
- B) O₂
- C) SiO₂
- D) SiC
- E) There is no limiting reactant.

43) A sample of 8.5 g NH₃ on oxidation produces 4.5 g of NO. Calculate the percent yield.



- A) 30%
- B) 70%
- C) 60%
- D) 15 %
- E) none of the above

44) Consider the following reaction: $2 \text{ Mg} + \text{ O}_2 \rightarrow 2 \text{ MgO}$ $\Delta H_{\text{rxn}} = -1203 \text{ kJ}$

Calculate the amount of heat (in kJ) associated with complete reaction of 4 moles of Mg.

- A) -4812 kJ
- B) -1203 kJ
- C) -2406 kJ
- D) -601.5 kJ
- E) none of the above

45) The reaction of one mole of nitrogen gas with three moles of hydrogen gas releases 92 kJ of

thermal energy to the surroundings. Which of the following is TRUE?

- A) This reaction has a negative enthalpy of reaction.
- B) This reaction is exothermic.
- C) Complete reaction of two moles of nitrogen gas would release 184 kJ of thermal energy in this reaction.
- D) All of the above are true.
- E) None of the above are true.

APPENDIX D
GASES PRETEST

Gases Pretest

Name _____

MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question.

- 1) Which of following statements are consistent with the Kinetic Molecular Theory?
- A) Gas particles collide with each other and surfaces without losing any energy.
 - B) Gases are compressible because the volume of atoms is almost entirely open space.
 - C) Gases assume the shape and volume of their container because they are in constant, straight-line motion.
 - D) Gases have a low density because there is so much empty space between the particles.
 - E) All of the above statements are consistent with the Kinetic Molecular Theory.
- 2) What is the equivalent pressure of 0.905 atm in units of mm Hg?
- A) 840
 - B) 688
 - C) 0.905
 - D) 13.3
 - E) none of the above
- 3) To solve problems using Boyle's Law, which mathematical equation should be used?
- A) $\frac{V_1}{P_1} = \frac{V_2}{P_2}$
 - B) $\frac{P_1}{V_1} = \frac{P_2}{V_2}$
 - C) $P_2V_1 = P_1V_2$
 - D) $P_1V_1 = P_2V_2$
 - E) none of the above
- 4) The initial volume of a gas cylinder is 750.0 mL. If the pressure of a gas inside the cylinder changes from to , what is the final volume the gas occupies?
- A) 1.750 L
 - B) 3.151 L
 - C) 630.0 mL
 - D) 321.4 mL
 - E) none of the above
- 5) Charles's Law describes the relationship between the
- A) temperature and volume of a gas, with pressure held constant
 - B) pressure and volume of a gas, with temperature held constant
 - C) pressure and temperature of a gas, with volume held constant

- D) temperature, pressure, and volume of a gas
 E) none of the above

6) A balloon originally had a volume of 0.439 L at 44°C and a pressure of 729

torr. To what temperature must the balloon be cooled to reduce its volume to 378 mL if the pressure remained constant?

- A) 38°C
 B) 95°C
 C) 0°C
 D) 273°C
 E) none of the above

7) What is the proper form of the combined gas law?

- A) $\frac{V_1 T_1}{P_1} = \frac{V_2 T_2}{P_2}$
 B) $\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$
 C) $\frac{P_1 T_1}{V_1} = \frac{P_2 T_2}{V_2}$
 D) $P_1 V_1 T_1 = P_2 V_2 T_2$
 E) none of the above

8) A sample of helium gas initially at 37.0°C, 785 torr and was heated to 58.0°C while the volume expanded to . What is the final pressure in atm?

- A) 3.21
 B) 517
 C) 1.79
 D) 0.681
 E) none of the above

9) According to the Ideal Gas Law, which set of changes will result in a decrease in the volume of a gas (when all other conditions remain constant)?

1. an increase in pressure
2. an increase in temperature
3. a decrease in the number of gas particles

A) 1, 2, and 3 B) 1 only C) 2 only D) 1 and 2 E) 1 and 3

10) Which conditions can cause nonideal gas behavior by 1) decreasing the space between gas particles or 2) by slowing gas particles so that interactions are significant?

- A) 1) high pressure; 2) low temperature
 B) 1) low pressure; 2) high temperature
 C) 1) low pressure ; 2) low temperature
 D) 1) high pressure; 2) high temperature

E) none of the above

11) 19.08 grams of which diatomic element would exert a pressure of 3630 mm Hg at 100°C in a 3.82 L container?

- A) H_2
- B) Br_2
- C) O_2
- D) F_2
- E) not enough information.

12) Hydrogen gas produced by a chemical reaction is collected over water at 24°C . It occupies a volume of 495 mL, and the atmospheric pressure in the room is 98.60 kPa. The partial pressure of water at 24°C is 2.99 kPa. How many grams of hydrogen gas were collected?

- A) 0.200
- B) 0.0200
- C) 0.0193
- D) 0.0399
- E) 0.0386

13) If a mixture of gases contained 78% nitrogen at a pressure of 984 torr and 22% carbon dioxide at 345 torr, what is the total pressure of the system?

- A) 17.5 cm Hg
- B) 1.75 atm
- C) 1,329 atm
- D) 639 torr
- E) none of the above

14) At constant volume, a sample of a gas will exert a higher pressure at 80°C than it will at 20°C . This is due to

1. the gas particles colliding with each other more frequently
2. the gas particles colliding with the walls of the container more frequently
3. the gas particles having more energy when they collide

- A) 1 only
- B) 2 only
- C) 1 and 2
- D) 1 and 3
- E) 2 and 3

15) Suppose you had a balloon containing 1 mole of helium at STP and a balloon containing 1 mole of oxygen at STP. Which statement is TRUE?

- A) The balloons will have the same volume.
- B) The balloons will have the same mass.
- C) Both A) and B) are true.
- D) Neither A) nor B) are true.
- E) not enough information

APPENDIX E
GASES POSTEST

Gases Posttest

Name _____

MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question.

1) A 3.76 g sample of a noble gas is stored in a 2.00 L vessel at 874 torr and 25°C. What is the noble gas?

($R = 0.0821 \text{ L atm/mol K}$)

- A) He
- B) Ne
- C) Ar
- D) Kr
- E) not enough information

2) A balloon originally had a volume of 0.439 L at 44°C and a pressure of 729 torr. To what temperature must the balloon be cooled to reduce its volume to 378 mL if the pressure remained constant?

- A) 273°C
- B) 38°C
- C) 0°C
- D) 95°C
- E) none of the above

3) Gas density can be calculated by dividing the mass of gas by its volume. If you took a balloon of gas and then warmed the balloon in a sunny window, what can now be said about the density of the gas in the balloon?

- A) The gas density will increase.
- B) The gas density will decrease.
- C) The gas density will remain the same.
- D) The density of gases is independent of temperature.
- E) none of the above

4) Which set of conditions reflect STP?

- A) 25°C, 14.7 psi
- B) 298 K, 1 atm
- C) 373 K, 760 torr
- D) 273 K, 760 mm Hg
- E) 273 K, 1 Pa

5) One liter of a gas is in a sealed chamber containing a moveable piston. If the piston is moved so that the volume of the gas is compressed to a volume of one-half liter, what will happen to the pressure on the gas? (Assume the temperature is constant and no gas particles are lost.)

- A) It would be impossible to move the piston since gases are not compressible.
- B) The pressure will remain the same.

- C) The pressure will be half of the original value.
D) The pressure will be twice the original value.
E) none of the above
- 6) Divers often inflate heavy duty balloons attached to salvage items on the sea floor. If a balloon is filled to a volume of V_1 at a pressure of P_1 , what is the volume of the balloon when it reaches the surface?
A) 5.50 L
B) 0.833 L
C) 1.20 L
D) 7.50 L
E) none of the above
- 7) Which conditions can cause nonideal gas behavior by 1) decreasing the space between gas particles or 2) by slowing gas particles so that interactions are significant?
A) 1) high pressure; 2) low temperature
B) 1) low pressure; 2) high temperature
C) 1) low pressure ; 2) low temperature
D) 1) high pressure; 2) high temperature
E) none of the above
- 8) What is the temperature ($^{\circ}\text{C}$) of 2.48 moles of gas stored in a 30.0 L container at 1559 mm Hg? ($R = 0.0821 \text{ L atm/ mol K}$)
A) -84
B) 189
C) 302
D) 29
E) none of the above
- 9) What is the final volume of a balloon that was initially 500.0 mL at 25°C and was then heated to 50°C ?
A) 461 mL
B) 1.00 L
C) 542 mL
D) 193 mL
E) none of the above
- 10) Charles's Law describes the relationship between the
A) pressure and volume of a gas, with temperature held constant
B) pressure and temperature of a gas, with volume held constant
C) temperature and volume of a gas, with pressure held constant
D) temperature, pressure, and volume of a gas
E) none of the above
- 11) A sample of helium gas initially at 37.0°C , 785 torr and 2.00 L was heated to 58.0°C while the volume expanded to 3.24 L. What is the final pressure in atm?

