THE EFFECTS OF FORMATIVE ASSESSMENTS ON PERFORMANCE AND ATTITUDES OF NINTH-GRADE SCIENCE STUDENTS

by

Christopher George Green

A professional paper submitted in partial fulfillment
of the requirements for the degree

of

Master of Science

in

Science Education

MONTANA STATE UNIVERSITY
Bozeman, Montana

June 2011

STATEMENT OF PERMISSION TO USE

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.

Christopher George Green

June 2011

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

The importance of formative assessments has been in the forefront of current pedagogy. In this study, ninth-grade urban science classes were taught using clear "I can" statements, given meaningful feedback on their assignments, and provided with multiple attempts to successfully reach the learning goals. While the overall performance of students showed marginal improvement, the data indicates that their attitudes towards science and learning seemed to become more positive.

INTRODUCTION AND BACKGROUND

Project Background

Teaching Experience & Classroom Environment

I have been teaching at Thomas W. Harvey High School in the Painesville City Schools, Ohio for the past ten years. The racial composition of the student body is 22.3% African-American, 33.5% Hispanic, 12.1% multiracial, and 31.4% Caucasian students (Ohio Department of Education Interactive Local Report Card, 2010). Many of the Hispanic students have limited proficiency in English and receive extra ESL services. The students represent Painesville's diverse socio-economic population with 73.8% qualifying for the free and reduced lunch program.

The ninth-grade Earth-Space-Physical (ESP) science class has been designed to teach Ohio's ninth-grade science standards. These standards include the structure and behavior of matter, formation and structure of the Earth and its atmosphere, forces and motion, energy and waves, and the universe, while integrating scientific inquiry processes. The Ohio Graduation Test (OGT), first given in the spring of the students' tenth-grade year, includes questions based on these standards. Our district is currently in the process of developing and using common summative assessments in order to gather data for improving instruction in crucial OGT courses such as the Earth-Space-Physical science class. During this process we are establishing "I can" statements and short cycle formative assessments that reflect the Ohio state standards. I have been teaching this course ten years and have seen several changes throughout its evolution as state requirements change.

Year after year I hear students claiming that they are “no good at science.” These students seem to have lost their confidence and interest in science somewhere along the way. They typically plod along with minimal interest and often struggle to pass the course, despite varieties of efforts to get them re-engaged. Lately, more and more students are failing to complete and turn in assignments in all subjects. What has happened to affect students’ confidence and attitudes? What can be done to bring students to a higher level of confidence and performance in science?

Our district’s efforts to use assessments to gather data includes the development and use of formative assessments in order to more formally keep track of which students have learned the materials and which need remediation. There has been some confusion among our faculty about the proper use of formative assessments. In comparison to summative assessments which are to be used at the end of a unit of study to measure the students’ learning, formative assessments are to be used as along the way to see how well the students are learning a given topic. Our hope is formative assessments can be used to help students learn while becoming more engaged in their own education.

Focus Question

Many of the students at our school struggle with the Ohio Graduation Test and are disconnected with science classes. I am constantly challenged to increase students’ attitudes and learning in science. These observations led to my primary focus question of the study: How will the use of formative assessments affect the performance and attitudes of my students? As components of this question, I am investigating the effects of clear learning goals, directed feedback, varied formative assessment techniques, and the

opportunities to have several attempts to master the learning goals on learning and attitudes of my students.

CONCEPTUAL FRAMEWORK

Formative assessments have many benefits in education. While summative assessments are used to measure what a student has learned at the end of a unit of study, formative assessments are used to evaluate the learning during the instruction. Information gathered from these tools can help teachers identify how well the students are receiving the lessons. This evidence is then used by the teacher to modify his or her instruction through identifying misconceptions, lack of understanding, and areas of mastery. Formative assessments can be compared to a routine medical exam as findings can be used by the doctor to prescribe specific treatments to help the patient. Likewise, teachers use formative assessments to direct daily instruction. Summative assessments are more analogous to an autopsy, providing evidence for what went wrong, but too late to many any meaningful changes useful to the patient/learner (Salpeter, 2007).

While most educators are aware of the use of formative assessment, many make limited use of the full scope of these tools to guide instruction (McMillan et al., 2010). When used properly, these assessments should:

- Provide a clear learning goal
- Measure the student's progress towards the goal
- Identify areas of each student's weaknesses or misunderstandings
- Provide meaningful feedback for the student that describes how they can improve

- Focus on mastery of the learning goal (Brookhart, Moss, & Long, 2008; Heritage, 2007; McMillan et al., 2010)

Since the focus of a formative assessment is on a clear learning goal and the progress towards it, students can become more effective learners as they develop the ability to self-assess their own progress towards these goals (Black & Wiliam, 1998). Teachers can lead students to analyze their own learning and help them make their own decisions about what steps are required to reach the goal (Cauley & McMillan, 2009). This process can also lead to greater student motivation (Brookhart et al. 2008; Cauley & McMillan, 2009).

Formative assessments start with a clear learning goal. Learning goals are sometimes considered to be synonymous with mastery goals or task goals. However, learning goals focus more on understanding and growth than other achievement goals. Learning goals measure the student's growing competence in a new skill or knowledge (Grant & Dweck, 2003). They relate new learning to prior knowledge. Failure in a learning goal reveals an area where the student did not learn the specific information. The teacher can use the new evidence gathered through formative assessment to correct the missed learning (Yorke, 2003). Students who have assessed their progress against clear learning goals understand where they are in their learning and what they need to do to achieve the goal. These students tend to be more intrinsically motivated and persistent when facing further challenges (Cauley & McMillan, 2009).

Performance goals measure a student's ability in a given area (Grant & Dweck, 2003). Failure in a performance goal sends a message to the student that their ability is not adequate to achieve the goal. This can be a crushing blow for the student and cause

them to become disconnected with the learning (Yorke, 2003). Chan and Lam (2008) found performance goals may turn into performance-avoidance while learning goals are more resilient to failure. Learning goals focus on the concept to be learned instead of focusing on the student's ability. Students and teachers mutually work towards finding ways for the student to reach each of these goals.

In the current educational climate of standards and high-stakes tests, care must be taken to be sure that the learning goals do not become a checklist of facts to be learned because they are on the graduation or end-of-course exams. Learning goals should be interconnected ideas that help the students develop cognitive connections throughout the content over time. While the students learn the content as such, teachers are better able to identify gaps in each student's knowledge and make more informed decisions regarding instruction in order to close those gaps. The interconnectedness of the learning goals helps students become more aware of their learning within a larger context. This also helps them make further connections in future learning (Keeley, 2008).

During the assessment process, teachers should analyze, adjust, and plan effective remediation to help all learners reach the goal. This differentiated instruction can redirect attention towards the learning goal and explore new ways to reach it (Guskey, 2003). It is important at this point to allow the students to safely make mistakes since this is often where the real learning takes place. The students should then be given another opportunity to improve and demonstrate their competence towards the learning goal (Black & Wiliam, 1998; Stiggins & Chappuis, 2005, Angelo & Cross, 1993).

A recent study of four school districts in Richmond, Virginia by McMillan et al. (2010) noted that research relating formative assessments to student motivation can be

difficult to undergo as motivation can be complicated to measure. Also, not all teachers use formative assessments in the same way. Some educators view their use as impractical or too time-consuming as they need to cover material needed for high-stakes tests. Difficulty was also noted in the development of meaningful research questions related to student motivation. The results of this study showed some connections between the use of formative assessments and student motivation. Students even develop positive attitudes in regards to formative assessment sessions (Yorke, 2003).

Student attitudes regarding academics are learned behaviors. Students who are focused on learning goals as used in formative assessments are usually more positive and resilient than those who are not so focused—even during failure (Grant & Dweck, 2003, Chan & Lam, 2010). Continued failure can lead to emotions that allow the student to think they are hopeless, unsafe, and incompetent. The classroom becomes a place full of negative feelings. A failing score leads a student to think, "I don't know what this means. I have no idea what to do next. I'm probably too dumb to learn this anyway. I give up" (Stiggins, 2007, p. 26).

In contrast, when students are being assessed formatively, they are able to identify the area(s) of failure and make the needed corrections in a safe learning atmosphere. Formative assessments allow students to build on their successes and learn from their failures (Stiggins, 2007). In response to failure, these students may say, "I understand. I know what to do next. I can handle this. I choose to keep trying" (Stiggins, p. 26). This productive response can lead to higher flexibility and motivation when faced with new learning (Cauley & McMillan, 2009).

The giving of grades is highly emphasized throughout the United States. The teacher marks are often done to simply sort the students rather than teach the students. Many times teachers neglect the opportunity to provide useful advice and a chance for students to make corrections to their work (Black & Wiliam, 1998; Heritage, 2007). The formative assessments should be used as assessments *for* learning. In this function, each student is given specific feedback regarding their progress toward the learning goal and how to close the gap. This allows them to be able to learn from the given feedback. These assessments provide students with data that can help them analyze their own learning and identify ways to help them improve (Angelo & Cross, 1993). The argument can be made that an assessment can only be formative if the exercise contributed to the student's learning (Yorke, 2003; Stiggins, 2005).

The motivation derived from formative assessments stems from the quality of the feedback provided by the instructor (Cauley & McMillan, 2009; McMillan et al., 2010). In providing the specific feedback, the teacher is able to analyze and plan for further learning to guide the student towards successfully reaching the learning goal. This feedback also provides the student with the power to self-evaluate and take more control over their own learning (Cauley & McMillan, 2009; McMillan & Hearn, 2008; Nicol & McFarlane-Dick, 2006). This sense of control helps the student to become more involved and motivated in their own learning and develop a greater sense of self-efficacy (Chan & Lam, 2008; McMillan et al., 2010; Zimmerman, 2000). The study by McMillan et al. (2010) showed that teachers who use several types of formative assessments are more likely to report higher student motivation.

There are many formative assessment techniques that teachers may use. They may be as simple as *Fist to Five* where a teacher asks the students to hold up their hands for an immediate check of understanding. During the lesson, students hold up zero to five fingers to signify how well they comprehend the material. Teachers can use this information to adjust their lesson. Another simple assessment technique, called *Muddiest Point*, directs students to write down materials from the previous lesson that were difficult or confusing. The teacher uses this information to evaluate the lesson and plan future lessons (Angelo & Cross, 1993; Keeley, 2008). Many of these informal assessment techniques help the students to stay focused on their progress while providing the teacher with evidence of student learning (Angelo & Cross, 1993; Cauley & McMillan, 2009).

Some formative assessment techniques may be given as a formal practice quiz. These quizzes can help students and teachers identify how well a specific learning goal is being met. While the feedback may not be as immediate as other informal techniques, it can help the teacher identify and correct problems of each individual student's work. Students are then given further opportunities to successfully demonstrate mastery of the learning goal (Cauley & McMillan, 2009; Guskey, 2003).

While formative assessments benefit all students, a summary of several studies has shown that low-achieving students can experience the greatest gains (Black & Wiliam, 1998). These students have experienced a long history of negative feedback and often feel hopeless. The teacher's specific feedback can attribute the student's lack of success to a factor that the student is able to modify. The key is to provide feedback and changes to successive instruction to help the student achieve the learning goal (Cauley &

McMillan, 2009). This achievement then leads to increased confidence as the student experiences success. If instituted early, these techniques may prevent students from giving up, rekindle hope, and help them to want to learn. Students are allowed several opportunities to demonstrate their competence. In this way, disaffected learners may become better involved in their learning. A student first experiences achievement, followed by increased confidence (Black & Wiliam, 1998; Stiggins & Chappuis, 2005). Low-achieving students begin to develop habits needed to become lifelong learners (Black & Wiliam, 1998; Brookhart et al. 2008; Yorke, 2003). Learning cannot happen without this feedback loop that supports self-efficacy (Zimmerman, 2000).

