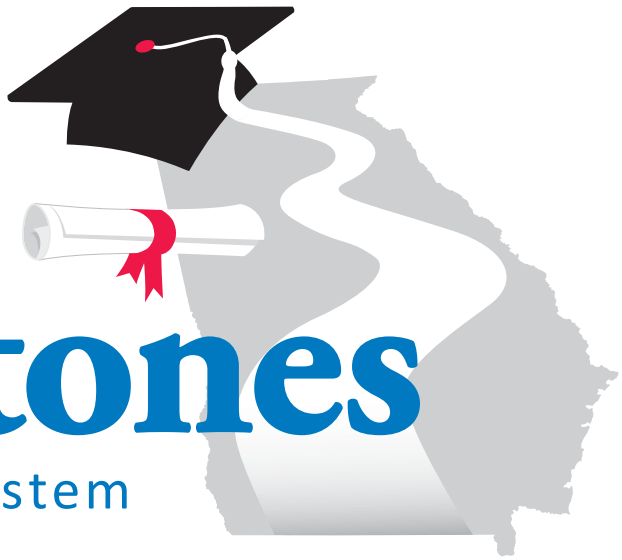
Georgia Milestones Assessment System



Assessment Guide

Physical Science

Assessment Guide

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THE GEORGIA MILESTONES ASSESSMENT SYSTEM

The purpose of the Georgia Student Assessment Program is to measure student achievement of the state-adopted content standards and inform efforts to improve teaching and learning. Results of the assessment program are utilized to identify students failing to achieve mastery of content, to provide educators with feedback about instructional practice, and to assist school districts in identifying strengths and weaknesses in order to establish priorities in planning educational programs.

The State Board of Education is required by Georgia law (O.C.G.A. §20-2-281) to adopt assessments designed to measure student achievement relative to the knowledge and skills set forth in the state-adopted content standards. The Georgia Milestones Assessment System (Georgia Milestones) fulfills this requirement and, as a key component of Georgia's Student Assessment Program, is a comprehensive summative assessment program spanning Grade 3 through high school. Georgia Milestones measures how well students have learned the knowledge and skills outlined in the state-adopted content standards in English Language Arts, Mathematics, Science, and Social Studies. Students in grades 3 through 8 take an end-of-grade assessment in English Language Arts and Mathematics, while students in grades 5 and 8 also take an end-of-grade assessment in Science and Social Studies. High school students take an end-of-course assessment for each of the ten courses designated by the State Board of Education. In accordance with State Board Rule, Georgia Milestones end-of-course measures serve as the final exams for the specified high school courses.

The main purpose of Georgia Milestones is to inform efforts to improve student achievement by assessing student performance on the standards specific to each course or subject/grade tested. Specifically, Georgia Milestones is designed to provide students and their parents with critical information about the students' achievement and, importantly, their preparedness for the next educational level. The assessment system is a critical informant of the state's accountability measure, the College and Career Ready Performance Index (CCRPI), providing an important gauge about the quality of the educational services and opportunities provided throughout the state. The ultimate goal of Georgia's assessment and accountability system is to ensure that all students are provided the opportunity to engage with high-quality content standards, receive high-quality instruction predicated upon those standards, and are positioned to meet high academic expectations.

Features of the Georgia Milestones Assessment System include:

- technology-enhanced items (all grades and courses);
- open-ended (constructed-response) items in English Language Arts and Mathematics (all grades and courses);
- a writing component (in response to passages read by students) at every grade level and course within the English Language Arts assessment;
- norm-referenced items in all content areas and courses to complement the criterion-referenced information and to provide a national comparison; and
- a transition to online administration over time, with online administration considered the primary mode of administration and paper/pencil as a backup until the transition is complete.

The primary mode of administration for the Georgia Milestones program is online, with the goal of completing the transition from paper/pencil within five years after the inaugural administration (i.e., the 2014–2015 school year). Paper/pencil test materials (such as Braille) will remain available for students with disabilities who may require them in order to access the assessment.

Georgia Milestones follows guiding principles to help ensure that the assessment system:

- is sufficiently challenging to ensure Georgia students are well positioned to compete with other students across the United States and internationally;
- is intentionally designed across grade levels to send a clear signal of student academic progress and preparedness for the next level, whether it is the next grade level, course, or college or career;
- is accessible to all students, including those with disabilities or limited English proficiency, at all achievement levels;
- supports and informs the state's educator-effectiveness initiatives, ensuring items and forms are appropriately sensitive to quality instructional practices; and
- accelerates the transition to online administration, allowing—over time—for the inclusion of innovative technology-enhanced items.

GEORGIA MILESTONES END-OF-COURSE (EOC) ASSESSMENTS

As previously mentioned, Georgia law (§20-2-281) mandates that the State Board of Education adopt EOC assessments for core courses to be determined by the Board. An EOC assessment serves as a student's final exam in the associated course. With educator input and State Board approval, the Georgia Milestones EOC assessments measure student achievement in the following courses: Ninth Grade Literature and Composition, American Literature and Composition, Algebra I, Geometry, Coordinate Algebra, Analytic Geometry, Physical Science, Biology, United States History, and Economics/Business/Free Enterprise.

Any student enrolled in and/or receiving credit for one of the above-mentioned courses, regardless of grade level, is required to take the Georgia Milestones EOC assessment upon completion of that course. This includes middle school students completing a course associated with a Georgia Milestones EOC assessment, regardless of whether they are receiving high school credit. Students enrolling from non-accredited programs are required to take and pass the Georgia Milestones EOC assessment prior to receiving credit for the course.

A student's final grade in the course will be calculated using the Georgia Milestones EOC assessment as follows (State Board Rule 160-4-2-.13):

- For students enrolled in Grade 9 for the first time before July 1, 2011, the EOC assessment counts as 15% of the final grade.
- For students enrolled in Grade 9 for the first time on or after July 1, 2011, the EOC assessment counts as 20% of the final grade.

Results of the EOC assessments, according to the legislated and identified purposes, must:

- provide a valid measure of student achievement of the state content standards across the full achievement continuum;
- serve as the final exam for each course, contributing 15% or 20% to the student's final course grade;
- provide a clear signal of each student's preparedness for the next course and ultimately post-secondary endeavors (college and career);
- allow for the detection of the academic progress made by each student from one assessed course to the next;
- support and inform educator-effectiveness measures; and
- inform state and federal accountability measures at the school, district, and state levels.

Additional uses of the EOC assessments include: (1) certifying student proficiency prior to the awarding of credit for students enrolling from non-accredited private schools, home study programs, or other non-traditional educational centers and (2) allowing eligible students to demonstrate competency without taking the course and earn course credit (e.g., "test out"). In both cases, students are allotted *one* administration.

ASSESSMENT GUIDE

The Georgia Milestones Physical Science EOC Assessment Guide is provided to acquaint Georgia educators and other stakeholders with the structure of and content assessed by the test. Importantly, this guide is not intended to inform instructional planning. It is essential to note that there are a small number of content standards that are better suited for classroom or individual assessment than for large-scale summative assessment. While those standards are not included in the tests and therefore are not included in this Assessment Guide, the knowledge, concepts, and skills inherent in those standards are often required for the mastery of the standards that are assessed. Failure to attend to all content standards within a course can limit a student's opportunity to learn and show what he or she knows and can do on the assessment.

The Georgia Milestones Physical Science EOC Assessment Guide is in *no way* intended to substitute for the state-mandated content standards; it is provided to help educators better understand the structure and content of the assessment, *but it is not all-encompassing of the knowledge, concepts, and skills covered in the course or assessed on the test*. The state-adopted content standards and associated standards-based instructional resources, such as the Content Frameworks, should be used to plan instruction. This Assessment Guide can serve as a *supplement* to those resources, in addition to any locally developed resources, ***but should not be used in isolation***. In principle, the Assessment Guide is intended to be descriptive of the assessment program and should not be considered all-inclusive. The state-adopted content standards are located at www.georgiastandards.org.

TESTING SCHEDULE

The Georgia Milestones Physical Science EOC assessment is offered during three Main Administrations. Main Administrations are primarily intended to provide an opportunity to assess student achievement at the completion of a course and to serve as the final exam for the associated course as required by State Board Rule. As a result, the EOC assessment should occur as close to the conclusion of the course as possible. Main Administrations can also be utilized to verify credit from a non-accredited school or home schooling. In addition to the Main Administrations, Mid-Month Administrations are provided in order to allow students additional testing opportunities for the various reasons noted below.

Purpose for EOC Assessment	Winter & Spring Main Administrations	Mid-Month Administrations	Summer Main Administration
Completion of Course	Yes	Yes	Yes
Makeup from Previous Administration	Yes	Yes	Yes
Retest	No*	Yes	Yes
Test Out	No	Yes**	Yes
Validation of Credit	Yes	Yes	Yes

*Winter and Spring Main Administrations cannot be used for the purpose of a retest.

**August, September, and March Mid-Month Administrations as well as the Summer Main Administration can be used for the purpose of a test out.