- A) 3.21
- B) 1.79
- C) 0.681
- D) 517
- E) none of the above

12) For an ideal gas, which of the following pairs of variables are inversely proportional to each other (if all other factors remain constant)?

- A) P, T
- B) n, P
- C) P, V
- D) V, T
- E) none of the above

13) A certain volume of gas was confined in a rigid container. If the pressure of the gas sample in the container was doubled, what happened to the temperature?

- A) The temperature increased four times.
- B) The temperature doubled.
- C) The temperature decreased one-third.
- D) The temperature became one half.
- E) not enough information

14) What is the proper form of the combined gas law?

- A) $\frac{V_1 T_1}{P_1} = \frac{V_2 T_2}{P_2}$
- B) $\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$
- C) $\frac{P_1 T_1}{V_1} = \frac{P_2 T_2}{V_2}$
- D) $P_1 V_1 T_1 = P_2 V_2 T_2$
- E) none of the above

15) Ammonia gas decomposes according to the equation:



If 15.0 L of nitrogen is formed at STP, how many liters of hydrogen will be produced (also measured at STP)?

- A) 30.0 L
- B) 15.0 L
- C) 45.0 L
- D) 90.0 L
- E) not enough information

16) The initial volume of a gas cylinder is 750.0 mL. If the pressure of a gas inside the cylinder changes from 840.0 mm Hg to 360.0 mm Hg, what is the final volume the gas occupies?

- A) 321.4 mL
- B) 3.151 L
- C) 630.0 mL
- D) 1.750 L
- E) none of the above

- 17) Which of following statements are consistent with the Kinetic Molecular Theory?
- A) Gases assume the shape and volume of their container because they are in constant, straight-line motion.
 - B) Gas particles collide with each other and surfaces without losing any energy.
 - C) Gases are compressible because the volume of atoms is almost entirely open space.
 - D) Gases have a low density because there is so much empty space between the particles.
 - E) All of the above statements are consistent with the Kinetic Molecular Theory.

18) 19.08 grams of which diatomic element would exert a pressure of 3630 mm Hg at 100°C in a 3.82 L container?

- A) Br₂
- B) F₂
- C) H₂
- D) O₂
- E) not enough information.

19) Hydrogen gas produced by a chemical reaction is collected over water at 24°C. It occupies a volume of 495 mL, and the atmospheric pressure in the room is 98.60 kPa. The partial pressure of water at 24°C is 2.99 kPa. How many grams of hydrogen gas were collected?

- A) 0.0386 B) 0.0399 C) 0.0193 D) 0.0200 E) 0.200

20) To solve problems using Charles's Law, which mathematical equation should be used?

- A) $\frac{P_1}{V_2} = \frac{P_2}{V_1}$
- B) $\frac{V_1}{T_1} = \frac{V_2}{T_2}$
- C) $P_2V_1 = P_1V_2$
- D) $T_1V_1 = T_2V_2$
- E) none of the above

21) Which of the following statements is TRUE for gases?

1. The temperature of a gas is inversely proportional to its pressure.
2. The volume of a gas is directly proportional to the pressure in torr.
3. The pressure of a gas is due to collisions of the gas molecules.

- A) 3 only
- B) 1 only
- C) 2 only
- D) 1 and 2 only
- E) 1 and 3 only

22) If the initial pressure of a system was 1.00 atm and the volume was halved and the temperature was tripled, what is the final pressure?

- A) 6.00 atm
- B) 2.00 atm
- C) 1.50 atm
- D) 0.667 atm
- E) not enough information

23) The vapor pressure of water at 20.0°C is . If the pressure of a gas collected over water was measured to be 453.0 mm Hg. What is the pressure of the pure gas?

- A) 0.619 atm
- B) 0.0230 atm
- C) 0.573 atm
- D) 0.596 atm
- E) none of the above

24) How many liters of O₂ (g) are needed to react completely with 56.0 L of CH₄ (g) at STP to produce CO₂ (g) and H₂O (g)?

Given: $\text{CH}_4(\text{g}) + 2\text{O}_2(\text{g}) \rightarrow \text{CO}_2(\text{g}) + \text{H}_2\text{O}(\text{g})$

- A) 28.0 L
- B) 56.0 L
- C) 112. L
- D) 84.0 L
- E) none of the above

25) What is the equivalent pressure of 0.905 atm in units of mm Hg?

- A) 688
- B) 0.905
- C) 840
- D) 13.3
- E) none of the above

26) What is the major component of the air we breathe?

- A) oxygen
- B) smog
- C) argon
- D) nitrogen
- E) carbon dioxide

27) What is the final volume of a 500.0 mL gas container that increased in temperature

- from 299 K to 333 K while the pressure increased from 1.00 atm to 1.54 atm?
- A) 2.77 L
 - B) 1.45 L
 - C) 0.362 L
 - D) 0.691 L
 - E) none of the above
- 28) 1 atm is equal to:
- A) 760 mm Hg.
 - B) 760 torr.
 - C) 14.7 psi.
 - D) 101,325 Pa.
 - E) all of the above
- 29) What is the initial temperature of a gas if the volume changed from 1.00 L to 1.10 L and the final temperature was determined to be 255.0°C?
- A) 232°C
 - B) 207°C
 - C) -41°C
 - D) 480°C
 - E) none of the above
- 30) What problem could happen if deep sea divers used pure oxygen in their tanks?
- A) nitrogen narcosis
 - B) rapture of oxygen
 - C) oxygen toxicity
 - D) hypoxia
 - E) none of the above
- 31) Suppose you had a balloon containing 1 mole of helium at STP and a balloon containing 1 mole of oxygen at STP. Which statement is TRUE?
- A) The balloons will have the same volume.
 - B) The balloons will have the same mass.
 - C) Both A) and B) are true.
 - D) Neither A) nor B) are true.
 - E) not enough information
- 32) According to the Ideal Gas Law, which set of changes will result in a decrease in the volume of a gas (when all other conditions remain constant)?
1. an increase in pressure
 2. an increase in temperature
 3. a decrease in the number of gas particles
- A) 1, 2, and 3 B) 1 only C) 2 only D) 1 and 2 E) 1 and 3
- 33) If a mixture of gases contained 78% nitrogen at a pressure of 984 torr and 22% carbon dioxide at 345 torr, what is the total pressure of the system?

- A) 1,329 atm
- B) 17.5 cm Hg
- C) 1.75 atm
- D) 639 torr
- E) none of the above

34) To solve problems using Boyle's Law, which mathematical equation should be used?

- A) $\frac{V_1}{P_1} = \frac{V_2}{P_2}$
- B) $\frac{P_1}{V_1} = \frac{P_2}{V_2}$
- C) $P_2V_1 = P_1V_2$
- D) $P_1V_1 = P_2V_2$
- E) none of the above

APPENDIX F

MODEL OF THE ATOM AND PERIODIC TRENDS PRETEST

Model of the Atom and Periodic Trends Pretest

Name _____

MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question.