Formative assessments are not a "magic bullet" for education (Black & Wiliam, 1998). Current practices will require teachers to make adjustments within the parameters of their own teaching circumstances and school community (Black & Wiliam, 1998). Students may become more motivated and engaged in their own learning if they are provided with clear learning goals, specific teacher feedback regarding progress towards these goals, and opportunities to successfully reach each goal.

METHODOLOGY

This project was designed to determine if there were links between the use of formative assessments and student motivation and performance in science. In the process of using formative assessments, students were provided with clear learning goals, useful feedback, and opportunities to improve on these goals. These strategies were implemented throughout the project. The four units of study during this semester project were The Properties of Matter, Interactions of Matter, How the Earth Works, and How

the Atmosphere Works. Since these strategies were normal educational practices, my building principal allowed me to do the study without informed consent. 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.

To begin the study, students took the Attitude Survey to determine their levels of confidence and motivation in science (Appendix A). During the initial survey taken during the first week of school, the students rated their experiences and attitudes in science on a scale of 1-5 with 1 being *most negative* and 5 being *most positive*. The survey was re-administered near the end of the Interaction of Matter unit. This survey included the same questions, but allowed only four choices, eliminating the middle, neutral position in order to elicit more meaningful data. This same survey was taken at the end of the study. Students' Ohio Achievement Assessment (OAA) scores and grades in previous science classes were also recorded and compared with the survey results to identify the achievement and attitude levels of students. Term grades were compared with students of the same course from the previous two years to help identify changes in student motivation throughout the school year.

The treatment for this study included the use of formative assessment strategies. Each student was given a list of clear learning goals in the form of an *I Can Dashboard* at the beginning of each unit (Appendix B). These goals were kept in their folder along with their related assignments. As the class worked through the lessons, the students referred back to each *I can* statement. They were given opportunity to self-assess their progress towards each using the dashboard scale included with each statement. They

were also encouraged to write important key terms or ideas worth remembering on their dashboard. The dashboards allowed the students to reflect on how much they had progressed and how much more effort would be needed to reach each goal.

Throughout the study, the students were provided with timely feedback on their assignments. The feedback was intended to provide each student with ideas on ways to improve and encouragement with what they were doing well. This meaningful feedback was given on nearly all daily assignments.

Identical Pre- and Post-tests were used to evaluate the students' learning during each of the four units (Appendix C). These quizzes were returned to the students right before the summative tests to allow them another opportunity to reflect on how much they had learned and provide them with further practice on the learning objectives. Periodic Practice Quizzes were used along the way to assess students' progress towards each of the *I can* statements (Appendix D). Each student was provided with direct feedback on each of these practice quizzes. The intent of the feedback was to provide the students with ways to improve their progress towards the learning goals. The students were given multiple opportunities to take these practice quizzes and demonstrate mastery of the *I can* statements.

Other formative assessment opportunities were used including lab reports, focused listing, minute papers, and muddiest points. During a focused listing activity, the students were asked to make a list of what they remember about a previous lesson. Similarly, during minute papers the students were asked to write for one minute about the day's lesson. Muddiest points were used to allow the students to reflect on the lesson and

identify areas that were unclear or confusing. This was be used in conjunction with other assessment techniques.

Student interviews were conducted using the Student Interview questions (Appendix E). Four interviewees were selected from each class to get a representation of my students' demographic and academic backgrounds. These responses were used to gather more qualitative data to further understand the students' prior experiences and motivators in their academics. Interviews were conducted at the beginning and end of the study.

Observations and field notes were made throughout the project. The Observer Checklist (Appendix F) was used to record behaviors including time on task, attempts to complete work before asking questions, types of questions asked, task completion, willingness to self-assess, and classroom participation. This information was evaluated to monitor changes in the student attitudes and behaviors during the study.

The students took the Attitude Survey again at the end of the study (Appendix A). The data was analyzed to see if the motivation level of the students had changed. The students' grades on summative assessments were also used to analyze the affect of the formative assessments on student learning and performance. The data sources for this project are summarized in Table 1 below.

Table 1
Triangulation Matrix

Primary Question: How will the use of formative assessments affect the attitude and performance of my students?			
Research questions	*Data Source1*	*Data Source 2*	*Data Source 3*
1. Will clear learning goals help students learn?	Pre- and post tests	Pre- and post-treatment student interviews	Pre- and post-treatment attitude surveys
2. How will students respond to specific feedback?	Student observations/ field notes	Pre- and post-treatment student interviews	Student-generated work
3. What formative assessment technique(s) are most useful for analyzing student learning?	Student observations/ field notes	Student self-assessments	Formative assessments results
4. Will multiple attempts to successfully reach learning objectives help students develop confidence?	Pre- and post-treatment attitude surveys	Pre- and post-treatment student interviews	Formative assessment results (number of times taken)
5. Will the use of formative assessments help students learn?	Pre- and post tests	Summative assessments	Ohio Achievement Assessment (archived data)

DATA AND ANALYSIS

Data from the *Student Attitude Survey* indicated an overall decrease in the number of students feeling negative about science (Figure 1). At the beginning of the study, 34% of the surveyed students replied *Not much* or *No* to the statement *I enjoy science* (*N*=54). This combined percentage remained at 34% on the mid-study survey, although the number of *No* replies decreased slightly. The number of negative responses decreased to 25% on the final survey although the number of *No* responses increased (*N*=52). While the positive responses grew over this time, the most positive choice of *Yes* response saw a decrease by the end of the study.

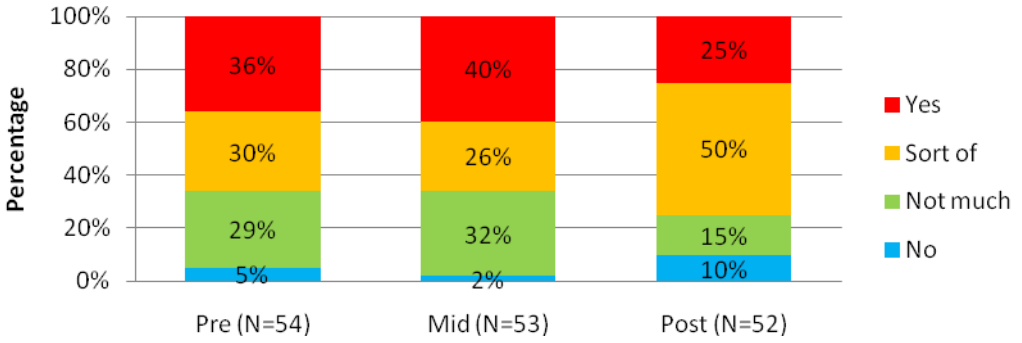


Figure 1. Student Responses to the Statement *I enjoy science.*

Over the course of the study, students' feelings towards their abilities in science did not show large changes. When responding to the statement *I am good at science*, those responding *Yes* remained near 27% (Figure 2). The percentage of negative responses grew from 13% to 19% and finally up to 27% by the end of the study.

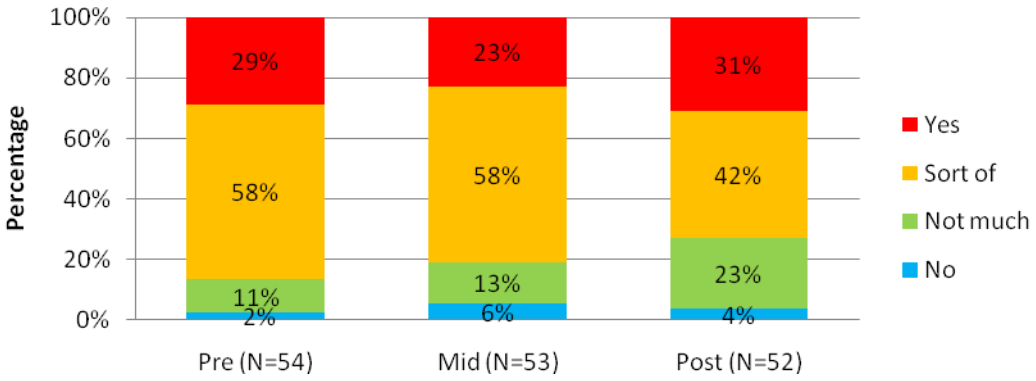


Figure 2. Student Responses to the Statement *I am good at science.*

One of the key components of the study was to have the students know the learning goals and reflect on their progress towards mastery of each goal. The data from the Student Attitude Survey indicated that students became more polarized regarding the statement, *Knowing the learning goals helps me to learn better*. The percentage of students replying *Yes* rose from the initial 8% to 23% while those replying *No* also rose from 6% to 19% (Figure 3).

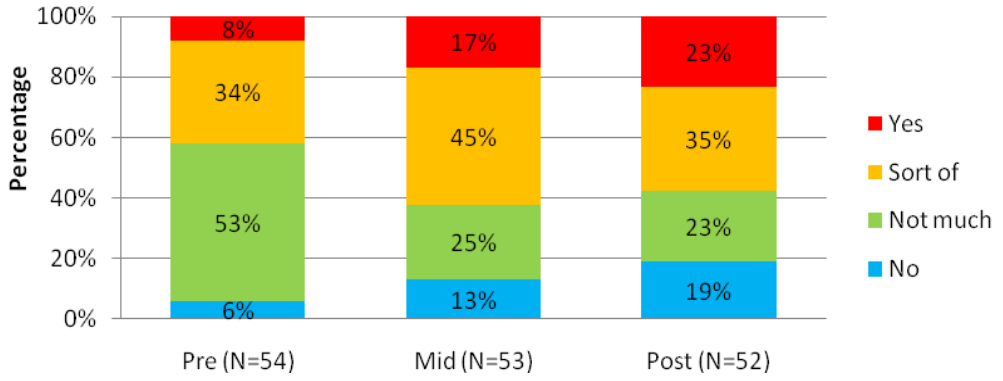


Figure 3. Student Responses to the Statement *Knowing the learning goals helps me to learn better.*

The student interviews also revealed similar trends. When the twelve interviewees were asked if knowing the learning goals help them learn about a topic, 33% said *no*. One student added, "It's just the titles of what we're learning." After thinking about their original negative responses for a moment, another student added, "If I see the learning goal and recognize it, it helps me remember what I know."

Similar reasons were shared by the 50% of interviewed students who affirmed that awareness of the *I can* statements helped them to learn. They recognized that it kept them on track for what they are expected to learn. One student stated, "It makes you think about it (what you're learning) and, when you learn, you can compare it to what you already knew." Another explained, "They tell you what you're expected to learn for the unit."

Seventeen percent of interviewed students perceived the learning goals as only marginally important. The repeated problem students had with them related to their understanding of the goals. "They help half the time—when I understand the goal," was one student's response. The same student thought that, "Teachers should try breaking them down into smaller terms to help everybody understand."

During classroom observations during time given for students to reflect on each *I Can Dashboard*, most were observed to be thoughtful in assessing their progress with each goal. Students did not ask for clarification during these times. A few would add ideas or key terms to the page to help them remember, especially before the summative tests. These goals were also posted on the bulletin board. Occasionally, students would need to be coaxed to honestly reflect on the *I can* statements.

Students grew in their positive views of the comments they received on their returned work. In responding to the statement, *Teacher's comments on my returned work helps me to learn*, 83% of the students responded *Yes* or *sort of* (Figure 4). In interviews, 75% of students thought that they received useful feedback on returned work in their classes. They found that these written comments from their teachers helped them to understand where they were making mistakes or misconceptions and explained why the assignments received the given grades.