Note: Each district determines a local testing window within the state-designated testing window.

TEST STRUCTURE

DESCRIPTION OF TEST FORMAT AND ORGANIZATION

The Georgia Milestones Physical Science EOC assessment is primarily a criterion-referenced test designed to provide information about how well a student has mastered the state-adopted content standards within the course. Each student will receive one of four Achievement Level designations, depending on how well the student has mastered the course content standards. The four Achievement Level designations are Beginning Learner, Developing Learner, Proficient Learner, and Distinguished Learner. In addition to criterion-referenced information, the Georgia Milestones measures will also include a limited sample of nationally norm-referenced items to provide a signal of how Georgia students are achieving relative to their peers nationally. The norm-referenced information provided is supplementary to the criterion-referenced Achievement Level designation and will not be utilized in any manner other than to serve as a barometer of national comparison. Only the criterion-referenced scores and Achievement Level designations will be utilized in the accountability metrics associated with the assessment program (such as student course grades, student growth measures, educator-effectiveness measures, and the CCRPI).

The Physical Science EOC assessment consists of both operational items (contribute to a student's criterion-referenced and/or norm-referenced score) and field test items (newly written items that are being tried out and do not contribute to the student's score). A subset of the norm-referenced operational items have been verified as aligned to the course content standards by Georgia educators and will also contribute to the criterion-referenced score and Achievement Level designation. The other norm-referenced items will contribute only to the national percentile rank, which is provided as supplemental information.

With the inclusion of the norm-referenced items, students may encounter items for which they have not received direct instruction. These items will not contribute to the students' criterion-referenced Achievement Level designation; only items that align to the course content standards will contribute to the criterion-referenced score. Students should be instructed to try their best should they ask about an item that is not aligned to the content they have learned as part of the course.

The table on the following page outlines the number and types of items included on the Physical Science EOC assessment.

Physical Science EOC Assessment Design

Description	Number of Items	Points for CR[1] Score	Points for NRT[2] Feedback
CR Selected-Response Items	47	47	0
NRT Selected-Response Items	20[3]	5[4]	20
CR Technology-Enhanced Items	4	8	0
CR Field Test Items	5	0	0
Total Items/Points[5]	**76**	**60**	**20**

[1]CR—Criterion-Referenced: items aligned to state-adopted content standards
[2]NRT—Norm-Referenced Test: items that will yield a national comparison; may or may not be aligned to state-adopted content standards
[3]Of these items, 5 will contribute to both the CR scores and NRT feedback. The other 15 of these items will contribute to NRT feedback only and will not impact the student's Achievement Level designation, scale score, or grade conversion.
[4]Alignment of national NRT items to course content standards was verified by a committee of Georgia educators. Only approved, aligned NRT items will contribute to a student's CR Achievement Level designation, scale score, and grade conversion score.
[5]Of the 76 total items, 56 items contribute to the CR score, for a total of 60 points; 20 total items contribute to NRT feedback, for a total of 20 points.

The test will be given in two sections. Students may have up to 70 minutes per section to complete Sections 1 and 2. The total estimated testing time for the Physical Science EOC assessment ranges from approximately 90 to 140 minutes. Total testing time describes the amount of time students have to complete the assessment. It does not take into account the time required for the test examiner to complete pre-administration and post-administration activities (such as reading the standardized directions to students). Sections 1 and 2 may be administered on the same day or across two consecutive days based on the district's testing protocols for the EOC measures (in keeping with state guidance).

During the Physical Science EOC assessment, a reference sheet will be available for students to use. There is an example of the reference sheet in the Additional Sample Items section of this guide. Another feature of the Physical Science EOC assessment is that students may use a scientific calculator throughout all sections of the test.

CONTENT MEASURED

The Physical Science EOC assessment will measure the Physical Science standards that are described at www.georgiastandards.org.

The content of the assessment is organized into four groupings, or domains, of standards for the purposes of providing feedback on student performance. A content domain is a reporting category that *broadly* describes and defines the content of the course, as measured by the EOC assessment. The standards for Physical Science are grouped into four domains: Chemistry: Atomic and Nuclear Theory and the Periodic Table; Chemistry: Chemical Reactions and Properties of Matter; Physics: Energy, Force, and Motion; and Physics: Waves, Electricity, and Magnetism. Each domain was created by organizing standards that share similar content characteristics. The content standards describe the level of expertise that Physical Science educators should strive to develop in their students. Educators should refer to the content standards for a full understanding of the knowledge, concepts, and skills subject to be assessed on the EOC assessment.

The approximate proportional number of points associated with each domain is shown in the following table. A range of cognitive levels will be represented on the Physical Science EOC assessment. Educators should always use the content standards when planning instruction.

Physical Science: Domain Structures and Content Weights

Reporting Category	Standard Assessed	Approximate Percentage of Test	Approximate Number of Points
Chemistry: Atomic and Nuclear Theory and the Periodic Table	SPS1 (a, b, c) SPS2 (a, b, c) SPS4 (a, b, c)	28%	17
Chemistry: Chemical Reactions and Properties of Matter	SPS3 (a, b) SPS5 (a, b) SPS6 (a, b, c, d, e)	22%	13
Physics: Energy, Force, and Motion	SPS7 (a, b, c, d) SPS8 (a, b, c, d)	28%	17
Physics: Waves, Electricity, and Magnetism	SPS9 (a, b, c, d, e) SPS10 (a, b, c)	22%	13

ITEM TYPES

Operational items in the Physical Science EOC assessment consist of selected-response and technology-enhanced items.

A selected-response item, sometimes called a multiple-choice item, is defined as a question, problem, or statement that appears on a test followed by several answer choices, sometimes called options or response choices. The incorrect choices, called distractors, usually reflect common errors. The student's task is to choose, from the alternatives provided, the best answer to the question posed in the stem (the question). The Physical Science selected-response items will have four answer choices.

A technology-enhanced item is an innovative way to measure student skills and knowledge using scaffolding within a multi-step response. For multiple-select items, the student is asked to pick two correct responses from five or six possible answer options. In multiple-part items, the student responds to a two-part item that combines two multiple-choice items. For these item types, the student selects the responses from the choices provided and receives two points for selecting all correct answers or partial credit for specific combinations of correct responses.

DEPTH OF KNOWLEDGE DESCRIPTORS

Items found on the Georgia Milestones assessments, including the Physical Science EOC assessment, are developed with a particular emphasis on cognitive complexity or Depth of Knowledge (DOK). DOK is measured on a scale of 1 to 4 and refers to the level of cognitive demand required to complete a task (or in this case, an assessment item). The higher the level, the *more complex* the item; however, higher levels do not necessarily mean *more difficult* items. For instance, a question can have a low DOK but a medium or even high difficulty level. Conversely, a DOK 4 question may have a low difficulty level but still require a great deal of cognitive thinking (e.g., analyzing and synthesizing information instead of just recalling it). The following descriptions and table show the expectations of the four DOK levels in greater detail.

Level 1 (Recall of Information) generally requires students to identify, list, or define, often asking them to recall who, what, when, and where. Consequently, this level usually asks students to recall facts, terms, concepts, and trends and may ask them to identify specific information contained in documents, excerpts, quotations, maps, charts, tables, graphs, or illustrations. Items that require students to "describe" and/or "explain" could be classified at Level 1 or Level 2, depending on what is to be described and/or explained. A Level 1 "describe" and/or "explain" would require students to recall, recite, or reproduce information.

Level 2 (Basic Reasoning) includes the engagement of some mental processing beyond recalling or reproducing a response. A Level 2 "describe" and/or "explain" would require students to go beyond a description or explanation of recalled information to describe and/or explain a result or "how" or "why."

Level 3 (Complex Reasoning) requires reasoning, using evidence, and thinking on a higher and more abstract level than Level 1 and Level 2. Students will go beyond explaining or describing "how and why" to justifying the "how and why" through application and evidence. Level 3 questions often involve making connections across time and place to explain a concept or "big idea."

Level 4 (Extended Reasoning) requires the complex reasoning of Level 3 with the addition of planning, investigating, applying significant conceptual understanding, and/or developing that will most likely require an extended period of time. Students should be required to connect and relate ideas and concepts *within* the content area or *among* content areas in order to be at this highest level. The distinguishing factor for Level 4 would be a show of evidence (through a task, a product, or an extended response) that the cognitive demands have been met.

The following table identifies skills that students will need to demonstrate at each DOK level, along with question cues appropriate for each level.