- 1) Which among the following statements is TRUE?
 - A) Red light has a shorter wavelength than violet light.
 - B) The wavelength of light is inversely related to its energy.
 - C) As the energy increases, the frequency of radiation decreases.
 - D) As the wavelength increases, the frequency also increases.
 - E) none of the above

- 2) Which form of electromagnetic radiation has the lowest frequency?
 - A) Gamma Rays
 - B) Infrared Radiation
 - C) Microwaves
 - D) Radio Waves
 - E) X-rays

- 3) What happens to an atom when it absorbs energy?
 - A) The atom re-emits the energy as light.
 - B) The atom stores the energy for later use.
 - C) The extra energy increases the speed of the electrons in their orbitals.
 - D) The atom re-emits the energy as heat.
 - E) none of the above

- 4) The principal quantum number (n):
 - A) specifies the subshell of the orbital.
 - B) specifies the principal shell of the orbital.
 - C) specifies the 3-D shape of the orbital.
 - D) specifies the maximum number of electrons.
 - E) none of the above

- 5) How many subshells are there in the $n = 2$ principal shell?
 - A) 1
 - B) 2
 - C) 4
 - D) 3
 - E) not enough information

- 6) Which one of the following is the correct orbital diagram for nitrogen?
 - A) $\uparrow\downarrow$ $\uparrow\downarrow$ \downarrow \downarrow \uparrow
 - B) $\uparrow\downarrow$ $\downarrow\downarrow$ \uparrow \uparrow \uparrow
 - C) $\uparrow\downarrow$ $\downarrow\downarrow$ \downarrow \uparrow \uparrow
 - D) $\uparrow\downarrow$ $\uparrow\downarrow$ \uparrow \uparrow \uparrow

- E) none of the above
- 7) How many electrons can exist in an orbital?
A) 3
B) 1
C) 4
D) 2
E) none of the above
- 8) Which orbital would the electron of a ground state hydrogen atom occupy?
A) 1p
B) 2p
C) 0s
D) 1s
E) none of the above
- 9) What is the electron configuration for P?
A) $[\text{Ar}]3s^23p^3$
B) $[\text{Ne}]3s^23p^3$
C) $[\text{Ne}]1s^21p^62s^22p^3$
D) $[\text{Ar}]3s^23p^64s^23d^{10}4p^3$
E) none of the above
- 10) How many valence electrons are in a chlorine atom?
A) 7
B) 1
C) 17
D) 10
E) none of the above
- 11) What do the alkali metals all have in common?
A) They all have similar physical properties.
B) They all form +1 ions.
C) They all have the same number of valence electrons.
D) They all undergo similar reactions.
E) all of the above
- 12) Consider the electron configuration of the ion to determine which ion shown below has an incorrect ionic charge?
A) Rb^+
B) Al^{3-}
C) Ba^{2+}
D) Se^{2-}
E) none of the above

- 13) Which of the following elements has the lowest ionization energy?
A) Rb B) He C) C D) F E) Na
- 14) Which of the following atoms is the largest?
A) Li B) Cs C) Na D) K E) Rb
- 15) Which of the following atoms has the least metallic character?
A) K B) Cs C) Rb D) Na E) Li

APPENDIX G

MODEL OF THE ATOM AND PERIODIC TRENDS POSTTEST

Model of the Atom and Periodic Trends Posttest

Name _____

MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question.

1) Determine the answer to the following equation with correct number of significant figures:

$$2.02 + 8.102 - 0.0297 = \underline{\hspace{2cm}}$$

- A) 10.0923
 - B) 10.092
 - C) 10.09
 - D) 10.1
 - E) none of the above
- 2) The distance between adjacent wave crests is called
- A) frequency.
 - B) trough.
 - C) nu.
 - D) wavelength.
 - E) none of the above
- 3) Which among the following statements is TRUE?
- A) The wavelength of light is inversely related to its energy.
 - B) Red light has a shorter wavelength than violet light.
 - C) As the wavelength increases, the frequency also increases.
 - D) As the energy increases, the frequency of radiation decreases.
 - E) none of the above
- 4) Which color of the visible spectrum has the longest wavelength (750 nm)?
- A) red
 - B) violet
 - C) orange
 - D) yellow
 - E) green
- 5) Which form of electromagnetic radiation has the shortest wavelength?
- A) Gamma Rays
 - B) Radio Waves
 - C) X-rays
 - D) Infrared Radiation
 - E) Microwaves
- 6) Which form of electromagnetic radiation has the lowest frequency?
- A) X-rays
 - B) Radio Waves
 - C) Gamma Rays
 - D) Infrared Radiation
 - E) Microwaves

- 7) The correct decimal representation of 1.201×10^{-7} is:
A) 0.0000001201
B) 1201.000
C) 12010000
D) 0.0001201
E) none of the above
- 8) What happens to an atom when it absorbs energy?
A) The extra energy increases the speed of the electrons in their orbitals.
B) The atom re-emits the energy as light.
C) The atom stores the energy for later use.
D) The atom re-emits the energy as heat.
E) none of the above
- 9) Determine the answer for the equation below with correct number of significant figures:
 $3.215 \times 13.2 \div 0.218 = \underline{\hspace{2cm}}$
A) 194.669
B) 194.7
C) 195
D) 194.67
E) none of the above
- 10) When sunlight is passed through a prism, what is observed?
A) white light
B) nothing
C) continuous spectrum
D) bright spots and lines
E) none of the above
- 11) The principal quantum number (n):
A) specifies the 3-D shape of the orbital.
B) specifies the principal shell of the orbital.
C) specifies the subshell of the orbital.
D) specifies the maximum number of electrons.
E) none of the above
- 12) The subshell letter:
A) specifies the principal quantum number of the orbital.
B) specifies the principal shell of the orbital.
C) specifies the maximum number of electrons.
D) specifies the 3-D shape of the orbital.
E) none of the above
- 13) How many subshells are there in the $n = 4$ principal shell?

- A) 4
- B) 1
- C) 2
- D) 3
- E) not enough information

14) How many subshells are there in the $n = 2$ principal shell?

- A) 2
- B) 1
- C) 3
- D) 4
- E) not enough information

15) The $n = \underline{\hspace{2cm}}$ principal shell is the lowest that may contain a d-subshell.

- A) 2
- B) 4
- C) 1
- D) 3
- E) not enough information

16) Which subshell letter corresponds to a spherical orbital?

- A) s
- B) d
- C) f
- D) p
- E) not enough information

17) Which one of the following is the correct orbital diagram for nitrogen?

- A) $\uparrow\downarrow$ $\downarrow\downarrow$ \downarrow \uparrow \uparrow
- B) $\uparrow\downarrow$ $\downarrow\downarrow$ \uparrow \uparrow \uparrow
- C) $\uparrow\downarrow$ $\uparrow\downarrow$ \uparrow \uparrow \uparrow
- D) $\uparrow\downarrow$ $\uparrow\downarrow$ \downarrow \downarrow \uparrow
- E) none of the above

18) The "d" subshell can hold a maximum of $\underline{\hspace{2cm}}$ electrons.

- A) 2
- B) 6
- C) 5
- D) 10
- E) none of the above

19) How many electrons can exist in an orbital?

- A) 3
- B) 4
- C) 1
- D) 2

- E) none of the above
- 20) The lowest energy orbital in the quantum-mechanical model is the
- A) 1s orbital.
 - B) 1a orbital.
 - C) zero orbital.
 - D) 1p orbital.
 - E) none of the above
- 21) Which orbital would the electron of a ground state hydrogen atom occupy?
- A) 2p
 - B) 1p
 - C) 0s
 - D) 1s
 - E) none of the above
- 22) How many electrons are unpaired in the orbitals of carbon?
- A) 6
 - B) 12
 - C) 4
 - D) 2
 - E) none of the above
- 23) An accepted abbreviation format is to write an electron configuration that includes a noble gas symbol in brackets. If you were writing an electron configuration for a bromine atom, which elemental symbol would you place in the bracket?
- A) Ar
 - B) Xe
 - C) Ne
 - D) He
 - E) Kr
- 24) Which element is represented by the electron configuration $1s^2 2s^2 2p^2$?
- A) O
 - B) C
 - C) Be
 - D) He
 - E) none of the above
- 25) What is the electron configuration for Ga?
- A) $1s^2 2s^2 2p^6 3s^2 3p^5 3d^{10} 4s^2 4p^1$
 - B) $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 4d^{10} 4p^1$
 - C) $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^1$
 - D) $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6$
 - E) none of the above
- 26) What is the electron configuration for P?
- A) $[\text{Ar}]3s^2 3p^6 4s^2 3d^{10} 4p^3$
 - B) $[\text{Ar}]3s^2 3p^3$

- C) $[\text{Ne}]1s^21p^62s^22p^3$
- D) $[\text{Ne}]3s^23p^3$
- E) none of the above

27) How many core electrons are in a chlorine atom?