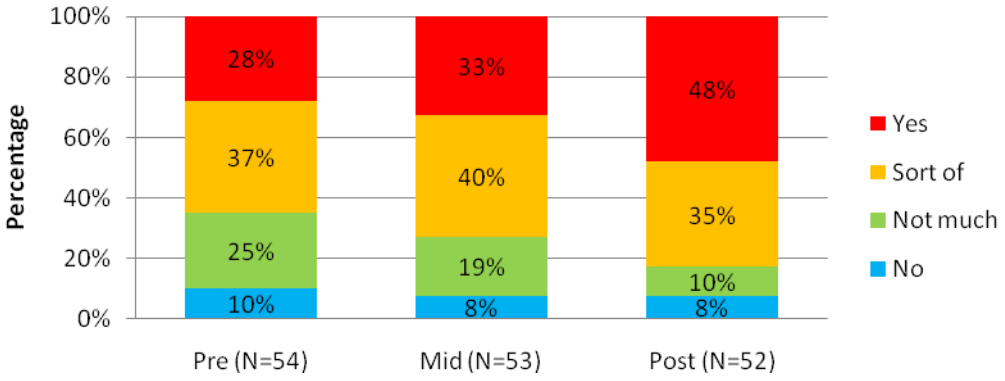


Figure 4. Student Responses to the Statement *Teacher's comments on my returned work helps me to learn.*

Over time, students seemed to realize the value in the returned assignments as a study tool. On the post-study student survey, 40% of the students said *Yes* to the statement, *When I study for a test or a quiz, I look at my returned work.* This percentage rose from the original 15% (Figure 5). It should be noted that the survey did not specify

only this science class, so this change in attitude can be shared with the work of other teachers.

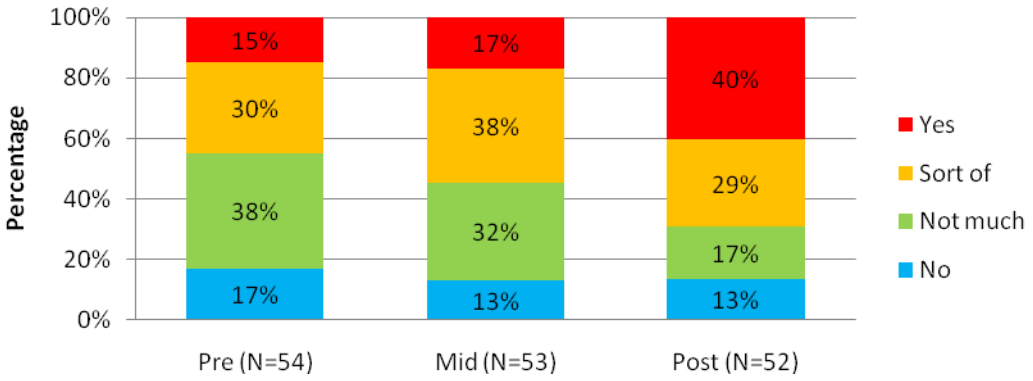


Figure 5. Student Responses to the Statement *When I study for a test or a quiz, I look at my returned work.*

Similarly, student surveys indicated a large increase in their attitudes towards the usefulness of practice quizzes. The percentage of students who responded *Yes* to the statement *Practice quizzes help me to see what I need to study* rose from 32% to 62% by the mid-study survey and to 79% by the end of the study (Figure 6). The Practice Quiz formative assessments were specifically mentioned by twenty-five percent of the interviewed students. Students found them useful in identifying missed learning and misconceptions and appreciated the ability to retake these quizzes after having a chance to review the concepts.

The positive view of practice quizzes was observed during classes. When the practice quizzes were being distributed, students in all classes quickly became focused on doing their best work. Students who routinely did not attempt the written response questions were making more consistent attempts at completing these answers. They showed less anxiety and were on-task sooner when compared with their behaviors during most other assignments. They were more comfortable asking for clarification if they didn't understand a question. Nearly all of the interviewed students reported that practice

quizzes did not usually make them nervous. One student understood, “If I do bad, I’ll just have to retake it.” Although it depended on the course and the topic, most of the interviewees felt confident as these types of assessments were being handed out.

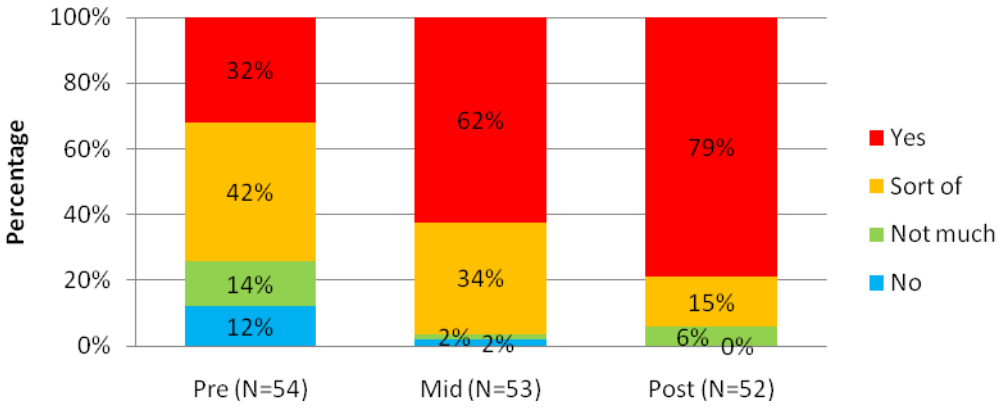


Figure 6. Student responses to the Statement *Practice quizzes help me to see what I need to study.*

In comparing the grade trends from the past three years of the students in the same course, an overall trend became evident. While the overall grades were higher this year due to the two honors classes, the trends showed a decline in student grades as the school year progressed (Figure 8). The course map for the ninth-grade ESP science class has changed little over the past three years, so the units and their supporting learning goals have remained largely the same. The time spent on each of the units was also largely comparable. The first nine week grading term consisted of several review topics as we prepared for the year before we started with describing matter. Since this material was rather familiar to many students, they usually started off fairly well. Students found the material in the second nine weeks to be less familiar and more challenging as they learned about atomic structure and interactions of matter. Much of the third unit was spent on the earth and its atmosphere. Students again found these topics to be more familiar and tangible than some of the abstract chemistry concepts. Unfortunately, as the

school year proceeds, many of our students were observed to have developed poor work and attendance habits that were difficult to overcome.

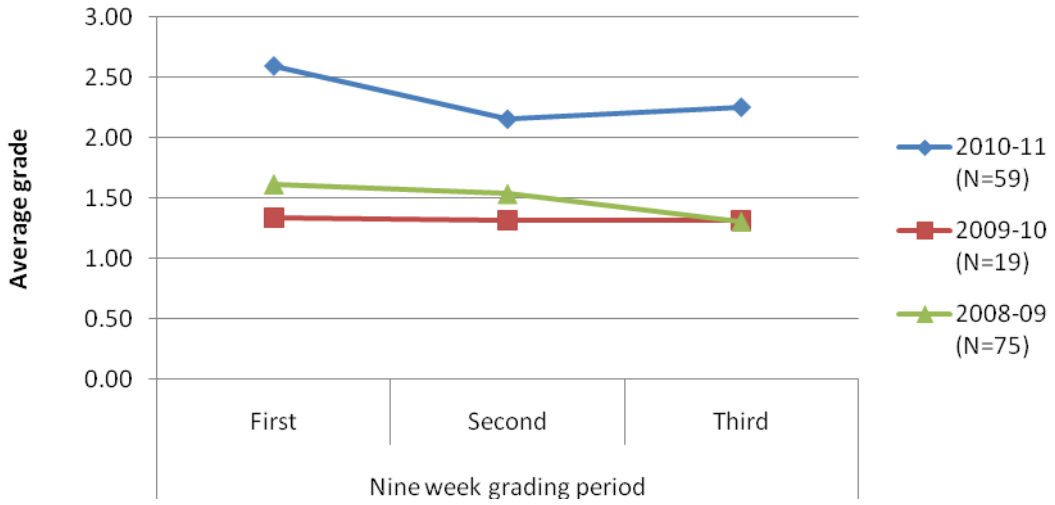


Figure 7. Comparing three years of student average Earth-Space-Physical science grades during the first three grading periods.

While 92% of the interviewed students said that grades were important, the survey data shows that students didn't work as hard for their grades over the course of the study. At the beginning of the school year, 82% of the students said *Yes* to the statement *I work hard for my grades* (Figure 9). By the second survey, this number had dropped to 49% and continued to fall to 44% by the last survey. Students seem to care less about their academics as the school year progresses. When asked, teachers of other subjects reported that student efforts and grades typically deteriorate through the school year for their classes as well.

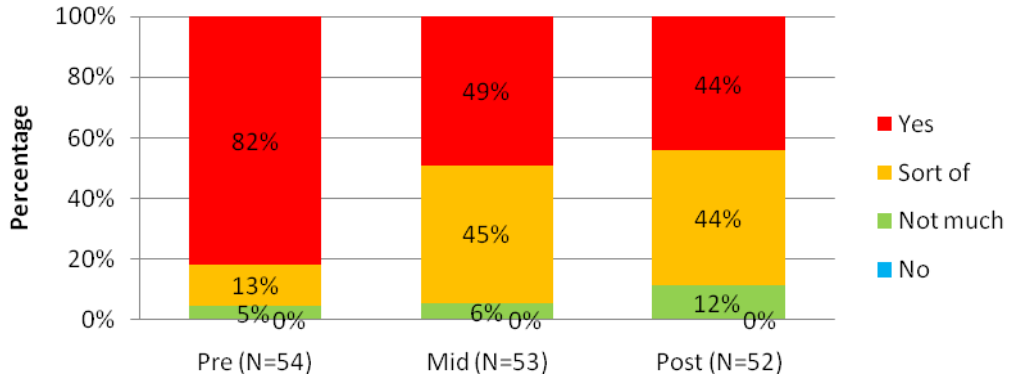


Figure 8. Student responses to the Statement *I work hard for my grades.*

When each class is analyzed, this trend was found to be due to a few students in the first period honors class (Figure 10). During the third nine-weeks, 14% of the students in the first period class (*n* =22) had begun to take time after school for further remediation and to retake practice quizzes. This attitude shift resulted in better grades on all of their assignments. The improvement of the grades for these students raised the class average. The other two classes from this year, one consisting of honors students and one of regular students, the average grades continued to decline as experienced by the students in previous years.

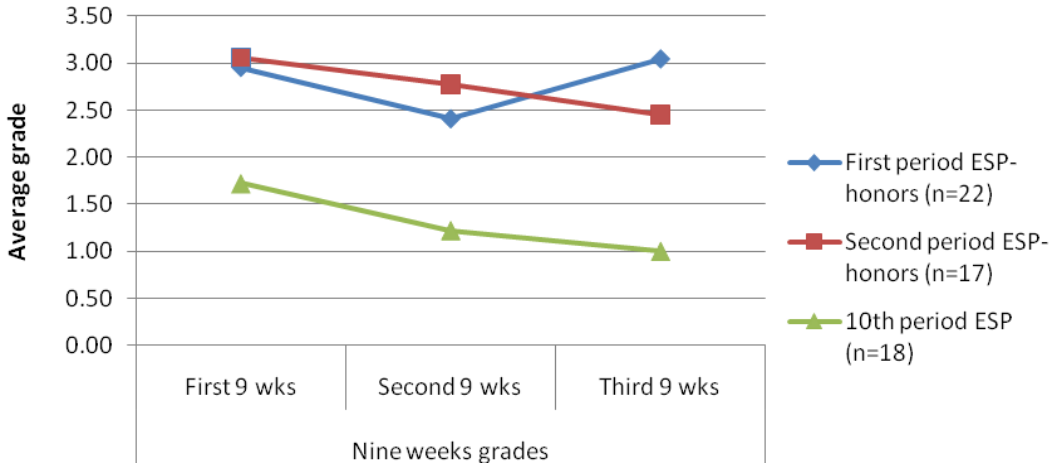


Figure 9. Nine week grade trends for the 2010-11 Earth-Space-Physical Science classes.