Level	Skills Demonstrated	Question Cues
Level 1 Recall of Information	• Make observations • Recall information • Recognize formulas, properties, patterns, processes • Know vocabulary, definitions • Know basic concepts • Perform one-step processes • Translate from one representation to another • Identify relationships	• Tell what, when, or where • Find • List • Define • Identify; label; name • Choose; select • Compute; estimate • Express • Read from data displays • Order
Level 2 Basic Reasoning	• Apply learned information to abstract and real-life situations • Use methods, concepts, theories in abstract and real-life situations • Perform multi-step processes • Solve problems using required skills or knowledge (requires more than habitual response) • Make a decision about how to proceed • Identify and organize components of a whole • Extend patterns • Identify/describe cause and effect • Recognize unstated assumptions, make inferences • Interpret facts • Compare or contrast simple concepts/ideas	• Apply • Calculate; solve • Complete • Describe • Explain how; demonstrate • Construct data displays • Construct; draw • Analyze • Extend • Connect • Classify • Arrange • Compare; contrast

Level	Skills Demonstrated	Question Cues
Level 3 Complex Reasoning	• Solve an open-ended problem with more than one correct answer • Create a pattern • Generalize from given facts • Relate knowledge from several sources • Draw conclusions • Make predictions • Translate knowledge into new contexts • Compare and discriminate between ideas • Assess value of methods, concepts, theories, processes, formulas • Make choices based on a reasoned argument • Verify the value of evidence, information, numbers, data	• Plan; prepare • Predict • Create; design • Ask “what if?” questions • Generalize • Justify; explain why; support; convince • Assess • Rank; grade • Test; judge • Recommend • Select • Conclude
Level 4 Extended Reasoning	• Analyze and synthesize information from multiple sources • Examine and explain alternative perspectives across a variety of sources • Apply mathematical models to illuminate a problem or situation • Design a mathematical model to inform and solve a practical or abstract situation • Combine and synthesize ideas into new concepts	• Design • Connect • Synthesize • Apply concepts • Critique • Analyze • Create • Prove

SCORES

Selected-response and technology-enhanced items are machine scored. The operational items in the Physical Science EOC assessment consist of selected-response and technology-enhanced items.

Students will receive a scale score and an Achievement Level designation based on total test performance. In addition, students will receive information on how well they performed at the domain level. Students will also receive a norm-referenced score based on a set of norm-referenced items included within the test; this score will allow comparison to a national norming group of students.

EXAMPLE ITEMS

Example items, which are representative of the applicable DOK levels across various Physical Science content domains, are provided.

All example and sample items contained in this guide are the property of the Georgia Department of Education.

Example Item 1

Selected-Response: 1 point

DOK Level: 1

Physical Science Domain: Physics: Waves, Electricity, and Magnetism

Standard: SPS10. Obtain, evaluate, and communicate information to explain the properties of and relationships between electricity and magnetism.

a. Use mathematical and computational thinking to support a claim regarding relationships among voltage, current, and resistance.

Which claim about current is shown to be mathematically supported from the relationship between the voltage, the current, and the resistance?

A. claim 1: $I = V + R$
B. claim 2: $I = V - R$
C. claim 3: $I = V \times R$
D. claim 4: $I = V / R$

Correct Answer: D

Explanation of Correct Answer: The correct answer is choice (D) claim 4: $I = V / R$. The formula sheet shows that voltage (V) equals current (I) multiplied by resistance (R). So solving for current, $I = V / R$. Choice (A) is incorrect because adding the voltage to the resistance will not give the current. Choice (B) is incorrect because subtracting the resistance from the voltage will not give the current. Choice (C) is incorrect because multiplying the voltage and the resistance will not give the current.

Example Item 2

Selected-Response: 1 point

DOK Level: 2

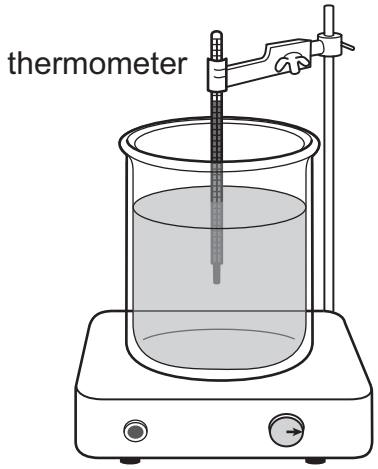
Physical Science Domain: Physics: Energy, Force, and Motion

Standard: SPS7. Obtain, evaluate, and communicate information to explain transformations and flow of energy within a system.

b. Plan and carry out investigations to describe how molecular motion relates to thermal energy changes in terms of conduction, convection, and radiation.

A student wants to set up two demonstrations to show different ways that heat can be transferred from a hot plate to a thermometer. Demonstration 1 is set up with the thermometer suspended in water as shown.

Heat Transfer Investigation



(Answer the question on the next page.)

How should the student change the setup in demonstration 2 to observe a single type of thermal energy transfer, and which explanation correctly describes the type of heat transfer shown in each demonstration?

A. **demonstration 2:** Replace the water with an equal amount of sand and keep the thermometer suspended in the sand.
explanation: In demonstration 1, the hot plate transfers heat to the thermometer by conduction and convection. In demonstration 2, the hot plate transfers heat to the thermometer by conduction only.

B. **demonstration 2:** Replace the water with an equal amount of sand and suspend the thermometer 3 centimeters above the sand.
explanation: In demonstration 1, the hot plate transfers heat to the thermometer by convection and radiation. In demonstration 2, the hot plate transfers heat to the thermometer by radiation only.

C. **demonstration 2:** Remove half of the water from the container. Place a copper plate barrier on top of the water, and replace the water above the barrier so that the water above and below the barrier does not mix. Place the thermometer so it is touching the copper plate barrier.
explanation: In demonstration 1, the hot plate transfers heat to the thermometer by conduction and convection. In demonstration 2, the hot plate transfers heat to the thermometer by conduction only.

D. **demonstration 2:** Remove half of the water from the container. Place a copper plate barrier on top of the water, and replace the water above the barrier so that the water above and below the barrier does not mix. Keep the thermometer suspended in the water above the copper plate barrier.
explanation: In demonstration 1, the hot plate transfers heat to the thermometer by convection and radiation. In demonstration 2, the hot plate transfers heat to the thermometer by radiation only.

Correct Answer: A

Explanation of Correct Answer: The correct answer choice is (A) **demonstration 2:** Replace the water with an equal amount of sand and keep the thermometer suspended in the sand.
explanation: In demonstration 1, the hot plate transfers heat to the thermometer by conduction and convection. In demonstration 2, the hot plate transfers heat to the thermometer by conduction only. Choice (A) is correct because there is no convection in a solid or a mass of solid particles like sand. Convection only occurs in fluids, such as water or air. Choice (B) is incorrect because demonstration 1 shows conduction and convection, and this demonstration 2 would show conduction, convection, and radiation. In addition to radiation from the hot sand to the thermometer, air warmed by conduction from the sand would then rise (convection) and then transfer heat energy to the thermometer by conduction. Choice (C) is incorrect because this demonstration 2 would still show convection (below the barrier). Choice (D) is incorrect because demonstration 1 shows conduction and convection and this demonstration 2 would not show radiation.

Example Item 3

Selected-Response: 1 point

DOK Level: 2

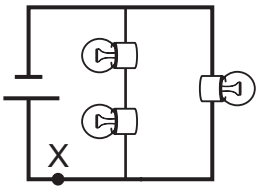
Physical Science Domain: Physics: Waves, Electricity, and Magnetism

Standard: SPS10. Obtain, evaluate, and communicate information to explain the properties of and relationships between electricity and magnetism.

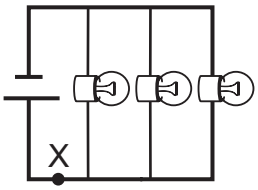
b. Develop and use models to illustrate and explain the conventional flow (direct and alternating) of current and the flow of electrons in simple series and parallel circuits.

A student is modeling an electric circuit containing three light bulbs and a battery. Which model shows a circuit where the current flowing through each bulb will be the same as the current at point X?

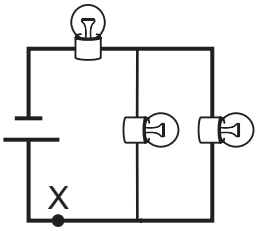
A.



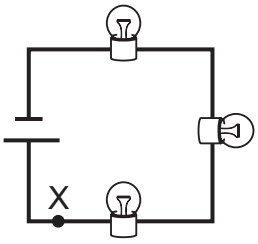
B.



C.



D.



Correct Answer: D

Explanation of Correct Answer: The correct answer is choice (D). All points on a series circuit experience the same current, so point X and each bulb will experience the same current. Choice (A) is incorrect because the current will be different through the two branches of the parallel circuit since a different number of light bulbs are on those branches. Choice (B) is incorrect because each bulb on the branch will have half the current that flows through point X or the other bulb. Choice (C) is incorrect because each of the three bulbs will experience one-third of the current that flows through point X since the current must divide to flow through each branch.