- A) 1
- B) 17
- C) 7
- D) 10
- E) none of the above

28) How many valence electrons are in a chlorine atom?

- A) 17
- B) 10
- C) 7
- D) 1
- E) none of the above

29) The element with a completely filled p-subshell is

- A) Na
- B) Ar
- C) Al
- D) P
- E) none of the above

30) What do the alkali metals all have in common?

- A) They all have similar physical properties.
- B) They all have the same number of valence electrons.
- C) They all undergo similar reactions.
- D) They all form +1 ions.
- E) all of the above

31) Which of the following elements has the electron configuration of $3s^23p^4$ in its outermost shell?

- A) Cl
- B) Al
- C) Si
- D) S
- E) none of the above

32) Chlorine and bromine have very similar chemical properties. This is best explained by the fact that both elements

- A) have the same number of valence electrons.
- B) are gases.
- C) are in period 3 of the Periodic Table.
- D) have equal number of protons and electrons.

- E) none of the above
- 33) Consider the electron configuration of the ion to determine which ion shown below has an incorrect ionic charge?
- A) Ba^{2+}
 - B) Al^{3-}
 - C) Se^{2-}
 - D) Rb^{+}
 - E) none of the above
- 34) Which one of the following species has the electron configuration of $1s^2 2s^2 2p^6$?
- 1. Na^{+}
 - 2. O^{2-}
 - 3. F^{-}
- A) 1 and 3 only
 - B) 1 and 2 only
 - C) 2 and 3 only
 - D) All of 1, 2, and 3
 - E) Neither 1, 2, or 3
- 35) The size of an atom generally increases
- A) down a group and from left to right across a period.
 - B) up a group and diagonally across the Periodic Table.
 - C) up a group and from left to right across a period.
 - D) down a group and from right to left across a period.
 - E) up a group and from right to left across a period.
- 36) Which of the following elements has the lowest ionization energy?
- A) Na
 - B) F
 - C) He
 - D) Rb
 - E) C
- 37) Which of the following atoms is the largest?
- A) Li
 - B) Na
 - C) Rb
 - D) Cs
 - E) K
- 38) Which of the following atoms has the least metallic character?
- A) K
 - B) Cs
 - C) Na
 - D) Rb
 - E) Li
- 39) How many low dose 81 mg aspirin tablets can be made from 1.21 kg of aspirin?
- A) 1.21×10^4 tablets
 - B) 1.5×10^3 tablets
 - C) 1.5×10^5 tablets
 - D) 1.21×10^3 tablets
 - E) 1.5×10^4 tablets

- 40) Which of the following is a homogeneous mixture?
- A) stainless steel
 - B) trail mix
 - C) water
 - D) molten iron
 - E) none of the above

APPENDIX H

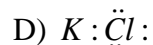
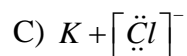
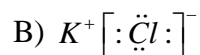
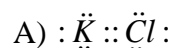
MOLECULAR GEOMETRY AND INTERMOLECULAR FORCES PRETEST

Molecular Geometry and Intermolecular Forces Pretest

Name _____

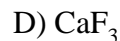
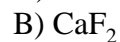
MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question.

1) Which Lewis structure below correctly represents KCl?



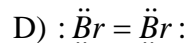
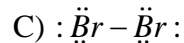
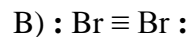
E) none of the above

2) Lewis theory predicts that the formula for a compound between fluorine and calcium is:



E) none of the above

3) What is the correct Lewis structure for Br₂?



E) none of the above

4) How many valence electrons are in the nitrate ion?

A) 23 B) 24 C) 26 D) 18 E) 22

5) The central atom in the chlorite anion, ClO₂⁻ is surrounded by

A) one bonding and three unshared pairs of electrons.

B) two bonding and one unshared pair of electrons.

- C) two double bonds and no unshared pairs of electrons.
D) two bonding and two unshared pairs of electrons.
E) none of the above
- 6) Which symbol should be used between two structures that represent resonance structures?
- A) \leftarrow
B) \rightarrow
C) \leftrightarrow
D) \equiv
E) none of the above
- 7) Which of the following is considered a single electron group?
- A) a triple bond
B) a single bond
C) a lone pair of electrons
D) a double bond
E) all of the above
- 8) What is the molecular geometry if you have 3 single bonds and 1 lone pair around the central atom?
- A) trigonal pyramidal
B) bent
C) linear
D) tetrahedral
E) not enough information
- 9) Which of the following compounds would have a linear molecular geometry?
1. N_2
 2. H_2S
 3. CO_2
- A) 1 and 3 only
B) 1,2 and 3
C) 1 and 2 only
D) 2 and 3 only
E) neither 1, 2, or 3
- 10) The electron geometry and the molecular geometry of ammonia (NH_3) are, respectively,
- A) trigonal planar, bent.
B) tetrahedral, tetrahedral.
C) tetrahedral, bent.
D) tetrahedral, trigonal pyramidal.
E) none of the above

- 11) Which state of matter has a low density and an indefinite volume?
- A) solids
 - B) gases
 - C) liquids
 - D) both solids and liquids
 - E) none of the above
- 12) The measure of the resistance to the flow of a liquid is called:
- A) condensation.
 - B) viscosity.
 - C) vapor pressure.
 - D) sublimation.
 - E) none of the above
- 13) A situation where two opposite processes are occurring at equal rates, and no net change is taking place, is called:
- A) dynamic equilibrium.
 - B) condensation.
 - C) evaporation.
 - D) vaporization.
 - E) none of the above
- 14) You can increase the vapor pressure of a liquid by:
- A) using a nonvolatile compound.
 - B) increasing temperature.
 - C) increasing the viscosity.
 - D) establishing dynamic equilibrium.
 - E) all of the above
- 15) The rate of vaporization of a liquid can be increased by
1. increasing the surface area
 2. increasing the temperature
 3. increasing the strength of the intermolecular forces
- A) 1 only
 - B) 2 only
 - C) 3 only
 - D) 1 and 2 only
 - E) 2 and 3 only
- 16) What is the heat of vaporization(kJ/mol) if it takes 3,452 J of heat to completely vaporize 68 moles of the liquid at its boiling point?
- A) 12.2
 - B) 0.776
 - C) 1.29

- D) 1288
- E) none of the above

17) Compare a small pot of water that is boiling vigorously to a large pot of water that is boiling gently. Which statement is TRUE?

- A) The vapor pressure of the liquid is greater than the pressure above the pot in each case.
- B) The small pot is boiling at higher temperature than the large pot.
- C) The large pot is boiling at a higher temperature than the small pot.
- D) Both pots are boiling at the same temperature.
- E) none of the above

18) In northern climates, it is common to have a layer of frost form on cars that have been out overnight in the winter. During the day the frost layer disappears despite its temperature remaining below freezing. How?

- A) The frost cycles as does the saturation level of moisture in the winter air does from night to day.
- B) The frost melts due to the sun heating the surface of the car above the melting point.
- C) The frost sublimates directly from solid ice to water vapor.
- D) The frost evaporates due to the sun heating the solid.
- E) none of the above

19) Which intermolecular force increases with increasing molar mass?

- A) dispersion forces
- B) hydrogen bonding
- C) X-forces
- D) dipole-dipole forces
- E) none of the above

20) Which molecule below has hydrogen bonding?

- A) H_2
- B) $\text{CH}_3\text{CH}_2\text{OH}$
- C) HCl
- D) CH_4
- E) all of the above

APPENDIX I

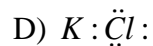
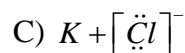
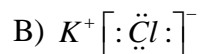
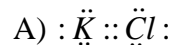
MOLECULAR GEOMETRY AND INTERMOLECULAR FORCES POSTTEST

Molecular Geometry and Intermolecular Forces Posttest

Name: _____

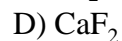
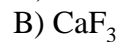
MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question.

1) Which Lewis structure below correctly represents KCl?



E) none of the above

2) Lewis theory predicts that the formula for a compound between fluorine and calcium is:



E) none of the above

3) When a nonmetal bonds with a nonmetal

A) electrons are shared.

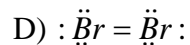
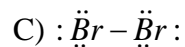
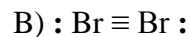
B) a molecular compound forms.

C) a covalent bond is involved.