In analyzing each student's grade and Ohio Achievement Assessment (OAA) scores from last year, trends were difficult to establish. An attempt was made to equate the OAA score with a grade. The grade from the latest grading period was then compared with the OAA "grade" and designated as being either above, at, or below the expected level (Figure 11). This comparison shows that 50% of the students are not performing at the level their OAA score should indicate, while 17% of the students are performing better than their OAA score may indicate.

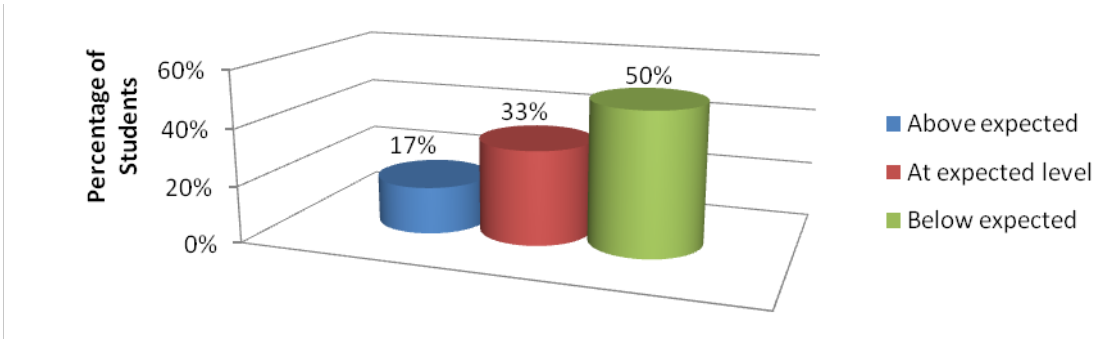


Figure 10. Comparing the students' grade with the OAA results, (*N*=48).

INTERPRETATION AND CONCLUSION

The formative assessment process offers teachers and students with many benefits and challenges. In providing for timely opportunities to evaluate the effectiveness of the teaching, the educator can better monitor how well the students are learning. The data from this study began to uncover several valuable aspects in formative assessments in their affects on attitude and performance of students. Some of the data was somewhat inconclusive while much of it showed that the formative assessment process used was yielding some of the desired results.

Did clear learning goals help students learn? Based on the student surveys, interviews, and informal observations, it can be concluded that formative assessments are only as good as the corresponding learning goals. If the goals are not understood by the students, then they are unable to reflect on how well they are progressing towards each goal. Clarifying the learning goals will make it more likely that the students will buy in to the formative assessment process and bring them to the place of self-assessment. I also found these goals useful in keeping me focused on the intended learning each day. It was valuable to see how the students rated themselves on the current goal(s) to see if there was a disconnect between what I believed they knew and how they assessed themselves. In some cases it spurred a *muddiest point* or similar assessment to attempt to close the gap.

How did students respond to specific feedback given on their work? The data shows a shift in this attitude towards becoming more positive about comments on their assignments. To be most effective, these comments needed to specifically address each students' progress towards the intended learning goal. In reviewing student work, not only are missed learning and student misconceptions identified, but it also can occasionally discover changes in student attitudes. Students also seemed to show a shift in looking over this work to help them study for other assessments to help them evaluate their own needs for future assessments, both formative and summative.

While many formative assessment techniques were used, I found myself putting more focus on the practice quizzes. The students responded well to them and they often supplied data for further instruction. In allowing students to have further attempts at the quizzes, it allowed them to experience more success. By the end of the study, more

students were seeing the benefits of these quizzes on their learning and their grade. The second practice quizzes were similar, but not identical to the first. Data supports that some students were developing more confidence in science as they were given multiple opportunities to successfully reach the objectives through the practice quizzes.

As the student OAA results are compared with their class grade, the trend was disturbing. It seems that many students are not receiving the grades of which they are capable. This is a difficult comparison to make as the OAA, as with other state testing devices, only takes a momentary snapshot of the students' learning during 90 minutes of the entire school year. It is not as directly affected by the students' behaviors, personal motivations, distractions, and attendance as the classroom grade. The high-stakes test seems to influence the students to do well. However students do not seem motivated to continue this level of concentration and effort on a day-to-day basis to achieve higher grades.

Did the use of these formative assessments help students to learn? If grades are the measure used to evaluate learning, the effect of the formative assessment process didn't demonstrate large-scale changes in student learning. Nor were shifts in attitudes about science class especially evident. Some positive shifts were apparent, but many students have fallen into deep-rutted bad habits and poor attitudes that are difficult to change. Nevertheless, the process provides students and teachers with data needed to improve instruction and learning one step at a time. While this data is a start, a more longitudinal study would be needed to generate more correlations regarding the effects of formative assessments on increasing students' performance.

VALUE

This study has helped me to be more attentive to the learning needs of my students from several different perspectives. Though I was hoping for more dramatic results, I believe that the teaching and the learning in my classroom have improved through the deliberate utilization of formative assessments. Some challenges emerged that I will continue to work on.

One of these challenges involves remediation or "closing the loop" for those who fall behind the majority of the class. I found it difficult to differentiate the lessons to address some of the individual needs that arose when some students needed more instruction when the majority of the class was ready to move on. The efforts to provide meaningful reinforcement materials for the students who "got" the lesson while re-teaching the students who still required more direct instruction was more of a challenge than I expected. This took extra planning time and resources that I didn't always have.

This challenge was compounded when students were absent. While it's not as evident in the honors classes, on any given day 10-20% of our student body is absent. I found the sequence of instruction was difficult to maintain when a student missed a day of class. Despite bribing and conversations with their parents, few of these students would return at the end of the day for remediation which caused poor results on the practice quizzes and subsequent learning. The integrity of the formal assessment process seemed to suffer as a result. I need to develop a more proactive plan for absent students.

Though time-consuming, I enjoyed providing feedback on the students' work. I would rarely look at the entire assignment. Many times there were a couple of key questions on an assignment that I would focus on. In our school's commitment to be a

"Professional Learning Community," teachers must accept late work with a maximum penalty of 50%. An assignment should be accepted even if it is over a month late. I found that students would seem to take advantage of this by not turning in their assignments on time in anticipation of finding someone to let them copy the assignment once the work was returned. To address this, I purposefully did not hand back assignments right away to create a larger window to encourage students to do their own work. One exception to this was the practice quizzes which I always returned the next day. By not returning graded work assignment it meant that I was holding back information that could help them learn. This has been an ongoing challenge that I continue to address.

The pre-tests evolved into a study tool that I have embraced. With very few exceptions, the students did very poorly on the pre-tests. When used as a graded post-test, they became a cumbersome added layer to our district's common summative assessments and students were asked to take two tests for the same learning goals. The result was that the students became a bit overwhelmed and they did not perform well on either and the data was not especially accurate as neither test accurately reflected the actual learning of the students. During the How the Earth Works unit, I chose to return their pretest before the summative test as a unit review to self-assess how much they had learned and help them focus on any weak areas before the unit test. Although I found the pre-tests will require some revisions, I believe this helped the students to realize what they have learned day by day.

As I assembled and organized the data, I was trouble by the trend of declining grades at each grading period. While I knew that some students declined, I had never

viewed it so intimately to realize how widespread the problem is. Many outside factors can contribute to this decline in overall grades. This study was performed with ninth-grade students in a high school of grades 9-12. After the excitement of high school wanes and the distractions grow, students focus less on academics. Athletic eligibility must also be taken into consideration as more students are involved in extra-curricular sports during the fall, so they must keep up their grades to be able to play. Fewer students are involved with these activities during the second term so they lose the concern to maintain eligibility. As mentioned earlier, of great concern is the attendance problem that our school experiences. Our building and district administration continually struggles to develop ways to get students to school with limited results. Also, students who leave to go to Mexico during Christmas rarely catch up on the work. They can return feeling behind despite our efforts help them. All of these factors contribute to the grading trends experienced.

This action research process has helped me to become more aware of the issues that may prevent students from learning as effectively as they should be. Although I have been teaching for eleven years, I had not been as methodical about my focus on the learning goals and the assessments of my students' progress towards them. Many good things have happened as a result of these changes. However, I feel that my work along these lines is only just beginning. I will continue to add further layers of assessment, remediation, differentiation, and feedback to help my students realize that success in science is for everyone every day.

REFERENCES CITED

Angelo, T, & Patricia, K. (1993). *Classroom assessment techniques: a handbook for college teachers*. San Francisco: Jossey-Bass.

Black, P. & Wiliam, D. (1998). Inside the Black Box: Raising Standards through Classroom Assessment. *Phi Delta Kappan, 80*, 139-148.

Brookhart, S., Moss, C. & Long, B. (2008). Formative Assessment That Empowers. *Educational Leadership, 66* (3), 52-57.

Cauley, K. M. & McMillan, J. H. (2009). Formative Assessment Techniques to Support Student Motivation and Achievement. *The Clearing House, 83* (1), 1-6.

Chan, J. & Lam, S. (2008). Effects of different evaluative feedback on students' self-efficacy in learning. *Instructional Science, 38* (1), 37-58. Retrieved February 15, 2010 from SpringerLink.

Grant, H. & Dweck, C. S. (2003). Clarifying Achievement Goals and Their Impact. *Journal of Personality and Social Psychology, 85* (3), 541-553.

Guskey, T. R. (2003). How Classroom Assessments Improve Learning. *Educational Leadership, 60* (5), 6-11.

Heritage, M. (2007). Formative Assessment: What Do Teachers Need to Know and Do? *Phi Delta Kappan, 89* (2), 140-145.

Keeley, P. (2008). *Science formative assessment: 75 practical strategies for linking assessment, instruction, and learning*. Thousand Oaks, CA: Corwin Pr.

Nicol, D. & MacFarlane-Dick, D. (2006). Formative assessment and self-regulated learning: A model and seven principles of good feedback practice. *Studies in Higher Education, 31* (2), 199-218.

McMillan, J., Cohen, J., Abrams, L., Cauley, K., Pannozzo, G. & Hearn, J. (2010, January). Understanding Secondary Teachers' Formative Practices and Their Relationship to Student Motivation. *ERIC Digest*. Retrieved February 13, 2010 from ERIC Database. (ERIC Identifier: ED507712)

McMillan, J. & Hearn, J. (2008). Student Self-Assessment: The Key to Stronger Student Motivation and Higher Achievement. *Educational Horizons, 87* (1), 40-49.

"Ohio Department of Education Interactive Local Report Card." *Ohio Department of Education Interactive Local Report Card*. N.p., n.d. Web. 12 Dec. 2010. <http://ilrc.ode.state.oh.us/Downloads

Salpeter, J. (2007). Is More Testing the Answer? *Technology & Learning*, 27 (10), 18-25.

Stiggins, R. (2005). From Formative Assessment to Assessment FOR Learning: A Path to Success in Standards-Based Schools. *Phi Delta Kappan, 87* (4), 324-328).

Stiggins, R. (2007). Assessment through the Student's Eyes. *Educational Leadership, 64* (8), 22-26.

Stiggins, R. & Chappuis, J. (2005). Using Student-Involved Classroom Assessments to Close Achievement Gaps, *Theory Into Practice, 44* (1), 11-18.

Yorke, M. (2003). Formative Assessment in Higher Education: Moves Towards Theory and the Enhancement of Pedagogical Practice. *Higher Education, 45* (4), 477-501.

Zimmerman, B. (2000). Self-Efficacy: An Essential Motive to Learn, *Contemporary Educational Psychology 25*, 82-91.