Example Item 4

Selected-Response: 1 point

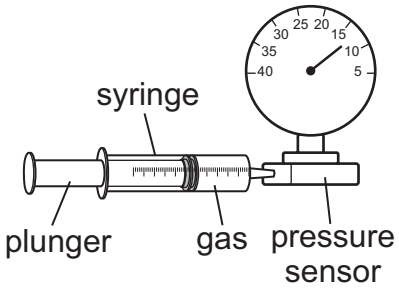
DOK Level: 3

Physical Science Domain: Chemistry: Chemical Reactions and Properties of Matter

Standard: SPS5. Obtain, evaluate, and communicate information to compare and contrast the phases of matter as they relate to atomic and molecular motion.

b. Plan and carry out investigations to identify the relationships among temperature, pressure, volume, and density of gases in closed systems.

A student wants to investigate the relationship between pressure and volume in nitrogen gas (N_2) by using a pressure sensor on an airtight 25-milliliter (mL) syringe as shown in the diagram.

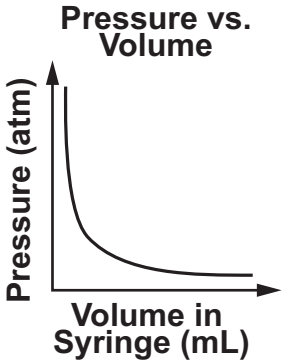


In step 1 of the investigation, the student will add N_2 to the syringe at 20°C.

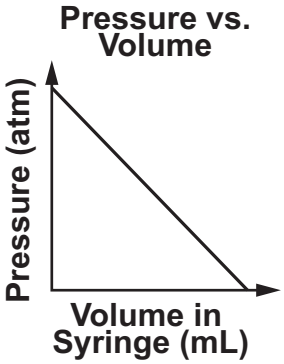
(Answer the question on the next page.)

How should the student proceed with the investigation, and which graph shows what the student will MOST LIKELY observe?

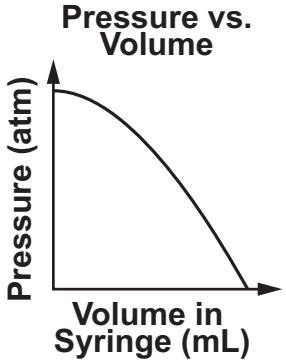
A. **step 2.** Keep the temperature of the gas constant.
step 3. Increase the volume of the gas in the syringe and record the resulting pressure of the gas.



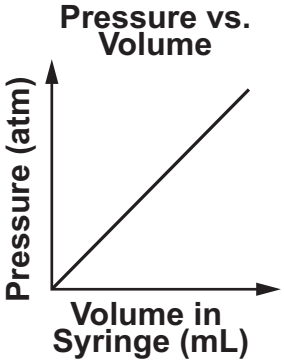
B. **step 2.** Increase the temperature of the gas.
step 3. Push the plunger on the syringe to apply different amounts of pressure on the gas and record the resulting volume of the gas.



C. **step 2.** Keep the temperature of the gas constant.
step 3. Push the plunger on the syringe to apply different amounts of pressure on the gas and record the resulting volume of the gas.



D. **step 2.** Increase the temperature of the gas.
step 3. Increase the volume of the gas in the syringe and record the resulting pressure of the gas.



Correct Answer: A

Explanation of Correct Answer: The correct answer is choice (A). Choice (A) is correct because the temperature of the gas should remain constant in this investigation since temperature will also affect the pressure; step 3 is correct because this change of volume will change pressure; and this is the correct graph for an inverse relationship of pressure and volume. Choice (B) is incorrect because the temperature of the gas should remain constant in this investigation and the graph shows a direct negative relationship, not an inverse proportional relationship. Choice (C) is incorrect because the graph shows that as the gas is compressed the pressure reaches a maximum value. Choice (D) is incorrect because the temperature of the gas should remain constant in this investigation, and this graph shows increasing pressure with increasing volume, which is the reverse of the correct relationship.

Example Item 5

Selected-Response: 1 point

DOK Level: 3

Physical Science Domain: Chemistry: Chemical Reactions and Properties of Matter

Standard: SPS6. Obtain, evaluate, and communicate information to explain the properties of solutions.
b. Plan and carry out investigations to determine how temperature, surface area, and agitation affect the rate solutes dissolve in a specific solvent.

Four students each prepare a cup of coffee. The students use similar amounts of brewed coffee, sugar, and cold milk. This table describes each student's method of dissolving the sugar in the coffee.

Dissolving Sugar in Coffee

Student 1	Adds sugar to hot coffee; then adds cold milk
Student 2	Adds sugar to hot coffee and stirs; then adds cold milk
Student 3	Adds cold milk to hot coffee; then adds sugar
Student 4	Adds cold milk to hot coffee; then adds sugar and stirs

Which student uses the method that will dissolve the sugar in the coffee the fastest?

A. Student 1
B. Student 2
C. Student 3
D. Student 4

Correct Answer: B

Explanation of Correct Answer: The correct answer is choice (B) Student 2. Sugar will dissolve more quickly in a hotter liquid than in a liquid that has been cooled. Additionally, stirring sugar into a liquid will increase the rate at which the sugar dissolves. Choice (A) is incorrect because stirring the coffee (as student 2 does) would cause the sugar to dissolve more quickly. Choices (C) and (D) are incorrect because adding the cold milk first will cool the coffee.

ADDITIONAL SAMPLE ITEMS

This section has two parts. The first part is a set of 14 sample items for Physical Science. The second part contains a table that shows for each item the standard assessed, the DOK level, the correct answer (key), and a rationale/explanation about the key and distractors. The sample items can be utilized as a mini-test to familiarize students with the item formats found on the assessment.

All example and sample items contained in this guide are the property of the Georgia Department of Education.

Physical Science Reference Sheet

Formulas

Energy, Force, and Motion

Velocity = $\frac{\text{displacement}}{\text{time}}$ $\left(v = \frac{d}{t}\right)$

Acceleration = $\frac{\text{final velocity} - \text{initial velocity}}{\text{time}}$ $\left(a = \frac{v_f - v_i}{t}\right)$

Weight = mass × acceleration of gravity $(w = mg)$

Force = mass × acceleration $(F = ma)$

Work = force × distance $(W = Fd)$

Mechanical advantage =

$\frac{\text{effort distance}}{\text{resistance distance}} = \frac{\text{resistance force}}{\text{effort force}}$ $\left(\text{MA} = \frac{d_e}{d_r} = \frac{f_r}{f_e}\right)$

Chemical Reactions and Properties of Matter

Volume of a rectangular solid = length × width × height $(V = lwh)$

Heat lost or gained =
mass × specific heat capacity × change in temperature $(Q = mc\Delta T)$

Waves, Electricity, and Magnetism

Voltage = current × resistance $(V = IR)$

Georgia Milestones Assessment System

Constants and Relationships

Kelvin = °Celsius + 273 (K = °C + 273)

Acceleration due to gravity: $g \approx 10 \frac{\text{m}}{\text{s}^2}$

newton: 1 N = 1 kg • $\frac{\text{m}}{\text{s}^2}$

joule: 1 J = 1 N • m

Turn over for the Periodic Table.

PERIODIC TABLE OF THE ELEMENTS

KEY

79 Au Gold 196.97	Atomic Number Element Symbol Element Name Average Atomic Mass

	1 IA	2 IIA	3 IIIB	4 IVB	5 VB	6 VIB	7 VIIB	8	9 VIIIB	10	11 IB	12 IIB	13 IIIA	14 IVA	15 VA	16 VIA	17 VIIA	18 VIIIA
1	1 H Hydrogen 1.01																	2 He Helium 4.00
2	3 Li Lithium 6.94	4 Be Beryllium 9.01											5 B Boron 10.81	6 C Carbon 12.01	7 N Nitrogen 14.01	8 O Oxygen 16.00	9 F Fluorine 19.00	10 Ne Neon 20.18
3	11 Na Sodium 22.99	12 Mg Magnesium 24.31											13 Al Aluminum 26.98	14 Si Silicon 28.09	15 P Phosphorus 30.97	16 S Sulfur 32.07	17 Cl Chlorine 35.45	18 Ar Argon 39.95
4	19 K Potassium 39.10	20 Ca Calcium 40.08	21 Sc Scandium 44.96	22 Ti Titanium 47.87	23 V Vanadium 50.94	24 Cr Chromium 52.00	25 Mn Manganese 54.94	26 Fe Iron 55.85	27 Co Cobalt 58.93	28 Ni Nickel 58.69	29 Cu Copper 63.55	30 Zn Zinc 65.41	31 Ga Gallium 69.72	32 Ge Germanium 72.64	33 As Arsenic 74.92	34 Se Selenium 78.96	35 Br Bromine 79.90	36 Kr Krypton 83.80
5	37 Rb Rubidium 85.47	38 Sr Strontium 87.62	39 Y Yttrium 88.91	40 Zr Zirconium 91.22	41 Nb Niobium 92.91	42 Mo Molybdenum 95.94	43 Tc Technetium (98)	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.91	46 Pd Palladium 106.42	47 Ag Silver 107.87	48 Cd Cadmium 112.41	49 In Indium 114.82	50 Sn Tin 118.71	51 Sb Antimony 121.76	52 Te Tellurium 127.60	53 I Iodine 126.90	54 Xe Xenon 131.29
6	55 Cs Cesium 132.91	56 Ba Barium 137.33	57 La Lanthanum 138.91	72 Hf Hafnium 178.49	73 Ta Tantalum 180.95	74 W Tungsten 183.84	75 Re Rhenium 186.21	76 Os Osmium 190.23	77 Ir Iridium 192.22	78 Pt Platinum 195.08	79 Au Gold 196.97	80 Hg Mercury 200.59	81 Tl Thallium 204.38	82 Pb Lead 207.2	83 Bi Bismuth 208.98	84 Po Polonium (209)	85 At Astatine (210)	86 Rn Radon (222)
7	87 Fr Francium (223)	88 Ra Radium (226)	89 Ac Actinium (227)															