D) all of the above are true

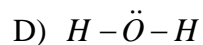
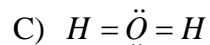
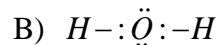
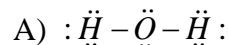
E) none of the above

4) What is the correct Lewis structure for Br₂?



E) none of the above

5) What is the correct Lewis structure for water?



E) none of the above

6) Which sequence below represents the proper order of increasing bond strength?

A) triple < double < single

B) double < single < triple

C) single < double < triple

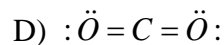
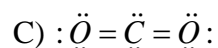
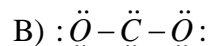
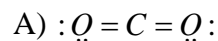
D) single < triple < double

E) none of the above

7) How many valence electrons are in the nitrate ion?

A) 18 B) 22 C) 23 D) 26 E) 24

8) What is the correct Lewis structure for CO_2 ?



E) none of the above

9) The correct Lewis structure for BF_3 would have exactly:

A) 2 double bonds.

B) no double bonds.

C) 1 double bond.

D) 1 triple bond.

E) none of the above

10) Which symbol should be used between two structures that represent resonance structures?

- A) \rightarrow
- B) \leftarrow
- C) \equiv
- D) \leftrightarrow
- E) none of the above

- 11) What is the angle between electron groups in the linear electron geometry?
- A) 90°
 - B) 120°
 - C) 109.5°
 - D) 180°
 - E) not enough information
- 12) What is the angle between electron groups in the trigonal planar electron geometry?
- A) 120°
 - B) 90°
 - C) 180°
 - D) 109.5°
 - E) not enough information
- 13) What is the angle between electron groups in the tetrahedral geometry?
- A) 180°
 - B) 109.5°
 - C) 120°
 - D) 90°
 - E) not enough information
- 14) What is the electron geometry if you have 4 electron groups around the center atom?
- A) trigonal bipyramidal
 - B) linear
 - C) trigonal planar
 - D) tetrahedral
 - E) not enough information
- 15) What is the electron geometry if you have 3 electron groups around the center atom?
- A) trigonal bipyramidal
 - B) tetrahedral
 - C) trigonal planar
 - D) linear
 - E) not enough information
- 16) What is the molecular geometry if you have 3 single bonds and 1 lone pair around the central atom?
- A) trigonal pyramidal
 - B) bent
 - C) linear

- D) tetrahedral
E) not enough information
- 17) What is the molecular geometry if you have a double bond, a single bond and 1 lone pair around the central atom?
A) linear
B) tetrahedral
C) trigonal pyramidal
D) bent
E) not enough information
- 18) Which of the following compounds would have a linear molecular geometry?
1. N_2
2. H_2S
3. CO_2
- A) 2 and 3 only
B) 1 and 2 only
C) 1,2 and 3
D) 1 and 3 only
E) neither 1, 2, or 3
- 19) What is the molecular geometry of SiH_4 ?
A) bent
B) tetrahedral
C) trigonal pyramidal
D) linear
E) not enough information
- 20) What is the molecular geometry of NH_4^+ ?
A) tetrahedral
B) trigonal pyramidal
C) linear
D) bent
E) not enough information
- 21) The electron geometry and the molecular geometry of ammonia (NH_3) are, respectively,
A) tetrahedral, bent.
B) tetrahedral, tetrahedral.
C) trigonal planar, bent.
D) tetrahedral, trigonal pyramidal.
E) none of the above
- 22) Which molecule listed below has a nonpolar covalent bond?

- A) H_2
 - B) H_2O
 - C) $NaCl$
 - D) all of the compounds
 - E) none of the compounds
- 23) Which molecule listed below is a polar molecule?
- A) NH_3
 - B) HCN
 - C) H_2O
 - D) all of the compounds
 - E) none of the compounds
- 24) Which compound listed below will dissolve in water?
- A) NH_3
 - B) SiO_2
 - C) CCl_4
 - D) all of the compounds
 - E) none of the compounds
- 25) Which compound listed below will dissolve in carbon tetrachloride, CCl_4 ?
- A) CS_2
 - B) NH_3
 - C) $NaCl$
 - D) all of the compounds
 - E) none of the compounds
- 26) The electronegativity value for N is 3.0 and that for O is 3.5. Based on these values, which of the following statements is TRUE about the compound NO?
- A) NO is a pure covalent compound.
 - B) NO is an ionic compound.
 - C) NO is a polar covalent compound.
 - D) There is not enough information to determine the nature of NO.
 - E) None of the above statements is true.
- 27) Which state of matter has a low density and an indefinite volume?
- A) liquids
 - B) solids
 - C) gases
 - D) both solids and liquids
 - E) none of the above
- 28) Which state of matter has a high density and an indefinite shape?
- A) liquids
 - B) gases

- C) solids
 - D) both solids and liquids
 - E) none of the above
- 29) The measure of the resistance to the flow of a liquid is called:
- A) sublimation.
 - B) viscosity.
 - C) vapor pressure.
 - D) condensation.
 - E) none of the above
- 30) The change of a substance from a liquid to a gaseous form is called:
- A) heat of fusion.
 - B) volatile.
 - C) condensation.
 - D) dynamic equilibrium.
 - E) vaporization.
- 31) Increasing the intermolecular forces of a liquid will do which of the following?
- A) increase the viscosity
 - B) decrease the evaporation rate
 - C) decrease the vapor pressure
 - D) increase the surface tension
 - E) all of the above
- 32) You can increase the vapor pressure of a liquid by:
- A) establishing dynamic equilibrium.
 - B) using a nonvolatile compound.
 - C) increasing the viscosity.
 - D) increasing temperature.
 - E) all of the above
- 33) Evaporation is:
- A) an endothermic process.
 - B) increased by increasing temperature.
 - C) the opposite process as condensation.
 - D) a cooling process for humans when they sweat.
 - E) all of the above
- 34) The rate of vaporization of a liquid can be increased by
1. increasing the surface area
 2. increasing the temperature
 3. increasing the strength of the intermolecular forces
- A) 1 only
 - B) 2 only

- C) 3 only
- D) 1 and 2 only
- E) 2 and 3 only

35) The amount of heat required to melt one mole of a solid is called the:

- A) heat of fusion.
- B) heat of vaporization.
- C) heating curve.
- D) cooling curve.
- E) none of the above

36) What is the heat of vaporization(kJ/mol) if it takes $3,452 \text{ J}$ of heat to completely vaporize 2.68 moles of the liquid at its boiling point?

- A) 1.29
- B) 1288
- C) 0.776
- D) 12.2
- E) none of the above

37) Compare a small pot of water that is boiling vigorously to a large pot of water that is boiling gently. Which statement is TRUE?

- A) Both pots are boiling at the same temperature.
- B) The small pot is boiling at higher temperature than the large pot.
- C) The large pot is boiling at a higher temperature than the small pot.
- D) The vapor pressure of the liquid is greater than the pressure above the pot in each case.
- E) none of the above

38) How many kilojoules of heat are needed to completely vaporize 42.8 grams of $\text{C}_4\text{H}_{10}\text{O}$ at its boiling point?

Given $\Delta H_{\text{vap}} = 26.5 \text{ kJ/mol}$

- A) 9.49
- B) 15.3
- C) 74.12
- D) 16.3
- E) none of the above

39) If we supply additional heat to a solid in equilibrium with its liquid at the melting point, the thermal energy added is used to:

- A) expand the solid.
- B) change the liquid back to solid.
- C) change solid to liquid.

- D) overcome the intermolecular forces that hold the solid together.
- E) raise the temperature of the solid above its melting point.

40) How many grams of $C_4H_{10}O$ can be melted by 2.00×10^3 J?

Given $\Delta H_{\text{fus}} = 7.27$ kJ/mol

- A) 3.64
- B) 20.4
- C) 74.1
- D) 14.5
- E) none of the above

41) In northern climates, it is common to have a layer of frost form on cars that have been out overnight in the winter. During the day the frost layer disappears despite its temperature remaining below freezing. How?

- A) The frost melts due to the sun heating the surface of the car above the melting point.
- B) The frost cycles as does the saturation level of moisture in the winter air does from night to day.
- C) The frost sublimates directly from solid ice to water vapor.
- D) The frost evaporates due to the sun heating the solid.
- E) none of the above

42) A mothball can change directly from its solid phase to its gaseous phase. This process is known as:

- A) condensation.
- B) sublimation.
- C) melting.
- D) deposition.
- E) none of the above

43) Which intermolecular force increases with increasing molar mass?