APPENDICES

APPENDIX A

STUDENT ATTITUDE SURVEY

Student Attitude Survey

Participation in this research is voluntary, and participation or non-participation will not affect your student's grade or class standing in any way.

	Yes	Sort of	Not much	No
I am good at science…….				
I enjoy science……..				
Science is important in my everyday life…….				
My grades usually reflect my abilities…….				
I work hard for my grades…….……...				
Knowing the learning goals ("I can" statements or learning objectives) helps me learn better……				
Teacher's comments on my returned work helps me to learn…….				
When preparing for a test or quiz, I often use my returned work to help me study …….…….				
Practice quizzes help me to see what I need to study….				
I like to be able to accomplish all the learning goals…...				

When a graded assignment is returned to me, I usually

- ❑ look carefully at what I missed and make the corrections so I can do better next time.
- ❑ ask the teacher to help me fix it so I can do better next time.
- ❑ look only at the grade and then put it away.
- ❑ put the assignment away without looking at it again
- ❑ put the assignment away at first but look it over later

When faced with a problem on an assignment, I usually

- ❑ look it up in the textbook or the Internet.
- ❑ ask for help.
- ❑ take a guess/ try a possible solution.
- ❑ move on to something else.

Is there anything else you'd like me to know? You may use the back of this sheet.

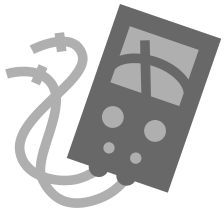
APPENDIX B

I CAN DASHBOARDS

"I Can Dashboard"

Chemistry A: Properties of Matter

Rank your knowledge in each of the statements. 1 = no understanding, 5 = I could teach it



I CAN...

1 2 3 4 5

1. ❍❍❍❍❍...distinguish between and give examples of chemical and physical properties.

2.❍❍❍❍❍ ...use the kinetic theory to describe the four states of matter.

3. ❍❍❍❍❍...classify matter into elements, compounds, and mixtures.

4. ❍❍❍❍❍...differentiate between endothermic and exothermic changes.

5. ❍❍❍❍❍...use the kinetic theory to describe the six phase changes of matter.

"I Can Dashboard"

Chemistry B Structure and Interactions of Atoms

Rank your knowledge in each of the statements. 1 = no understanding, 5 = I could teach it

I CAN...

1 2 3 4 5

1. ❍❍❍❍❍ ...describe a model of an atom and how this model has changed over time

2. ❍❍❍❍❍ ... identify and explain patterns in the periodic table of elements

3. ❍❍❍❍❍ ...determine the number of protons, neutrons, electrons, atomic mass and charge.

4. ❍❍❍❍❍ ...show how atoms bond together by losing, gaining, and sharing electrons.

5. ❍❍❍❍❍ ... diagram Lewis dot structures and Bohr models.

6. ❍❍❍❍❍ ...use the pH scale to classify substances as acidic, alkaline, or neutral.

"I Can Dashboard"
How the Earth Works

Rank your knowledge in each of the statements. 1 = no understanding, 5 = I could teach it

I CAN...

1 2 3 4 5

1. ❍❍❍❍❍ ... analyze data from current technology to explain the past, present and future changes of the Earth's surface due to plate tectonics.

2. ❍❍❍❍❍ ... identify and describe the formation of igneous, metamorphic, and sedimentary rock types.

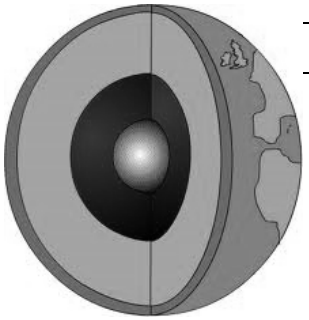
igneous

metamorphic

sedimentary

3. ❍❍❍❍❍ ... apply the theory of plate tectonics to explain geological events (faulting, folding, earthquakes, rock cycles and sea floor spreading).

4. ❍❍❍❍❍ ... explain the energy transfer from the core to the lithosphere (convection currents).



I CAN DASHBOARD: How the Atmosphere Works

Rank your knowledge in each of the statements. 1 = no understanding, 5 = I could teach it

I CAN...

1 2 3 4 5

1. ❍❍❍❍❍ ...name and describe the four layers of the atmosphere

2. ❍❍❍❍❍ ...analyze and interpret atmospheric data to predict weather events.

3. ❍❍❍❍❍ ...describe the effects of solar radiation, the tilt of the Earth, and the rotation of the Earth on climate patterns.

4. ❍❍❍❍❍ ...describe how convection, conduction, and radiation transfer thermal energy through the atmosphere.

5. ❍❍❍❍❍ ...describe the interactions between the hydrosphere and the atmosphere and how these interactions affect earth's climate.

6. ❍❍❍❍❍ ...relate global atmospheric patterns to Painesville's weather.

7. ❍❍❍❍❍ ...evaluate ways that human actions impact the atmosphere and climate.

APPENDIX C

UNIT PRE-/ POSTTESTS

Properties of Matter Pretest

1. Compare and contrast physical and chemical properties.

2. List and describe the 3 states of matter.

① _____

② _____

③ _____

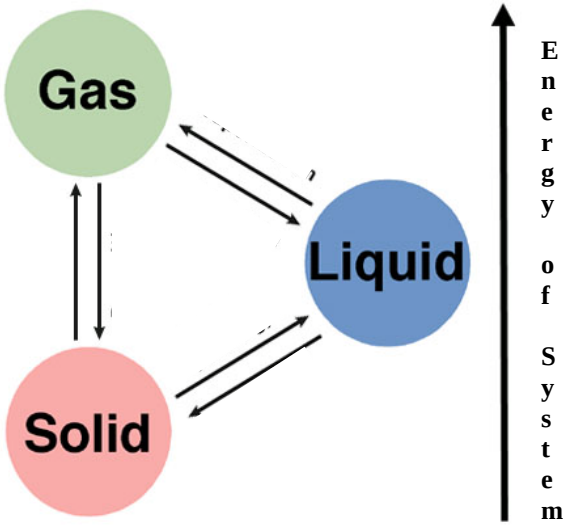
3. Label the following as *element*, *compound* or *mixture*:

a. Salt _____ b. Chlorine _____

c. Chalk _____ d. Sand _____

4. Is combustion of fuel an endothermic or exothermic reaction? Explain.

5. Label the 6 phase changes of matter on each small arrow:



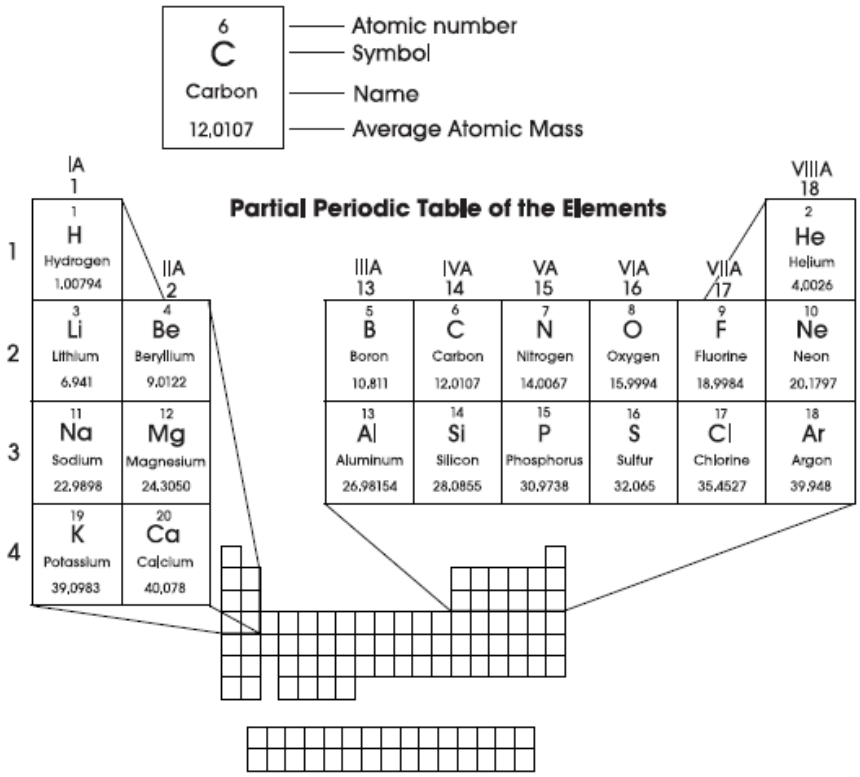
Name_____

Structure and Interaction of Atoms Pretest

1. Draw and describe a model of an atom.

2. Identify and explain 2 patterns in the periodic table below:

   a.
   b.



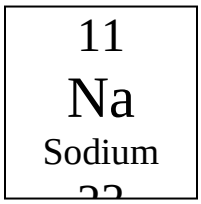
3. An atom of Carbon has 6 protons and 6 neutrons. How many electrons does it have and what is its atomic mass?

   a.
   b.