58 Ce Cerium 140.12	59 Pr Praseodymium 140.91	60 Nd Neodymium 144.24	61 Pm Promethium (145)	62 Sm Samarium 150.36	63 Eu Europium 151.96	64 Gd Gadolinium 157.25	65 Tb Terbium 158.93	66 Dy Dysprosium 162.50	67 Ho Holmium 164.93	68 Er Erbium 167.26	69 Tm Thulium 168.93	70 Yb Ytterbium 173.04	71 Lu Lutetium 174.97
90 Th Thorium 232.04	91 Pa Protactinium 231.04	92 U Uranium 238.03	93 Np Neptunium (237)	94 Pu Plutonium (244)	95 Am Americium (243)	96 Cm Curium (247)	97 Bk Berkelium (247)	98 Cf Californium (251)	99 Es Einsteinium (252)	100 Fm Fermium (257)	101 Md Mendelevium (258)	102 No Nobelium (259)	103 Lr Lawrencium (262)

Item 1

Selected-Response: 1 point

Metals in group 1 on the periodic table most commonly form which type of ion?

A. 2^- ion
B. 1^- ion
C. 1^+ ion
D. 2^+ ion

Item 2

Selected-Response: 1 point

Use this chemical equation to answer the question.

$$\_\_CuS + \_\_KCl \rightarrow \_\_CuCl_2 + \_\_K_2S$$

What coefficient of KCl will balance the equation?

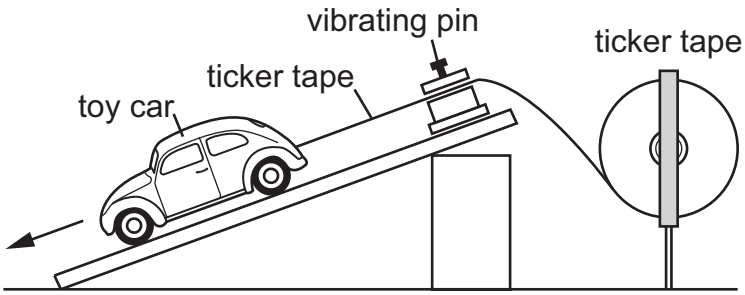
A. 1
B. 2
C. 3
D. 4

Item 3

Selected-Response: 1 point

A student sets up an investigation to analyze the motion of a battery-powered toy car. The student uses a machine with a vibrating pin that makes a mark every 0.1 second on a long narrow piece of paper called ticker tape.

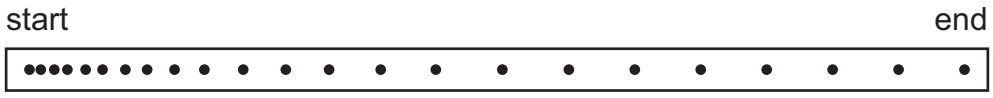
Investigation Setup



Steps 1 and 2 are shown.

> **step 1.** Attach one end of the ticker tape to the toy car; the rest of the ticker tape is in the spool.
>
> **step 2.** Release the toy car so that it moves away from the machine.

The student conducts the first two steps. The ticker tape from the investigation is shown.



Which action should the student take in step 3 to determine the speed of the car, and which analysis of the speed of the car is correct?

A. **step 3.** Count the total number of dots on the ticker tape.
analysis: The speed remained constant during the entire period.

B. **step 3.** Measure the distance between each successive dot on the ticker tape.
analysis: The speed decreased at first and then became constant.

C. **step 3.** Count the total number of dots on the ticker tape.
analysis: The speed continued to increase during the entire period.

D. **step 3.** Measure the distance between each successive dot on the ticker tape.
analysis: The speed increased at first and then became constant.

Item 4

Selected-Response: 1 point

The table compares data for two different light-emitting diodes (LEDs).

LED Type	Emission Wavelength (nanometers)	Current through LED (milliamps)
green diffused	565	40
gallium arsenide	930	120

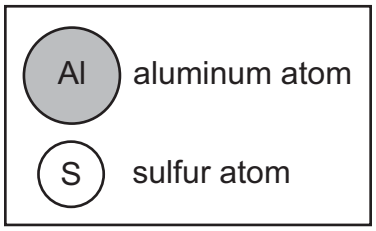
Based on the data, what can be identified about the energy of the waves emitted by the LEDs?

A. The wave energy of the green diffused LED is 1.65 times that of the gallium arsenide LED.
B. The wave energy of the green diffused LED is 0.333 times that of the gallium arsenide LED.
C. The wave energy of the green diffused LED is 0.608 times that of the gallium arsenide LED.
D. The wave energy of the green diffused LED is 3.00 times that of the gallium arsenide LED.

Item 5

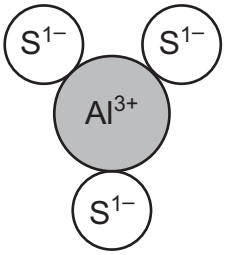
Selected-Response: 1 point

A student is modeling the units in the formula for aluminum sulfide using the spheres shown below to represent aluminum (Al) and sulfur (S) atoms.

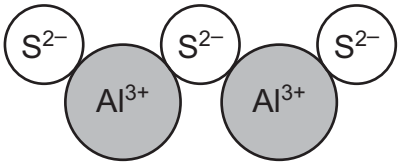


Which model correctly shows a stable ionic compound for aluminum sulfide?

A.

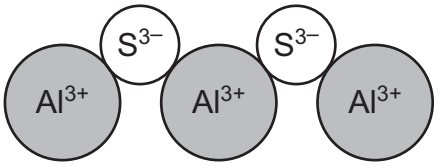


B.



C.

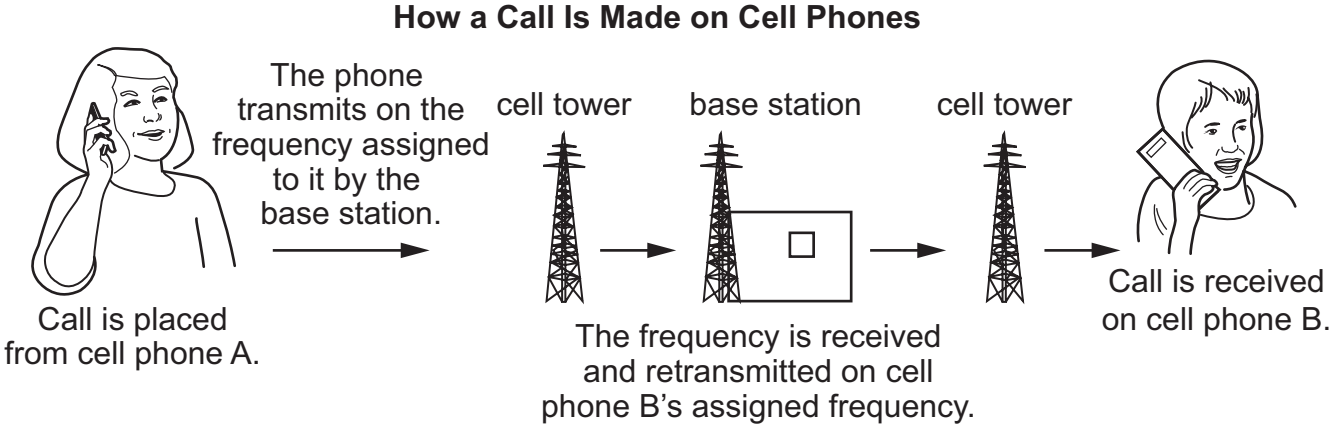
D.



Item 6

Selected-Response: 1 point

A student investigated the energy transformations that occur when a call is placed from cell phone A and received by cell phone B. The student drew a diagram to show the process.



Based on the diagram, what evidence is there for the transformation of chemical energy into electrical energy, and which other energy transformations must occur for the call to be received by cell phone B?

A. **evidence:** Cell phones are powered by a battery that produces the electricity used to send or receive a call.
transformation 1: Sound energy is transformed into electrical energy by cell phone A.
transformation 2: Electrical energy is transformed into mechanical energy in the cell towers and base station.

B. **evidence:** Cell phones are powered by a battery that produces the electricity used to send or receive a call.
transformation 1: Sound energy is transformed into electromagnetic waves by cell phone A.
transformation 2: Electromagnetic waves are transformed back into sound energy by cell phone B.