- A) dispersion forces
- B) X-forces
- C) dipole-dipole forces
- D) hydrogen bonding
- E) none of the above

44) Assuming that the molecules carbon monoxide (CO) and nitrogen (N_2) have similar electron clouds, which statement below is TRUE?

- A) Both CO and N_2 must have the same boiling point.
- B) The N_2 has the higher boiling point because it has greater dispersion forces.
- C) N_2 has the higher boiling point because it experiences dipole-dipole forces.

- D) CO has the higher boiling point because it experiences dipole-dipole forces.
E) none of the above
- 45) Which molecule below has hydrogen bonding?
A) H_2O
B) CH_3OH
C) HF
D) NH_3
E) all of the above
- 46) Which compound will have the highest boiling point?
A) CH_3CH_3
B) $\text{CH}_3\text{CH}_2\text{OH}$
C) CH_4
D) $\text{CH}_3\text{C}(\text{O})\text{CH}_3$
E) not enough information
- 47) Which intermolecular force is the strongest?
A) hydrogen bonding
B) X-forces
C) dispersion forces
D) dipole-dipole forces
E) none of the above
- 48) Rank the compounds NH_3 , CH_4 , and PH_3 in order of increasing boiling point.
A) $\text{PH}_3 < \text{NH}_3 < \text{CH}_4$
B) $\text{NH}_3 < \text{PH}_3 < \text{CH}_4$
C) $\text{CH}_4 < \text{NH}_3 < \text{PH}_3$
D) $\text{CH}_4 < \text{PH}_3 < \text{NH}_3$
E) $\text{NH}_3 < \text{CH}_4 < \text{PH}_3$
- 49) Dry ice (solid CO_2) is which type of solid?
A) molecular solid
B) metallic atomic solid
C) covalent atomic solid
D) nonbonding atomic solid
E) ionic solid
- 50) NaCl is which type of solid?
A) molecular solid
B) ionic solid
C) covalent atomic solid
D) metallic atomic solid
E) nonbonding atomic solid

APPENDIX J

SOLUTIONS, ACIDS, AND BASES PRETEST

Solutions, Acids, and Bases Pretest

Name _____

MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question.

- 1) Which of the following substances is NOT a solution?
 - A) vodka
 - B) copper
 - C) air
 - D) brass
 - E) All of the above are solutions.

- 2) The oxygen in the air we breath is classified as:
 - A) the solute in a homogeneous gas mixture.
 - B) the solvent in a simple mixture.
 - C) the solvent in a homogeneous gas mixture.
 - D) the solute in a heterogenous gas-liquid mixture.
 - E) none of the above

- 3) Which of these compounds would you expect to be *least* soluble in water?
 - A) NaCl
 - B) NH₃
 - C) N₂
 - D) CH₃OH
 - E) not enough information

- 4) If the solubility of sodium chloride is 36 grams per 100 grams of water, which of the following solutions would be considered unsaturated?
 - A) 5.8 moles of NaCl dissolved in 1 L of water
 - B) 1.85 moles of NaCl dissolved in 300 ml of water
 - C) 3.25 moles of NaCl dissolved in 500 ml of water
 - D) none of the above

- 5) Which of the following compounds is a strong electrolyte?
 - A) C₇H₁₄O₅
 - B) NaC₂H₃O₂
 - C) C₆H₁₂O₆
 - D) C₄H₈O₂
 - E) all of the above

- 6) Solubility of gases in water:
 - A) decreases with increasing pressure above solution.
 - B) is independent of pressure above solution.
 - C) increases with increasing pressure above solution.
 - D) Gases are not soluble in water.

- E) none of the above
- 7) We dissolve 2.45 g of sugar in 200.0 g water. What is the mass percent of sugar in the solution?
- A) 123%
 - B) 2.42%
 - C) 1.23%
 - D) 1.21%
 - E) none of the above
- 8) What is the molarity of a solution prepared by dissolving 10.7g NaI in 0.250 L?
- A) 0.0714
 - B) 0.286
 - C) 2.86×10^{-4}
 - D) 42.8
 - E) none of the above
- 9) What is the molarity of a solution prepared by dissolving 54.3 g of $\text{Ca}(\text{NO}_3)_2$ into 355 mL of water?
- A) 0.932 *M*
 - B) 1.99 *M*
 - C) 0.331 *M*
 - D) 0.117 *M*
 - E) none of the above
- 10) What volume of 12.0 M HCl is required to make 75.0 mL of 3.50 M HCl?
- A) 21.9 mL
 - B) 0.560 mL
 - C) 560. mL
 - D) 257 mL
 - E) none of the above
- 11) Which of the following statements about acids are TRUE?
1. An acid is used in car batteries.
 2. The active ingredient of vinegar is an acid.
 3. Acids are used for cleaning metals.
- A) 2 and 3 only
 - B) 1 and 2 only
 - C) 1 and 3 only
 - D) All of 1, 2, and 3
 - E) Neither 1, 2, or 3
- 12) Which of the following statements about a base are TRUE?
1. Bases are used in the manufacturing of soap.
 2. Bases have a sour taste.

3. Fertilizer manufacture and cotton processing use bases.

- A) 1 and 3 only
- B) 2 and 3 only
- C) 1 and 2 only
- D) All of 1, 2, and 3
- E) Neither 1, 2, or 3

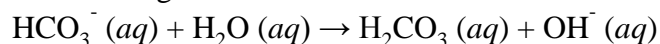
13) The Bronsted-Lowry definition of a base is:

- A) a proton acceptor.
- B) produces H^+ in solution.
- C) a proton donor.
- D) produces OH^- in solution.
- E) none of the above

14) Which of the following is a weak base?

- A) potassium hydroxide
- B) calcium hydroxide
- C) sodium fluoride
- D) ammonia
- E) none of the above

15) In the following reaction:



- A) H_2O is an acid and OH^- is its conjugate base.
- B) H_2O is an acid and HCO_3^- is its conjugate base.
- C) HCO_3^- is an acid and OH^- is its conjugate base.
- D) HCO_3^- is an acid and H_2CO_3 is its conjugate base.
- E) H_2O is an acid and H_2CO_3 is its conjugate base.

16) What is the concentration of the hydroxide ions in an acidic solution?

- A) $1.0 \times 10^{-7} M$
- B) $0.0 M$
- C) $1.0 \times 10^{-14} M$
- D) $< 1.0 \times 10^{-7} M$
- E) $> 1.0 \times 10^{-7} M$

17) What are the products of a neutralization reaction?

- A) salt and carbon dioxide
- B) carbon dioxide and water
- C) oil and water
- D) water and salt
- E) none of the above

18) Consider a 1.6×10^{-3} M solution of HNO_3 . Which of the following statements is NOT true?

- A) This solution has a pH of 11.20.
- B) This solution could dissolve metal.
- C) This solution could neutralize a base.
- D) This solution would turn litmus to red.
- E) none of the above

19) In order for a solution to be basic,

- A) $[\text{H}_3\text{O}^+] < [\text{OH}^-]$
- B) $[\text{H}_3\text{O}^+] > [\text{OH}^-]$
- C) $[\text{H}_3\text{O}^+] = [\text{OH}^-]$
- D) $\text{pH} = \text{pOH}$
- E) none of the above

20) What is the $[\text{OH}^-]$ in a solution that has a pOH of 9.65?

- A) 4.5×10^5 M
- B) 4.5×10^{-9} M
- C) 9.8×10^{-1} M
- D) 2.2×10^{-10} M
- E) none of the above

APPENDIX K
SOLUTIONS, ACIDS, AND BASES POSTTEST

Solutions, Acids, and Bases Posttest

Name _____

MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question.

- 1) Which of the following substances is NOT a solution?
 - A) air
 - B) brass
 - C) copper
 - D) vodka
 - E) All of the above are solutions.

- 2) Which of the following substances is NOT a solution?
 - A) soda
 - B) bronze
 - C) homogenized milk
 - D) sea water
 - E) All of the above are solutions.