4. Why do compounds form?

5. Is a liquid with a pH of 4 acidic, basic or neutral? Explain.

6. Draw a Lewis Dot Structure and Bohr Model for Sodium:



Name_____

Planet Earth Pretest

1. What is radiometric dating used for?

_____

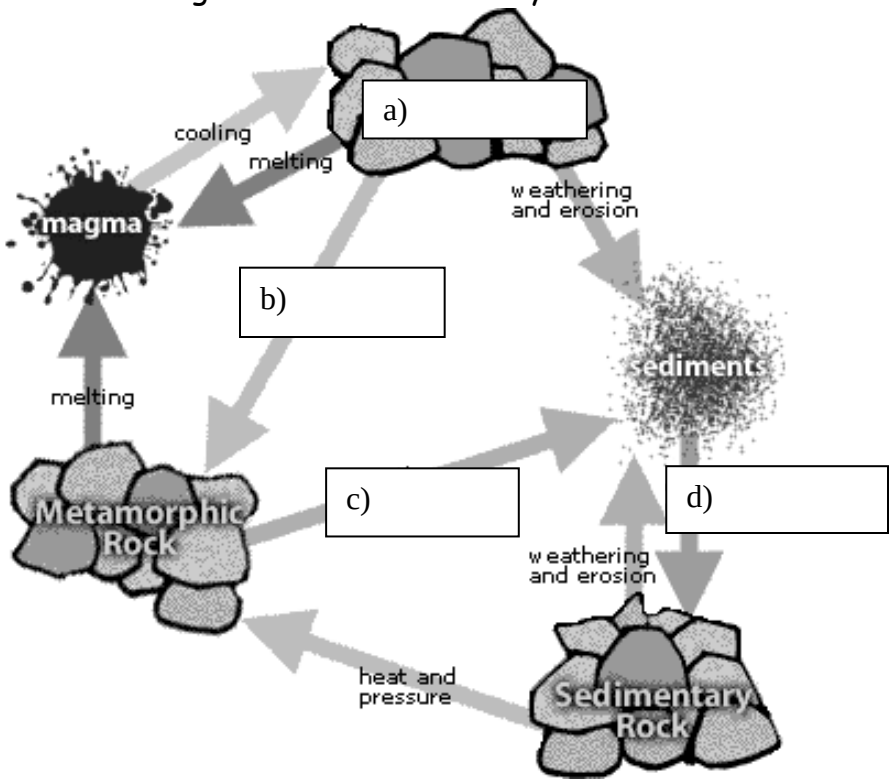
_____

2. What is meant by *relative dating* of rocks or fossils?

_____

_____

3. Label the following letters on the rock cycle:



4. List 2 pieces of evidence that support the theory of plate tectonics.

_____

_____

_____

5. What are 2 effects of plate tectonics?

6. List and describe the 3 types of plate boundaries.

①

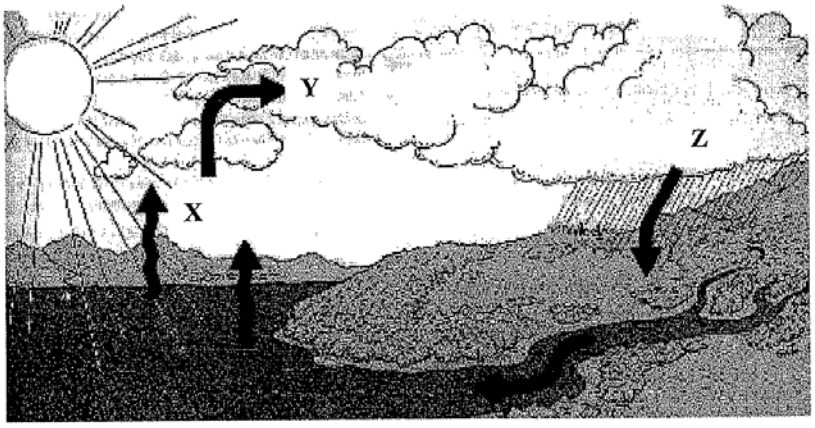
②

③

7. What causes the movement of Earth's crustal plates?

Atmosphere Pretest

1. Label the letters of the processes X, Y and Z on the diagram of the water cycle below:



X_____
Y_____
Z_____

2. List the four layers of the atmosphere in order of increasing elevation.

3. Painesville is located near Lake Erie. Describe two ways the lake affects our weather.

4. How would Ohio's climate be different if the Earth was not tilted on its axis?

5. Conduction, convection and radiation carry thermal energy through the atmosphere. Provide an example of each.

6. England is at the same latitude as areas in Canada. Why is the climate warmer in England than in Canada?

7. What causes global warming?

8. What causes ozone depletion? What are affects of thinning ozone?

APPENDIX D

PRACTICE QUIZZES

Classification of Matter Practice Quiz 1

Multiple Choice
Identify the letter of the choice that best completes the statement or answers the question.

____ 1. Three examples of physical change are _____.
A) boiling of water, bursting a balloon, and melting a candle
B) burning of gasoline, rotting of an egg, and exploding fireworks
C) freezing of water, evaporation of gasoline, and rusting a nail
D) sawing of wood, crushing a can, and toasting a marshmallow

____ 2. _____ is a substance.
A) Lemonade
B) Soil
C) Seawater
D) Salt

____ 3. The color of ink is a _____.
A) chemical change
B) chemical property
C) physical change
D) physical property

____ 4. A mixture is different from a compound because each substance in a mixture
A) retains its own properties.
B) changes its electric charge.
C) forms an ion.
D) becomes a new substance.

____ 5. A substance that cannot be broken down into simpler substances is
A) a compound.
B) a mixture.
C) an element.
D) an atom.

____ 6. The chemical symbol for sulfuric acid is H_2SO_4. How many atoms are contained in each molecule of sulfuric acid?
A) 3 B) 5 C) 6 D) 7

____ 7. Knowing the chemical properties of a substance will tell you how the substance
A) looks.
B) smells.
C) can be broken down into atoms.
D) reacts with other substances.

____ 8. Which of the following is an example of a physical change?
A) dissolving salt in water
B) burning wood into charcoal
C) cooking an egg
D) rusting iron

____ 9. Grinding quartz crystals down to produce sand is an example of a
A) change of state.
B) chemical change.
C) chemical reaction.
D) physical change.

____ 10. Which of the following is ***not*** a potential sign of chemical change?
A) release of gas
B) will dissolve in water
C) change of color
D) release of heat

____ 11. A material that can be represented by a chemical formula is
A) an element.
B) a mixture.
C) a homogeneous solution.
D) a pure substance.

____ 12. Which warning label indicates a chemical property of the material being handled?
A) “Fragile”
B) “Flammable”
C) “Handle with care”
D) “Shake well”

____ 13. A combination of elements that are chemically attached together are called
A) compound
B) homogeneous mixture
C) heterogeneous mixture
D) Solution

____ 14. Water is a compound because it
A) can be broken down into simpler substances.
B) always has two hydrogen atoms for each oxygen atom.
C) is made of water atoms joined together.
D) both a and b

____ 15. Which of the following is a heterogeneous mixture?
A) water in a swimming pool
B) sugar water
C) a jar of mixed nuts
D) stainless steel

____ 16. Which of the following has the highest viscosity?
A) corn syrup B) milk C) water D) orange juice

____ 17. A material that is malleable and conducts electricity is most likely
A) wood. B) ice. C) a metal. D) motor oil.

Matching

Match the labeled parts of Figure 9-1 to the correct terms below.

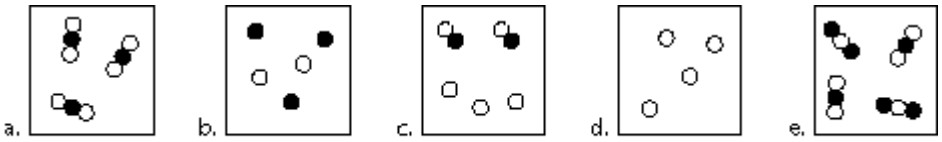


Figure 9-1

____ 18. pure element
____ 19. mixture of two elements
____ 20. pure compound
____ 21. mixture of two compounds
____ 22. mixture of a compound and an element

Short Answer

23. Explain how you could separate a mixture of sand and sugar. Be complete! (2 points)

_____

_____

24. A glass is filled with water and ice. Are the contents of the glass a substance or a mixture? Explain. (2 pts)

_____

_____

25. Is combustion of fuel an endothermic or exothermic change? Explain. *(2 points)*

_____

_____

Chemistry A Practice Quiz 2

Multiple Choice
Identify the choice that best completes the statement or answers the question.

____ 1. A material that is malleable and conducts electricity is most likely
a. wood.
b. ice.
c. a metal.
d. motor oil.

____ 2. What happens in a chemical reaction?
a. atoms are destroyed
b. atoms are created
c. atoms are heated and cooled
d. atoms are rearranged

____ 3. Matter that has a definite volume but no definite shape is a
a. liquid.
b. solid.
c. gas.
d. plasma.

____ 4. A mixture that appears to contain only one substance is a(an)
a. homogeneous mixture.
b. heterogeneous mixture.
c. compound.
d. element.

____ 5. A mixture is different from a compound because each substance in a mixture
a. retains its own properties
b. changes its electric charge
c. forms an ion
d. changes from a solid to a liquid

____ 6. At 25^{o} C, water has a density of 1.0 g/mL and vegetable oil has a density of 0.90 g/mL. How would a substance with a density of 0.95 g/mL behave when placed in both oil and water?
a. sink in both oil and water
b. sink in oil and float on water
c. float on oil and sink in water
d. float on both oil and water

____ 7. During which phase change does the arrangement of water molecules become more orderly?
a. melting
b. Freezing
c. boiling
d. condensing

____ 8. Which of the following is a heterogeneous mixture?
a. water in a swimming pool
b. sugar water
c. a jar of mixed nuts
d. stainless steel

____ 9. Forces of attraction limit the motion of particles most in
a. a solid.
b. a liquid.
c. a gas.
d. both b and c

____ 10. All matter is made of atoms and molecules that are:
a. fixed in position
b. in motion, but never collide
c. motionless
d. constantly in motion

____ 11. A gas has
a. a definite volume but no definite shape.
b. a definite shape but no definite volume.
c. no definite shape or definite volume.
d. a definite volume and definite shape.

____ 12. A substance that undergoes a change in a chemical reaction is
a. a product
b. a chemical
c. a reactant
d. an enzyme

____ 13. Suppose 50 grams of liquid hydrogen peroxide is heated in a closed system. While heating, it chemically breaks down into liquid water and oxygen gas. Which best describes that total mass of the water and oxygen that was produced?
a. more that 50 grams because heat is added
b. more that 50 grams because there are now two substances
c. less than 50 grams because oxygen gas is very light
d. exactly 50 grams because no matter is added or removed

____ 14. Which statement about endothermic reactions is correct
a. Energy is always created in the form of heat.
b. Energy is transferred from the surroundings to the reactants.
c. Energy is used to force electrons to move to higher energy levels
d. Energy is transferred from the reactants to the surroundings

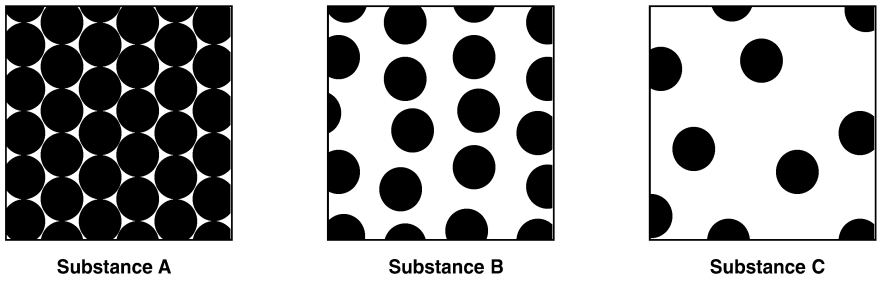


Figure 3-1

____ 15. In which of the substances in Figure 3-1 are the forces of attraction among the particles so weak that they can be ignored under ordinary conditions?
a. Substance A
b. Substance B
c. Substance C
d. all of the above

____ 16. A metal that can be hammered out or rolled into thin sheets is best described as
a. brittle
b. ductile
c. reactive
d. malleable

____ 17. Which of the following is NOT a clue that a chemical change has occurred?
a. change in color
b. production of a gas
c. formation of a precipitate
d. change in shape

____ 18. The kinetic theory states that the higher the temperature, the faster the:
a. particles that make up a substance move
b. bonds between atoms break down
c. molecules of gas rush together
d. lighter particles within a substance clump together

____ 19. A substance that is made up of only one kind of atom is a(an)
a. compound.
b. homogeneous mixture.
c. element.
d. solution.

____ 20. Which of the following are pure substances?
a. solutions
b. compounds
c. homogeneous mixtures
d. colloids

____ 21. You burn a log of wood, and only a small pile of ashes is left. What has happened?
a. A large amount of mass has been lost.
b. A small amount of mass has been converted into a large amount of heat energy.
c. The total mass of the wood and oxygen is the same as the total mass of the ash and gases.
d. The total amount of energy is less than before.

Matching

Match the labeled parts of Figure 9-1 to the correct terms below.

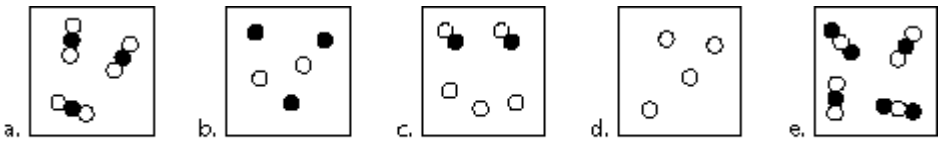


Figure 9-1

a. pure element
b. mixture of two elements
c. pure compound
d. mixture of two compounds
e. mixture of a compound and an element

____ 22. mixture of two compounds

____ 23. pure compound

____ 24. mixture of a compound and an element

____ 25. mixture of two elements

____ 26. pure element

Other

27. A. State if each of the following is a physical property (P) or a chemical properties (C)

_____ ability to oxidize
_____ density
_____ ability to react with acid
_____ solubility
_____ ability to react with base
_____ conductivity

B. State if each of the following is a physical change (PC) or a chemical change (CC).

_____ sugar dissolving in tea
_____ evaporating
_____ rusting
_____ fermentation
_____ producing a precipitate
_____ stretching a rubber band

Atoms Quiz

Multiple Choice
Identify the choice that best completes the statement or answers the question.