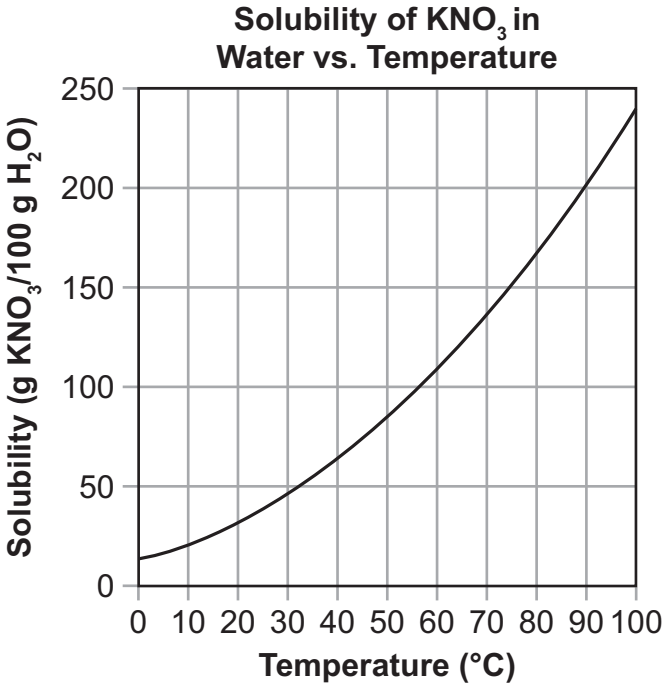
C. **evidence:** Base stations are powered by a battery that produces the electricity used to receive and forward a call.
transformation 1: Sound energy is transformed into electrical energy by cell phone A.
transformation 2: Electrical energy is transformed into mechanical energy in the cell towers and base station.

D. **evidence:** Base stations are powered by a battery that produces the electricity used to receive and forward a call.
transformation 1: Sound energy is transformed into electromagnetic waves by cell phone A.
transformation 2: Electromagnetic waves are transformed back into sound energy by cell phone B.

Item 7

Selected-Response: 1 point

A solubility curve for potassium nitrate (KNO_3) is shown.



According to the graph, what is the maximum approximate mass of KNO_3 that would dissolve at 60°C and what is the relationship between temperature and solubility?

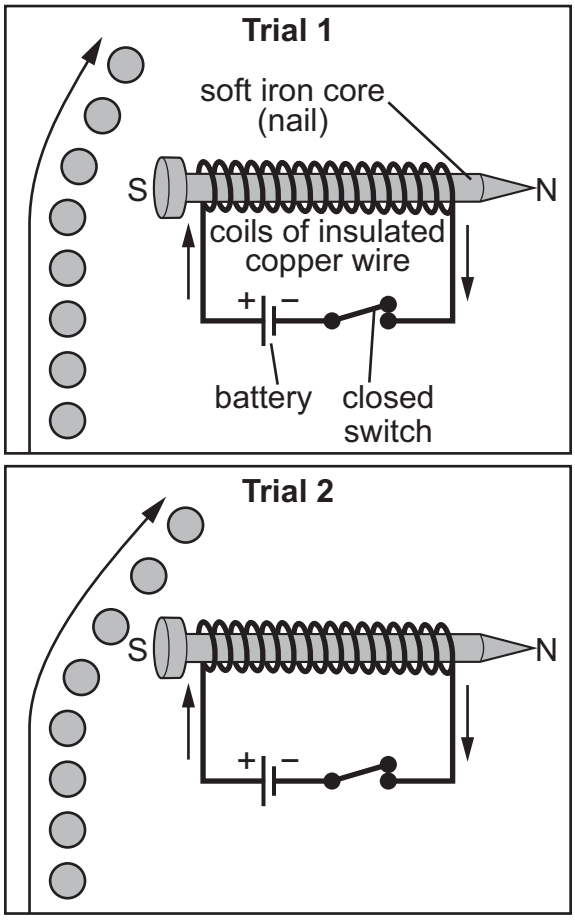
A. The mass is approximately 140 g; increased temperatures lead to a decrease in solubility.
B. The mass is approximately 110 g; increased temperatures lead to an increase in solubility.
C. The mass is approximately 140 g; increased temperatures lead to an increase in solubility.
D. The mass is approximately 110 g; increased temperatures lead to a decrease in solubility.

Item 8

Selected-Response: 1 point

A student did an investigation to determine the effect of a magnetic field on a moving steel sphere. The student recorded the motion of the steel sphere in trial 1 and then drew the desired motion of the steel sphere for trial 2 as shown in the diagram.

Electromagnetic Investigation



If the steel sphere has the same initial velocity in both trials, which action would BEST help to achieve the motion of the steel sphere shown in trial 2?

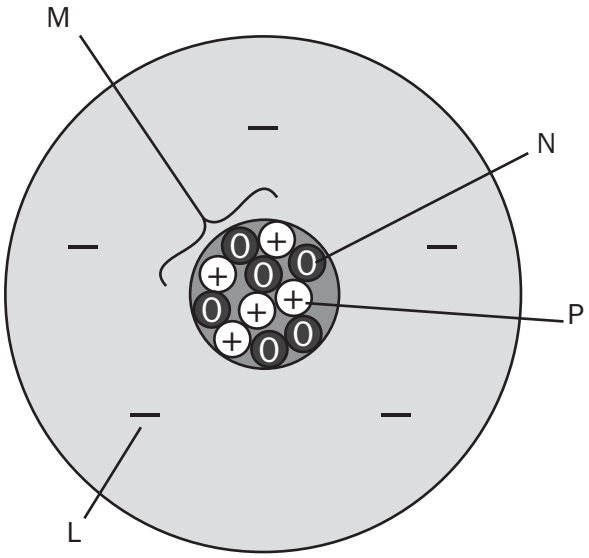
A. putting a resistor between the battery and switch
B. replacing the nail with one made out of aluminum
C. reversing the direction of the poles of the iron core
D. increasing the number of coils of insulated copper wire

Item 9

Selected-Response: 1 point

A scientist is measuring the mass of two boron atoms. One atom has a mass of 10 units. The other atom has a mass of 11 units.

This is a model of a boron atom with a mass of 11 units.



Which subatomic particle needs to be removed from the model to represent a boron atom with a mass of 10 units?

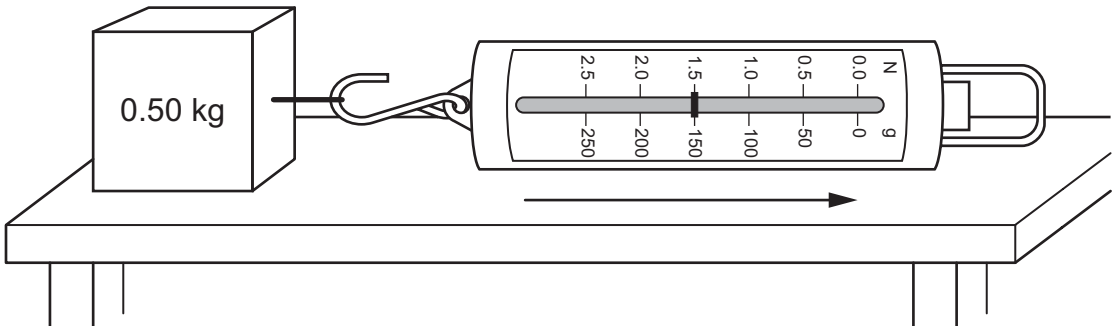
A. particle L
B. particle M
C. particle N
D. particle P

Item 10

Selected-Response: 1 point

To investigate Newton's second law of motion, a student used a motion sensor and a spring scale to measure the force acting on a lead block as it was pulled in the direction of the arrow, across the top of a table. A diagram of the setup is shown.

Newton's Second Law Investigation



The student measured a force of 1.5 newtons (N) acting on the lead block. The student expected the block to accelerate in the same direction as the arrow; however, as the block moved across the table, the motion sensor detected a constant velocity. The student interpreted the results and claimed that Newton's second law does not always apply.

Which explanation BEST describes why the student's claim is invalid?

A. The 1.5 N reading on the spring scale is due to the force of friction acting in the opposite direction of the motion, since the net force is zero at constant velocity. Without friction, the lead block would have accelerated at 0.33 m/s^2.

B. The 1.5 N reading on the spring scale is due to the net force of 1.50 N to the right acting on the block, as indicated by the constant velocity to the right. Without this force, the lead block would have accelerated at 0.33 m/s^2.

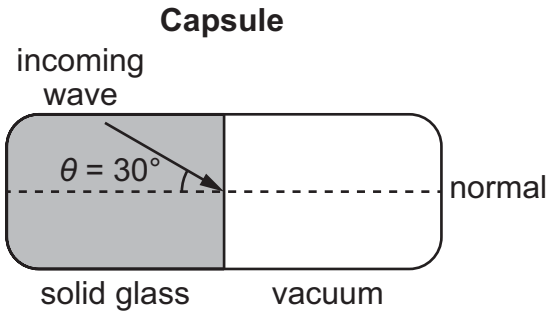
C. The 1.5 N reading on the spring scale is due to the force of friction acting in the opposite direction of the motion, since the net force is zero at constant velocity. Without friction, the lead block would have accelerated at 3.0 m/s^2.