- 3) The oxygen in the air we breath is classified as:
 - A) the solvent in a homogeneous gas mixture.
 - B) the solute in a heterogeneous gas-liquid mixture.
 - C) the solvent in a simple mixture.
 - D) the solute in a homogeneous gas mixture.
 - E) none of the above

- 4) Hexane, a nonpolar solvent, will dissolve which of the following substances?
 - A) oil
 - B) ammonium acetate
 - C) sodium chloride
 - D) vinegar (acetic acid)
 - E) none of the above

- 5) Which of these compounds would you expect to be *least* soluble in water?
 - A) NaCl
 - B) N₂
 - C) CH₃OH
 - D) NH₃
 - E) not enough information

- 6) If the solubility of sodium acetate (Molar mass = 82 g/mol) is 76 grams per 100 grams of water, which of the following solutions would be considered supersaturated?
 - A) 8.5 moles of sodium acetate dissolved in 1 L of water
 - B) 5.5 moles of sodium acetate dissolved in 500 mL of water

- C) 1.2 moles of sodium acetate dissolved in 200 mL of water
D) 1.8 moles of sodium acetate dissolved in 300 mL of water
E) none of the above
- 7) If the solubility of sodium chloride is 36 grams per 100 grams of water, which of the following solutions would be considered unsaturated?
- A) 3.25 moles of NaCl dissolved in 500 ml of water
B) 1.85 moles of NaCl dissolved in 300 ml of water
C) 5.8 moles of NaCl dissolved in 1 L of water
D) 6.50 moles of NaCl dissolved in 1 L of water
E) none of the above
- 8) If you prepare a solution by adding sufficient amount of solute so that after heating and cooling the solution there is a visible amount of solid solute left in the bottom of the beaker, the solution would be considered _____.
- A) saturated.
B) unsaturated.
C) supersaturated.
D) thermally saturated.
E) none of the above
- 9) Which of the following compounds is a strong electrolyte?
- A) $C_7H_{14}O_5$
B) $C_6H_{12}O_6$
C) $C_4H_8O_2$
D) $NaC_2H_3O_2$
E) all of the above
- 10) The solubility of solids in water:
- A) increases with increasing temperature.
B) is independent of the temperature.
C) decreases with increasing temperature.
D) Solids are not soluble in water.
E) none of the above
- 11) The solubility of gases in water:
- A) decreases with increasing temperature.
B) increases with increasing temperature.
C) is independent of temperature.
D) gases are not soluble in water.
E) none of the above
- 12) We dissolve 2.45 g of sugar in 200.0 g water. What is the mass percent of sugar in the solution?
- A) 1.21%

- B) 123%
- C) 1.23%
- D) 2.42%
- E) none of the above

13) What is the mass percent of a solution prepared by dissolving 18.9 grams of solid into 39.5 grams of water?

- A) 32.4%
- B) 58.4%
- C) 47.8%
- D) The identity of the compound must be known.
- E) none of the above

14) How many grams of a 23.4% by mass NaF solution is needed if you want to have 1.33 moles of NaF?

- A) 239
- B) 55.9
- C) 13.1
- D) 31.1
- E) none of the above

15) What is the molarity of a solution prepared by dissolving 10.7 g NaI in 0.250 L?

- A) 2.86×10^{-4}
- B) 0.286
- C) 0.0714
- D) 42.8
- E) none of the above

16) Given that you wished to use exactly 0.325 mole of NaCl to prepare a 2.50 M NaCl solution, how many milliliters of solution must you prepare?

- A) 0.130 mL
- B) 7.69 mL
- C) 0.813 mL
- D) 130. mL
- E) none of the above

17) What is the molarity of a solution prepared by dissolving 54.3 g of $\text{Ca}(\text{NO}_3)_2$ into 355 mL of water?

- A) 0.331 M
- B) 0.117 M
- C) 1.99 M
- D) 0.932 M
- E) none of the above

18) A 90.0 g sample of NaOH is dissolved in water and the solution is diluted to give a final volume of 3.00 liters. The molarity of the final solution is _____.

- A) 1.00 M
- B) 2.25 M
- C) 0.750 M
- D) 0.500 M
- E) none of the above

19) Which solution below contains the highest total quantity of dissolved sodium ions?

- A) 100. mL of 4.0 M NaCl
- B) 50.0 mL of 2.0 M Na₃PO₄
- C) 75.0 mL of 3.0 M Na₂SO₄
- D) 50.0 mL of 8.0 M NaOH
- E) none of the above

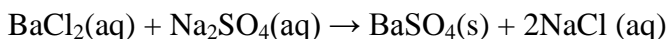
20) What volume of 12.0 M HCl is required to make 75.0 mL of 3.50 M HCl?

- A) 257 mL
- B) 0.560 mL
- C) 560. mL
- D) 21.9 mL
- E) none of the above

21) What molarity should the stock solution be if you want to dilute 25.0 mL to 2.00 L and have the final concentration be 0.103 M?

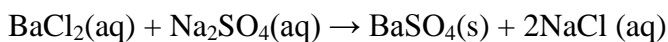
- A) 8.24 M
- B) 0.243 M
- C) 0.206 M
- D) 4.12 M
- E) none of the above

22) How many grams of barium sulfate are produced if 25.34 mL of 0.113 M BaCl₂ completely react given the reaction:



- A) 26.3
- B) 1039
- C) 0.668
- D) 5.90
- E) none of the above

23) How many mL of 0.218 M sodium sulfate react with exactly 25.34 mL of 0.113 M BaCl₂ given the reaction:



- A) 24.6
- B) 2.86
- C) 13.1

- D) 5.52
- E) none of the above

24) Which of the following statements about acids are TRUE?

1. An acid is used in car batteries.
2. The active ingredient of vinegar is an acid.
3. Acids are used for cleaning metals.

- A) 1 and 3 only
- B) 2 and 3 only
- C) 1 and 2 only
- D) All of 1, 2, and 3
- E) Neither 1, 2, or 3

25) Which of the following statements about a base are TRUE?

1. Bases are used in the manufacturing of soap.
2. Bases have a sour taste.
3. Fertilizer manufacture and cotton processing use bases.

- A) 1 and 2 only
- B) 2 and 3 only
- C) 1 and 3 only
- D) All of 1, 2, and 3
- E) Neither 1, 2, or 3

26) Which of the following is the active ingredient of baking soda?

- A) NaHCO_3
- B) KOH
- C) NaOH
- D) NH_3
- E) none of the above

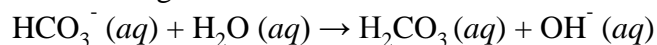
27) The Arrhenius definition of an acid is:

- A) produces OH^- in solution.
- B) a proton acceptor.
- C) produces H^+ in solution.
- D) a proton donor.
- E) none of the above

28) The Bronsted-Lowry definition of a base is:

- A) a proton acceptor.
- B) produces OH^- in solution.
- C) produces H^+ in solution.
- D) a proton donor.
- E) none of the above

29) In the following reaction:



- A) H_2O is an acid and OH^- is its conjugate base.
- B) H_2O is an acid and HCO_3^- is its conjugate base.
- C) HCO_3^- is an acid and H_2CO_3 is its conjugate base.
- D) H_2O is an acid and H_2CO_3 is its conjugate base.
- E) HCO_3^- is an acid and OH^- is its conjugate base.

30) What is the conjugate acid of OH^- ?

- A) H_2O
- B) NaOH
- C) O^{2-}
- D) OH^-
- E) none of the above

31) A substance that acts as an acid *or* a base is called

- A) hydrophilic.
- B) isoprotic.
- C) a salt.
- D) amphoteric.
- E) none of the above

32) What are the products of a neutralization reaction?

- A) carbon dioxide and water
- B) water and salt
- C) salt and carbon dioxide
- D) oil and water
- E) none of the above

33) A 25.0 ml sample of 0.105 M HCl was titrated with 31.5 mL of NaOH. What is the concentration of the NaOH?

- A) 0.132 M
- B) 0.075 M
- C) 0.0833 M
- D) 0.105 M
- E) none of the above

34) What is the concentration of H^+ in 2.0 M acetic acid, $\text{HC}_2\text{H}_3\text{O}_2$?

- A) 2.0 M
- B) 1.0 M
- C) >2.0 M
- D) <2.0 M
- E) none of the above

35) Which of the following is a weak base?