____ 1. Which subatomic particle has a negative charge?
a. electron
b. alpha particle
c. neutron
d. proton

____ 2. Which statement about subatomic particles is NOT true?
a. Protons and neutrons have almost the same mass.
b. Protons and electrons have opposite charges.
c. Unlike protons and electrons, neutrons have no charge.
d. Protons and neutrons have the same charge.

____ 3. Which of the following is unique for any given element?
a. the number of neutrons
b. the charge on the electrons
c. the number of protons
d. the mass of a neutron

____ 4. Which statement is true about oxygen-17 and oxygen-18?
a. They do not have the same number of protons.
b. Their atoms have an identical mass.
c. They are isotopes of oxygen.
d. The have the same mass number.

Fill in the table *(3 points)***:**

5. FIll in the following table:

Subatomic particle	charge	location

Fill in the table with the required information. Do not use your periodic table. *(5 points)*

6.

Element	Atomic #	Atomic Mass	# protons	# neutrons	# electrons
Selenium-80					34
Zinc	30			36	
K-40		40	19		
C-14			6		
S^{-2}					

You may use your periodic table for this side

7. Draw Bohr models for the following two elements *(3 points each)*:

Aluminum **Fluorine**

8. Draw Lewis dot diagrams for the following three elements *(2 points each)*

oxygen	magnesium	BONUS: Xenon

Chemical Bonding Practice Quiz

Multiple Choice
Identify the choice that best completes the statement or answers the question.

____ 1. Which of the following groups contain three elements with stable electron configurations?
a. lithium, krypton, argon
b. argon, neon, barium
c. xenon, neon, boron
d. helium, xenon, neon

____ 2. Typically, atoms gain or lose electrons to achieve
a. an exchange of energy.
b. ionization.
c. a stable electron configuration.
d. vaporization.

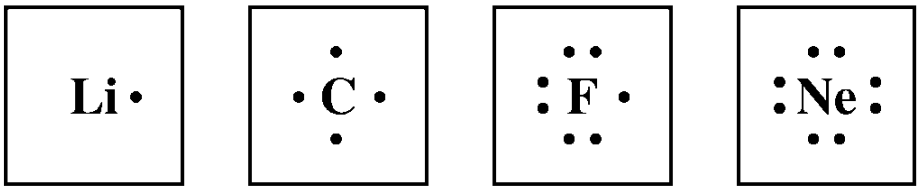


Figure 6-1

____ 3. Study the electron dot diagrams for lithium, carbon, fluorine, and neon in Figure 6-1. Choose the statement that correctly identifies the most stable of the elements.
a. Lithium is the most stable element because it has to lose only one electron to achieve a stable configuration.
b. Carbon is the most stable element because it can form four bonds.
c. Fluorine is the most stable element because it has to gain only one electron to achieve a stable configuration.
d. Neon is the most stable element because its highest occupied energy level is filled.

____ 4. The formation of an ionic bond involves the
a. transfer of electrons.
b. transfer of neutrons.
c. transfer of protons.
d. sharing of electrons.

____ 5. In the compound $MgCl_2$, the subscript 2 indicates that
a. there are two magnesium ions for each ion of chlorine
b. the chloride ion is twice the size of the magnesium ion.
c. magnesium and chlorine form a double covalent bond.
d. there are two chloride ions for each magnesium ion.

____ 6. Which of the following is a typical property of an ionic compound?
a. low melting point
b. poor conductor of electric current when melted
c. tendency to shatter when struck
d. all of the above

____ 7. The forces that hold different atoms or ions together are
a. electric currents.
b. chemical bonds.
c. physical bonds.
d. nuclear forces.

____ 8. Each molecule of table sugar, $C_{12}H_{22}O_{11}$, contains
a. 0 atoms of carbon.
b. 1 atom of carbon.
c. 6 atoms of carbon.
d. 12 atoms of carbon.

____ 9. Often atoms join so that each atom will have
a. an even number of electrons.
b. an outermost energy level that is full of electrons.
c. an equal number of protons and electrons.
d. more electrons than either protons or neutrons.

____ 10. When two hydrogen atoms bond, the positive nucleus of one atom attracts the
a. negative nucleus of the other atom.
b. positive electron of the other atom.
c. negative electron of the other atom.
d. positive nucleus of the other atom.

____ 11. An ionic bond is a bond that forms between
a. ions with opposite charges.
b. atoms with neutral charges.
c. one atom's nucleus and another atom's electrons.
d. the electrons of two different atoms.

____ 12. Covalent bonds are formed between
a. ions.
b. metal atoms.
c. nonmetal atoms.
d. compounds.

Short Answer

13. Are covalent bonds more likely to be found in compounds containing both metals and nonmetals or compounds containing only nonmetals?

_____

Essay

14. Fluorine is the most reactive nonmetal. To fluorine's immediate right in the periodic table is neon, a noble gas that does not form chemical bonds. Explain this contrast in reactivity in terms of atomic structure. (2 points)

_____

_____

_____

_____

Acids and Bases

Multiple Choice
Identify the choice that best completes the statement or answers the question.

____ 1. Which of the following is NOT a property of an acid?
A) tastes sour
B) usually reacts with a metal
C) changes the color of an indicator
D) feels slippery

____ 2. A girl tasted each of the following foods. Which of the following would NOT taste acidic to her?
A) lime
B) tomato
C) orange
D) celery

____ 3. A base is defined as a compound that produces
A) hydroxide ions in solution.
B) hydrogen ions in solution.
C) hydronium ions in solution.
D) sodium ions in solution.

____ 4. Which of the following is NOT a common property of bases?
A) feels slippery
B) tastes bitter
C) reacts with metals
D) changes colors of indicators

____ 5. The products of the neutralization reaction between hydrochloric acid (HCl)and magnesium hydroxide ($Mg(OH)_2$) are
A) NaCl and H_2O.
B) $MgCl_2$ and H_2O.
C) HCl and MgOH.
D) HCl and $Mg(OH)_2$.

____ 6. Distilled water has a hydronium ion concentration of 1×10^{-7} M. What is the pH of a distilled water?
A) 7 B) –7 C) 10 D) 1×10^{-7}

____ 7. A compound has a pH of 6 in solution, where very little of it has ionized. The compound is a
A) weak base. B) strong base. C) weak acid. D) strong acid.

Short Answer

8. What are the products of a neutralization reaction?

9. Draw and number the pH scale.
Label: STRONG ACID, STRONG BASE, WEAK ACID, WEAK BASE, and NEUTRAL (3 points)

Earth Structure and Processes

Multiple Choice
Identify the choice that best completes the statement or answers the question.

____ 1. The earth's layer of solid rock that flows under pressure is called the
a. crust.
b. asthenosphere.
c. Lithosphere.
d. hydrosphere.

____ 2. Oceanic crust is
a. thicker and less dense than continental crust.
b. thinner and less dense than continental crust.
c. thicker and more dense than continental crust.
d. thinner and more dense than continental crust.

____ 3. About 80 percent of Earth's volume is made up of
a. crust.
b. mantle.
c. inner core.
d. outer core.

____ 4. Earth's inner core is
a. hot and solid.
b. hot and liquid.
c. cool and solid.
d. cool and liquid.

____ 5. Earth's lithosphere is composed of
a. the crust only.
b. the mantle only.
c. the crust and the upper portion of the mantle.
d. the mantle and the upper portion of the outer core.

____ 6. Igneous rock forms from
a. weathered rock particles.
b. evaporation of water.
c. magma.
d. None of the above

____ 7. Sedimentary rocks are the only rocks that can potentially contain
a. fossils.
b. minerals.
c. fractures.
d. faults.

____ 8. The rock labeled "A" is
a. igneous.
b. metamorphic.
c. sedimentary.
d. magma.

____ 9. The two layers that make up the lithosphere are the
a. upper mantle and lower mantle.
b. oceanic crust and continental crust.
c. inner core and outer core.
d. crust and upper mantle.

____ 10. Intense heat, intense pressure, or reactions with hot water can modify a pre-existing rock to form a(an)
a. metamorphic rock.
b. sedimentary rock.
c. igneous rock.
d. organic rock.

Short Answer

11. Using your knowledge of temperature and pressure, explain why the inner core of Earth is solid. (2 points)

_____

_____

12. Which rock type appeared first on Earth? Why? (2 points)

_____

_____

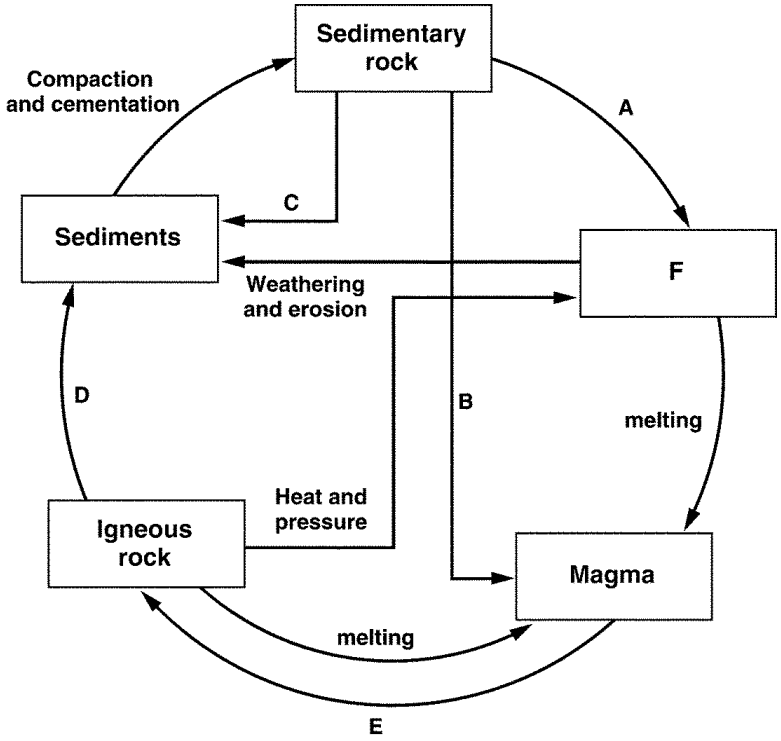


Figure 22-2

13. What type of rock would fit into Figure 22-2 at the location shown by the letter F?

_____

14. In Figure 22-2, what processes are represented by the arrow labeled A?

_____

15. In Figure 22-2, what process is represented by the arrow labeled D?

_____

16. Use Figure 22-2 to describe how an igneous rock could turn into a sedimentary rock and then into a metamorphic rock. (2 points)

_____

_____

_____

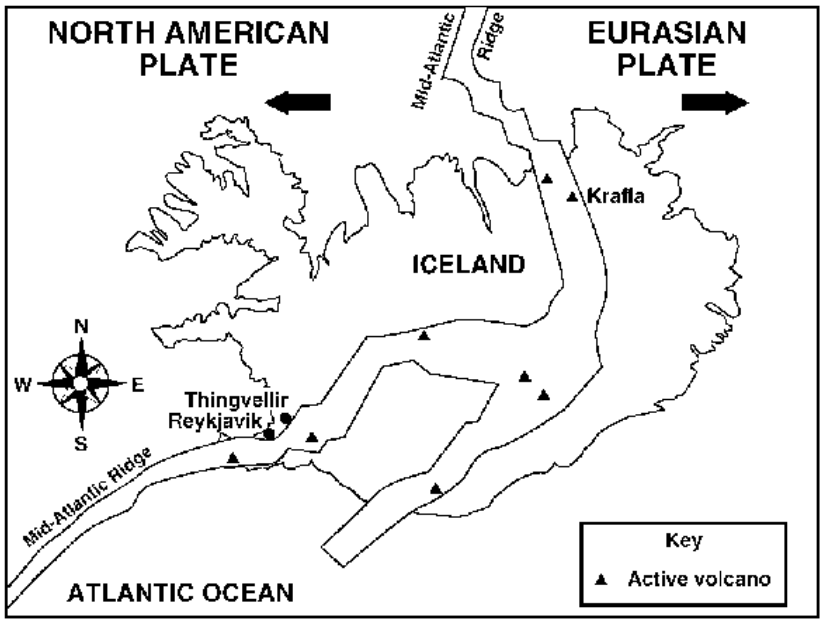
_____

_____

Plate Tectonics Quiz

Multiple Choice
Identify the letter of the choice that best completes the statement or answers the question.