D. The 1.5 N reading on the spring scale is due to the net force of 1.50 N to the right acting on the block, as indicated by the constant velocity to the right. Without this force, the lead block would have accelerated at 3.0 m/s^2.

Item 11

Multi-Select Technology-Enhanced: 2 points

A student is investigating the differences between light waves and sound waves. The student does this by using a capsule filled with solid glass at one end and a vacuum at the other end. The student will transmit waves into the capsule at a 30° angle to the (normal) centerline.



Which TWO questions should the student ask, and which predictions are MOST LIKELY correct based on this investigation?

A. **question:** How are electromagnetic waves and mechanical waves affected when traveling from a solid glass medium to a vacuum?
prediction: The electromagnetic waves and mechanical waves will continue through the vacuum at a lower speed.

B. **question:** How is the speed of electromagnetic waves affected when traveling from a solid glass medium to a vacuum at a 30° angle?
prediction: The electromagnetic waves will travel in a straight line, showing that they have maintained a constant speed.

C. **question:** How are electromagnetic waves and mechanical waves affected when traveling from a solid glass medium to a vacuum?
prediction: The electromagnetic waves will continue through the vacuum, while the mechanical waves will go no farther.

D. **question:** Can electromagnetic waves and mechanical waves travel from a solid glass medium into a liquid medium?
prediction: Both electromagnetic waves and mechanical waves will bend, showing that they have passed through each medium.

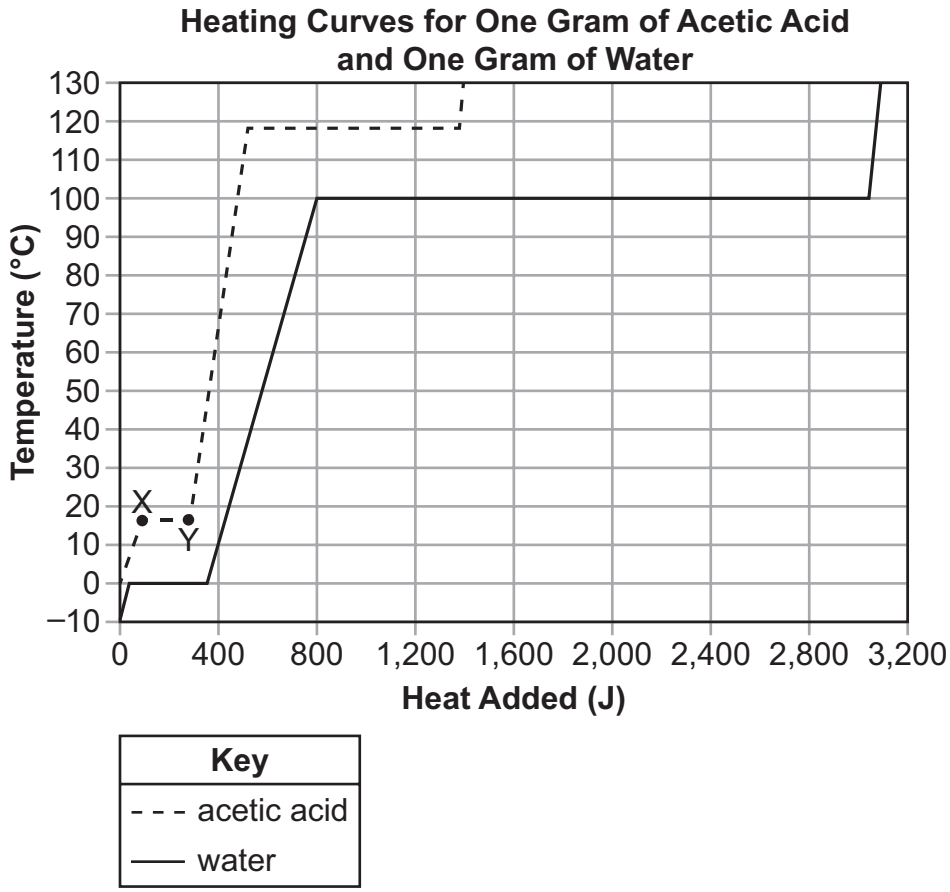
E. **question:** How is the speed of electromagnetic waves affected when traveling from a solid glass medium to a vacuum at a 30° angle?
prediction: The electromagnetic waves will bend downward, showing that they have sped up slightly.

F. **question:** Can electromagnetic waves and mechanical waves travel from a solid glass medium into a liquid medium?
prediction: The electromagnetic waves will continue through the liquid medium, while the mechanical waves will go no farther.

Item 12

Multi-Part Technology-Enhanced: 2 points

A student collected thermal data for acetic acid (CH_3COOH) and water (H_2O) and graphed the heating curves for the two substances.



Part A

What is happening to the acetic acid between points X and Y on the graph?

A. Liquid acetic acid is becoming warmer as it absorbs heat energy from the surroundings.

B. Liquid acetic acid is being converted from a liquid to a gas by absorbing heat energy from the surroundings.

C. Solid acetic acid is becoming warmer as it absorbs heat energy from the surroundings.

D. Solid acetic acid is being converted from a solid to a liquid by absorbing heat energy from the surroundings.

(This question continues on the next page.)

Part B

Which comparison can be made about a phase change common to acetic acid and water based on the graph?

A. More heat energy is required to melt a gram of acetic acid than to melt a gram of water.

B. More heat energy is required to vaporize a gram of water than to vaporize a gram of acetic acid.

C. Given the same rate of added heat, the temperature of a gram of water will increase at a faster rate than a gram of acetic acid.

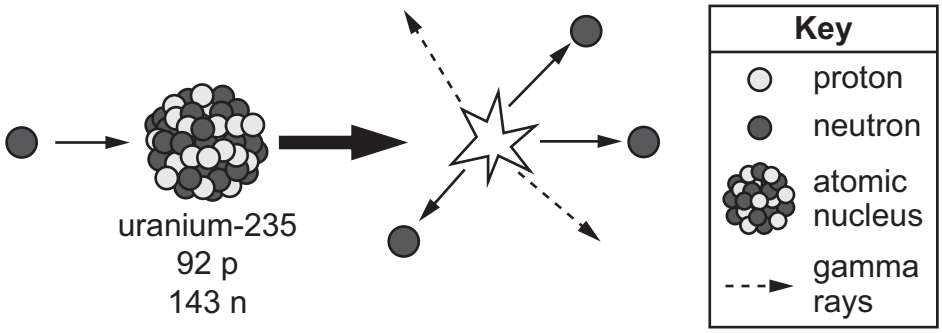
D. Given the same rate of heat loss, the temperature of a gram of acetic acid vapor will decrease at a slower rate than a gram of water.

Item 13

Multi-Select Technology-Enhanced: 2 points

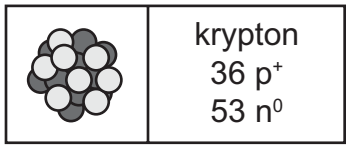
A student is modeling the fission of uranium nuclei. The student started the model as shown in the diagram.

Nuclear Fission Model

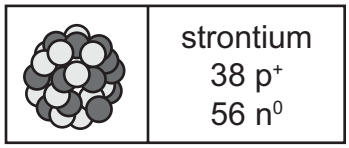


Which TWO particles should the student add to the right-hand side of the model to complete the fission reaction?

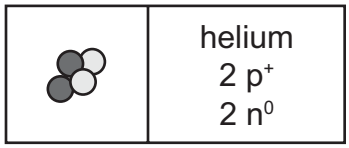
A.



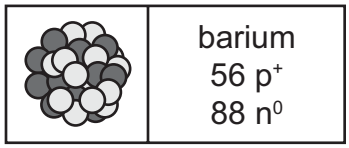
B.



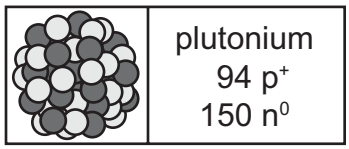
C.



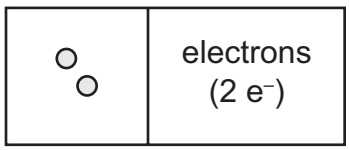
D.



E.



F.



Item 14

Multi-Part Technology-Enhanced: 2 points

A student plans to investigate how different factors affect the dissolving rate of a certain mass of potassium chloride (KCl) in water. The student will test a different variable in each investigation: the diameter of the crystals in millimeters (mm), the temperature of the solution in degrees Celsius (°C), and agitation (stirring) of the solution. The first table shows details and predictions for investigation 1.