- A) ammonia
- B) sodium fluoride
- C) calcium hydroxide
- D) potassium hydroxide
- E) none of the above

36) Consider a 1.6×10^{-3} M solution of HNO_3 . Which of the following statements is NOT true?

- A) This solution could dissolve metal.
- B) This solution could neutralize a base.
- C) This solution would turn litmus to red.
- D) This solution has a pH of 11.20.
- E) none of the above

37) What is the concentration of the hydronium ions in a neutral solution?

- A) 0.0 M
- B) 1.0×10^{-7} M
- C) $> 1.0 \times 10^{-7}$ M
- D) $< 1.0 \times 10^{-7}$ M
- E) 1.0×10^{-14} M

38) What is the concentration of the hydroxide ion given that the concentration of the hydronium ion is 1.5×10^{-5} M?

- A) 1.0×10^{-14} M
- B) 6.7×10^{-10} M
- C) 1.5×10^9 M
- D) 1.0×10^{-19} M
- E) none of the above

39) What is the pH of a solution that has a H^+ concentration equal to 1.7×10^{-5} M?

- A) 4.77
- B) 10.20
- C) 5.20
- D) 0.22
- E) none of the above

40) The pH of a solution is 5.00. Which of the following is TRUE about the solution?

- A) Its $[\text{H}_3\text{O}^+]$ is 1.0×10^{-5} M
- B) Its $[\text{H}_3\text{O}^+]$ is 1.0×10^{-9} M
- C) Its $[\text{H}_3\text{O}^+]$ is 1.0×10^5 M
- D) It is more acidic than a solution whose pH is 4.00.
- E) none of the above

41) In order for a solution to be basic,

- A) $[\text{H}_3\text{O}^+] < [\text{OH}^-]$

- B) $\text{pH} = \text{pOH}$
- C) $[\text{H}_3\text{O}^+] = [\text{OH}^-]$
- D) $[\text{H}_3\text{O}^+] > [\text{OH}^-]$
- E) none of the above

42) If the pH of an aqueous solution changed from 9.10 to 4.67, what happened to the hydronium ion concentration?

- A) It became less than zero.
- B) It became zero.
- C) It decreased.
- D) It increased.
- E) none of the above

43) What is the pOH of a solution that has a OH^- concentration equal to $1.3 \times 10^{-10} \text{ M}$?

- A) 4.12
- B) 9.89
- C) -4.3
- D) 4.29
- E) none of the above

44) What is the $[\text{OH}^-]$ in a solution that has a pOH of 9.65?

- A) $4.5 \times 10^{-9} \text{ M}$
- B) $9.8 \times 10^{-1} \text{ M}$
- C) $2.2 \times 10^{-10} \text{ M}$
- D) $4.5 \times 10^5 \text{ M}$
- E) none of the above

45) What is the $[\text{H}^+]$ in a solution that has a pH of 3.35?

- A) $4.5 \times 10^{-4} \text{ M}$
- B) $1 \times 10^{3.35} \text{ M}$
- C) $2.2 \times 10^3 \text{ M}$
- D) $3.35 \times 10^{-14} \text{ M}$
- E) none of the above

APPENDIX L
VIDEO REWIND DOCUMENT

Video Rewind

* Required

Name *

School Email Address *

Today's topic *

Summarize 3 to 5 main ideas from the video. *

Do you have a muddiest point from this lesson? Explain. *

How confident do you feel about your understanding of the lesson? *

0 1 2 3 4 5

Not confident at all. I can answer the most difficult questions on this topic.

Do you have a question for the instructor? If yes, what is it? *

Never submit passwords through Google Forms.

APPENDIX M
PRETREATMENT INTERVIEW

Pretreatment Interview

1. Do you consider yourself a visual, auditory, or kinesthetic learner for chemistry? Upon what evidence have you made this estimation of your abilities?
2. Do you take notes during chemistry lessons? Do you take notes when you read chemistry textbook material?
3. During the lessons taught in the classroom, with the instructor providing notes and verbal instruction, do you ever feel overwhelmed by the amount of material presented? Are you able to learn some of the concepts or are you just trying to get the notes into your notebook?
4. Do you feel bored or unengaged during traditional, teacher-directed lessons? If yes, explain the circumstances under which this occurs. Is it because the lessons are too easy for you?
5. Do you feel comfortable asking questions during teacher-directed lessons?
6. When you complete Mastering Chemistry[®] and other homework problems at home, do you feel that it reinforces your learning?
7. Do you ever work with a friend on your homework? If yes, is this for social or educational benefit?
8. Do you feel adequately challenged by the work assigned in this class?
9. What part of our curriculum have you most enjoyed, so far? Why?
10. Is there anything else you'd like me to know?

APPENDIX N
POSTTREATMENT INTERVIEW

Posttreatment Interview

1. Did you take notes during the viewing of the videos?
2. While viewing the videos of the lessons, did you stop the video, or rewind the video to review the lesson? Explain the situations in which you stopped or rewound the video.
3. While viewing the videos of the lessons, did you fast-forward through any part of the video? Explain the situations in which you fast-forwarded through the video.
4. While viewing the video, did you write down any questions you had? Did you ask them in class the next day? Explain any differences you experienced compared to asking questions during a teacher-directed lesson.
5. Do you feel bored or unengaged during viewing of videos? If yes, explain the circumstances under which this occurs. Explain any differences you perceived between the two types of lessons.
6. While viewing the videos, were you more likely to be distracted by other people, text messages, music, television, or social media? Explain. If yes, how did you overcome these distractions?
7. Do you feel the videos helped you to learn the chemistry concepts? Explain.
8. Do you feel that the videos of the lessons helped you to learn the material at your own pace? Explain.
9. Did you find the use of class time for working on problems useful for your learning? Did you feel adequately challenged by the problems assigned to you?
10. Is there anything else you'd like me to know?

APPENDIX O
PRETREATMENT SURVEY

Pretreatment Survey

Please answer the following questions using the following key:

1 = Strongly Disagree

2 = Disagree

3 = Neutral

4 = Agree

5 = Strongly Agree

1. I take notes during classroom lessons. 1 2 3 4 5
2. I am often distracted by other students during classroom lessons. 1 2 3 4 5
3. I enjoy interacting with my peers. 1 2 3 4 5
4. Classroom lessons are too long. 1 2 3 4 5
5. Classroom lessons are too short. 1 2 3 4 5
6. I learn the concepts by reading the textbook. 1 2 3 4 5
7. I don't usually read the textbook. 1 2 3 4 5
8. Classroom lessons allow me to learn at my own pace. 1 2 3 4 5
9. I like to practice problems and reinforce learning at home. 1 2 3 4 5
10. I am motivated to learn chemistry concepts. 1 2 3 4 5
11. Describe two things you enjoyed about traditional teacher-directed lessons with problem practice at home. Describe two things you did not like.
12. If you could decide how a teacher would teach his or her class, how would you describe the best type of lesson? What would be the role of the teacher? What would be your role?
13. Do you feel confident in your ability to learn chemistry? Explain.
14. How do you learn chemistry best? Explain.

APPENDIX P
POSTTREATMENT SURVEY

Posttreatment Survey

Please answer the following questions using the following key:

1 = Strongly Disagree

2 = Disagree

3 = Neutral

4 = Agree

5 = Strongly Agree

1. I watched all of the videos as homework. 1 2 3 4 5
2. The videos were informative and effectively presented. 1 2 3 4 5
3. The videos were too short. 1 2 3 4 5
4. The videos were too long. 1 2 3 4 5
5. I wrote down questions and points of difficulty while viewing. 1 2 3 4 5
6. Teacher-directed lessons helped me to learn chemistry concepts. 1 2 3 4 5
7. Video lessons helped me to learn the chemistry concepts. 1 2 3 4 5
8. The videos helped me to learn at my own pace. 1 2 3 4 5
9. I was able to practice the material more effectively during the classroom sessions compared to practicing problems at home. 1 2 3 4 5
10. I liked screencast videos of lessons and would like to do it again. 1 2 3 4 5
11. Describe two things you enjoyed about the lessons being screencast as videos.
Describe two things you did not like.
12. If you could decide how a teacher would teach his or her class, how would you describe the best type of lesson? What would be the role of the teacher? What would be your role?
13. Did your role as a student change when the lessons were prepared as screencasts? Explain.
14. How do you learn chemistry best? Explain.