Iceland



Iceland was settled by the Viking more than one thousand years ago. At the time Iceland was apparently covered with forests, but these have disappeared as people invaded the small bits of land not covered by glaciers or solid rock. This is a land of ice and heat, heat from active volcanoes.

The map shows Iceland with the Mid-Atlantic Ridge running through it. This ridge is formed by two tectonic plates that are moving apart at an average rate of 2.5 centimeters per year. As the ocean crust spreads, magma rises up into the gap and hardens to form new crust. Along the ridge are strings of volcanoes, some of which formed islands such as Iceland.

____ 1. Due to the spreading of the tectonic plates, rocks from the center of Iceland, when compared to rock formations making up its eastern and western coasts, are found to be
a. denser.
b. harder.
c. more magnetic.
d. younger.

____ 2. What type of plate boundary is shown above?
a. convergent
b. divergent
c. submergent
d. transform

____ 3. Oceanic crust is
a. thicker and less dense than continental crust.
b. thinner and less dense than continental crust.
c. thicker and more dense than continental crust.
d. thinner and more dense than continental crust.

____ 4. About 80 percent of Earth's volume is made up of
a. crust.
b. mantle.
c. inner core.
d. outer core.

____ 5. A geologic feature of divergent plate boundaries in oceanic crust is the formation of
a. trenches. c. U-shaped valleys.
b. fossils. d. rift valleys.

____ 6. A zone where oceanic crust dives beneath continental crust is called a zone of
a. subduction. c. reduction.
b. divergence. d. rifting.

____ 7. A convergent boundary occurs where two plates
a. move toward each other. c. move past each other.
b. move away from each other. d. move over each other.

____ 8. A transform fault boundary occurs where two plates
a. move toward each other. c. move past each other.
b. move away from each other. d. move over each other.

____ 9. Earthquakes occur mostly
a. in the middle of continents. c. at plate boundaries.
b. in the asthenosphere. d. at the edges of the continents.

____ 10. Many scientists believe that the motion of lithospheric plates is due to
a. the formation of magma. c. Convection in the mantle.
b. reversal of magnetic polarity. d. faulting.

____ 11. Mountains most likely occur at this type of plate boundary?
a. convergent c. subduction
b. divergent d. transform

____ 12. New crust is formed at this type of plate boundary.
a. convergent c. subduction
b. divergent d. transform

Short Answer

13. Using your knowledge of temperature and pressure, explain why the inner core of Earth is solid. (2 points)

_____

_____

_____

14. **Describe** three pieces of evidence that support the theory of plate tectonics. (3 points)

_____

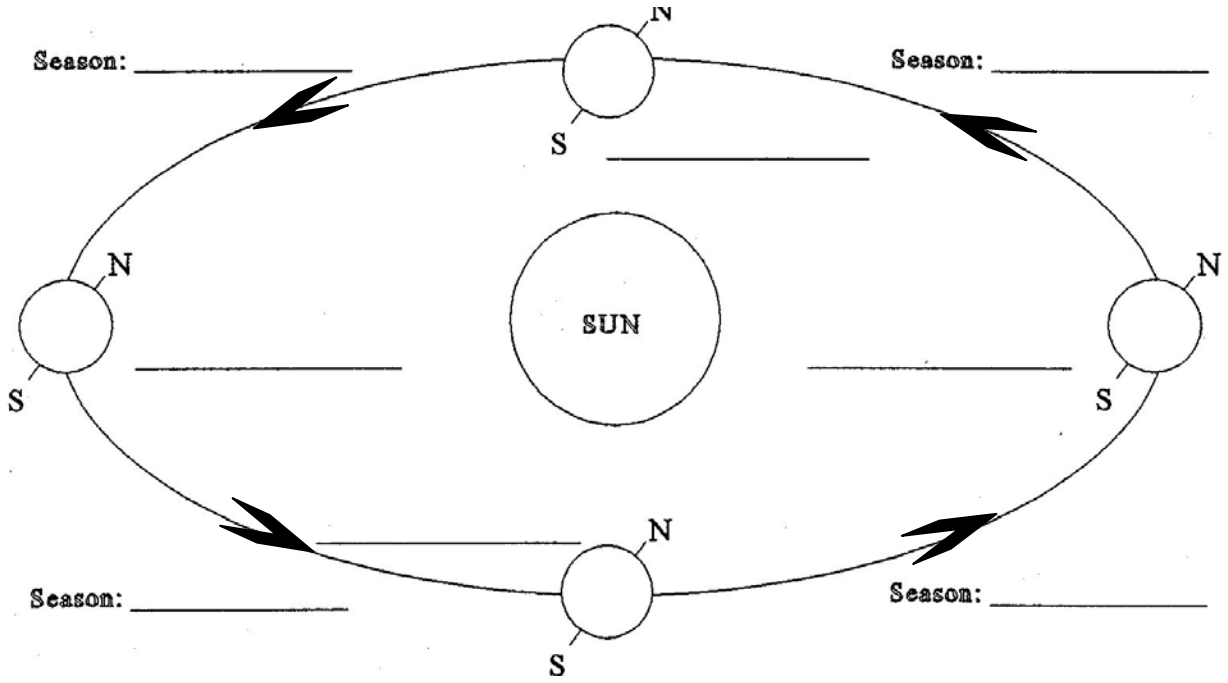
_____

_____

_____

_____

Sun and Seasons Quiz



1. ***Fill in the blanks with these terms:***

SUMMER	VERNAL EQUINOX
WINTER	AUTUMNAL EQUINOX
FALL	SUMMER SOLSTICE
SPRING	WINTER SOLSTICE

2. In terms of the position of the earth and sun, what makes an equinox?

_____

_____

3. Earth's axis is tilted _____ degrees.

____ 4. Day and night are caused by Earth's
   a. rotation. c. orbit.
   b. revolution. d. tilt.

____ 5. Earth's temperate zone is the result of
   a. the equator receiving the most direct sunlight throughout the year.
   b. regions north and south of the equator receiving direct sunlight only part of the year.
   c. the earth being closer to the sun during part of the year.
   d. regions in the northern hemisphere receiving more direct sunlight throughout the year.

Thermal Energy Quiz

Multiple Choice

Identify the choice that best completes the statement or answers the question.

____ 1. Which of the following processes is primarily responsible for heating air in the lower part of the atmosphere near earth?
A) refraction
B) convection
C) reflection
D) conduction

____ 2. The transfer of heat that takes place when liquids or gases are unevenly heated is called
A) reflection.
B) conduction.
C) radiation.
D) convection.

____ 3. Heat is the transfer of thermal energy from one object to another because of a difference in
A) specific heat.
B) phase.
C) temperature.
D) waste heat.

____ 4. Matter is needed to transfer thermal energy by
A) conduction.
B) convection.
C) radiation.
D) both a and b.

____ 5. The primary reason an ice cube feels cold to the touch is that
A) conduction causes coldness to leave the ice.
B) radiation from the hand enters the ice.
C) conduction causes heat to leave the hand.
D) convection currents leave the hand.

____ 6. A students walks from inside an air-conditioned building to stand outside on a sunny, sandy beach. The students says that her face and the bottoms of her feet feel warm.

Which statement best describes the thermal energy transfers taking place?
A) Thermal energy is transferred to her face by radiation and to the bottoms of her feet by radiation.
B) Thermal energy is transferred to her face by convection and to the bottoms of her feet by radiation.
C) Thermal energy is transferred to her face by radiation and to the bottoms of her feet by conduction.
D) Thermal energy is transferred to her face by conduction and to the bottoms of her feet by conduction.

7. How do convection currents form in air?

_____

_____

_____

_____

Atmosphere Quiz 1

Multiple Choice

Identify the choice that best completes the statement or answers the question.

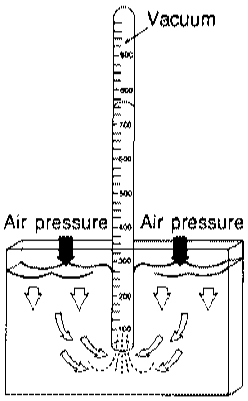
____ 1. The ozone layer is located in the
A. mesosphere.
B. troposphere.
C. thermosphere.
D. stratosphere.

____ 2. The most abundant gas in the earth's atmosphere is
A. oxygen.
B. nitrogen.
C. carbon dioxide.
D. argon.

____ 3. The layer of the atmosphere in which weather changes occur is the
A. mesosphere.
B. troposophere.
C. thermosphere.
D. stratosphere.

____ 4. What would be the long-range effect on the earth's surface if the ozone layer were destroyed?
A. decreased infrared radiation
B. increased acid precipitation
C. increased ultraviolet radiation
D. decreased atmospheric temperature

____ 5. Which of the following is a unit used to measure atmospheric pressure?
A. millibar
B. newton
C. milligram
D. degree



____ 6. Which of the following meteorological instruments does this illustration represent?
A. altimeter
B. mercurial barometer
C. thermometer
D. aneroid barometer

____ 7. The coldest layer of the atmosphere is the
A. mesosphere.
B. exosphere.
C. stratosphere.
D. ionosphere.

____ 8. The atmospheric layer closest to the earth's surface is called the
A. troposphere.
B. stratosphere.
C. ionosphere.
D. mesosphere.

____ 9. As distance from Earth's surface increases, the temperature of the stratosphere
A. decreases.
B. increases.
C. remains the same.
D. None of the above

Write complete sentences as you answer the following:

10. Why does the temperature decrease with altitude in the troposphere? (2 pts)

_____
_____
_____

11. Why does air pressure decrease with altitude? (2 pts)

_____
_____
_____

12. Mars has a very thin atmosphere (less than 1% of Earth's). Imagine you have crash-landed on Mars. **Describe** <u>three</u> ways this lack of atmosphere will make it difficult to survive?

_____
_____
_____
_____

APPENDIX E

STUDENT INTERVIEW QUESTIONS

Student Interview Questions

Focus question: *How will the use of formative assessments affect student's motivation and performance in science?*

1. In what subject are you most confident? Why?
2. In what subject are you least confident? Why?
3. How important are grades to you?
4. Do you feel your grades reflect your actual abilities? Explain any differences.
5. How do you feel while the teacher is passing out a quiz?
6. Is there something that a teacher does that make you want to do well on a particular assignment?
7. Is there anything a teacher does that makes you give up on or not care about an assignment?
8. In general, how well do you think your teachers explain their learning goals, learning objectives, or "I can" statements to students?
9. Does knowing the learning goals help you learn about the topic?
10. Do you feel that teachers give you sufficient feedback for ways to improve in their subject? Can you give an example?
11. When an assignment is returned to you, do you usually:
    - Look carefully at what you missed and make the corrections so you can do better next time.
    - Ask the teacher to help you fix it so you can do better next time.
    - Look only at the grade and then put it away.
    - Put the assignment away without looking at it again.
    - Put the assignment away at first but look it over later.
12. Is there anything else you'd like to me to know?

APPENDIX F

OBSERVER CHECKLIST

Observer checklist

Date _____
Class_____
Period _____