Investigation 1

Trial Number	Diameter of Crystals (mm)	Temperature (°C)	Stirring	Predicted Dissolving Time (minutes)
1	1.0	20	no	20
2	2.0	20	no	?

The second table shows details and predictions for investigation 2.

Investigation 2

Trial Number	Diameter of Crystals (mm)	Temperature (°C)	Stirring	Predicted Dissolving Time (minutes)
3	1.0	20	no	20
4	1.0	40	no	10

Part A

Based on the predicted dissolving times for trials 1, 3, and 4, which statement contains the BEST prediction for the dissolving time in trial 2?

A. 5 minutes, because the larger diameter of crystals increases the total surface area of the solute exposed to the solvent, decreasing the length of exposure to the solvent

B. 15 minutes, because the larger diameter of crystals increases the total surface area of the solute exposed to the solvent, increasing the length of exposure to the solvent

C. 20 minutes, because the larger diameter of crystals decreases the total surface area of the solute exposed to the solvent, but the length of exposure to the solvent stays the same

D. 30 minutes, because the larger diameter of crystals decreases the total surface area of the solute exposed to the solvent, increasing the length of exposure to the solvent

(This question continues on the next page.)

Part B

How should the student design investigation 3 to finish testing the factors that affect the dissolving rate of KCl?

A. Increase the diameter of crystals to 2.0 mm.
Keep the temperature at 40°C.
Do not stir the solution.

B. Keep the diameter of crystals at 1.0 mm.
Keep the temperature at 20°C.
Stir the solution.

C. Increase the diameter of crystals to 4.0 mm.
Decrease the temperature to 0°C.
Do not stir the solution.

D. Keep the diameter of crystals at 1.0 mm.
Increase the temperature to 60°C.
Stir the solution.

ADDITIONAL SAMPLE ITEM KEYS

Item	Standard/ Element	DOK Level	Correct Answer	Explanation
1	SPS1b	1	C	The correct answer is choice (C) 1^+ ion. A metal in group 1 has one valence electron, which can easily be removed. When this happens, the resulting metal ion has one more proton than electron, giving it a 1^+ charge. Choices (A) and (B) are incorrect because nonmetals typically form negatively charged ions. Choice (D) is incorrect because metals in group 2 typically form ions with 2^+ charges.
2	SPS3b	2	B	The correct answer is choice (B) 2. Two units of KCl combine with one unit of CuS to produce one unit of $CuCl_2$ and one unit of K_2S. Choices (A) and (C) are incorrect because the products contain an even number of potassium (K) ions; therefore, the reactants cannot have an odd number of potassium ions. Choice (D) is incorrect because the equation can be simplified by dividing each coefficient in half.
3	SPS8a	2	D	The correct answer is choice (D) **step 3.** Measure the distance between each successive dot on the ticker tape. **analysis:** The speed increased at first and then became constant. The farther apart the marks on the ticker tape are, the faster the toy car is going. When the marks are equally spaced, the toy car is moving at a constant speed. Choice (A) is incorrect because counting reveals only the length of the investigation and because the speed increased at first and then became constant. Choice (B) is incorrect because the speed increased at first according to the increasing distance between the dots. Choice (C) is incorrect because counting reveals only the length of the investigation and the speed eventually became constant.

Item	Standard/ Element	DOK Level	Correct Answer	Explanation
4	SPS9a	2	A	The correct answer is choice (A) The wave energy of the green diffused LED is 1.65 times that of the gallium arsenide LED. This can be understood because the energy of an electromagnetic wave is proportional to the wavelength, so the ratio of energies of the two waves is proportional to the ratio of the wavelengths, so 930 nm/565 nm = 1.65. Note that one does not have to actually calculate the energy; just understanding the relationship of proportionality allows one to find the ratio of energies based on the ratio of wavelengths. Choice (B) is incorrect because the ratio of the current through the LED does not identify the relative energy of the two LEDs. Choice (C) is incorrect because the energy is calculated as inversely proportional to the wavelength, not directly proportional, so the ratio of the energy is not 565 nm/930 nm = 0.608. Choice (D) is incorrect because the inverse ratio of the current through the LED does not identify the relative energy of the two LEDs.
5	SPS2b	2	B	The correct answer is choice (B). Choice (B) is correct because based on the families that the elements sulfur and aluminum are found in on the periodic table, sulfur ions should have a -2 charge and aluminum ions a +3 charge and combine in a 3:2 ratio as shown in this model. Choice (A) is incorrect because sulfur's valence is -2 not -1 and the number of aluminum atoms in aluminum sulfide is two not one. Choice (C) is incorrect because sulfur's valence is -2 not -1, aluminum's valence is +3 not +1, and there are two aluminum atoms and three sulfur atoms in aluminum sulfide. Choice (D) is incorrect because sulfur's valence is -2 not -3 and there are two aluminum atoms and three sulfur atoms in aluminum sulfide.

Item	Standard/ Element	DOK Level	Correct Answer	Explanation
6	SPS7a	2	B	The correct answer is choice (B) **evidence:** Cell phones are powered by a battery that produces the electricity used to send or receive a call. **transformation 1:** Sound energy is transformed into electromagnetic waves by cell phone A. **transformation 2:** Electromagnetic waves are transformed back into sound energy by cell phone B. Choice (A) is incorrect because sound energy is transformed into electromagnetic waves and cell towers receive and transmit electromagnetic waves using electrical energy, not mechanical energy. Choice (C) is incorrect because a base station is powered by electricity from a larger source than a chemical battery, sound energy is transformed into electromagnetic waves, and cell towers receive and transmit electromagnetic waves using electrical energy, not mechanical energy. Choice (D) is incorrect because a base station is powered by electricity from a larger source than a chemical battery.
7	SPS6c	2	B	The correct answer is choice (B) The mass is approximately 110 g; increased temperatures lead to an increase in solubility. This is correct because the correct reading of the graph is this value, and this correctly describes the solubility trend that can be seen from the curve on the graph. Choice (A) is incorrect because 140 g is too much to dissolve completely at 60°C. Increasing the temperature increases the solubility. Choice (C) is incorrect because 140 g is too much to dissolve completely at 60°C. Choice (D) is incorrect because increasing the temperature increases the solubility.
8	SPS10c	2	D	The correct answer is choice (D) increasing the number of coils of insulated copper wire. This is correct because increasing the number of wire coils within the same length around the core allows each individual coil's magnetic field to add up, thereby increasing the strength of the electromagnet. Choice (A) is incorrect because this would decrease the current in the wire and decrease the magnetic field strength, so the electromagnet would have less of an effect on the motion of the steel sphere. Choice (B) is incorrect because the lack of ferromagnetism in aluminum would cause the magnetic field strength to decrease and result in less of an effect on the motion of the steel sphere. Choice (C) is incorrect because this change would have little effect on the path of the steel sphere since the change does not affect the magnetic field strength.

Item	Standard/ Element	DOK Level	Correct Answer	Explanation
9	SPS1a	2	C	The correct answer is choice (C) particle N. An atom's mass approximately equals the sum of its protons and neutrons. Particle N has zero charge, so it represents a neutron. Removing a neutron from the atom's nucleus would leave 5 protons and 5 neutrons, resulting in a boron atom with a mass of 10 units. Choice (A) is incorrect because particle L represents an electron, and electrons are too small to affect an atom's mass by an entire unit. Choice (B) is incorrect because M represents the atom's nucleus, which cannot be removed from the atom. Choice (D) is incorrect because particle P represents a proton; removing a proton would change the boron atom to a beryllium atom.
10	SPS8b	3	C	The correct answer is choice (C) The 1.5 N reading on the spring scale is due to the force of friction acting in the opposite direction of the motion, since the net force is zero at constant velocity. Without friction, the lead block would have accelerated at 3.0 m/s^2. Choice (A) is incorrect because $a = F/m$ = 1.5 N/0.50 kg = 3.0 m/s^2. Choice (B) is incorrect because if the net force were 1.5 N to the right, then the lead block would have accelerated to the right, not moved at constant velocity, and the acceleration would be 3.0 m/s^2. Choice (D) is incorrect because the explanation is incorrect and does not account for the zero net force and force of friction in the opposite direction of the motion.

Item	Standard/ Element	DOK Level	Correct Answer	Explanation
11	SPS9b	3	C, E	The correct answers are choice (C) **question:** How are electromagnetic waves and mechanical waves affected when traveling from a solid glass medium to a vacuum? **prediction:** The electromagnetic waves will continue through the vacuum, while the mechanical waves will go no farther., and choice (E) **question:** How is the speed of electromagnetic waves affected when traveling from a solid glass medium to a vacuum at a 30° angle? **prediction:** The electromagnetic waves will bend downward, showing that they have sped up slightly. These are correct because both questions can be answered with this experiment, and both predictions correctly describe the behavior of the waves. Mechanical waves cannot travel through a vacuum, and electromagnetic waves will bend away from the normal, or downward, when moving from a denser medium to a less dense medium because they will speed up. Choice (A) is incorrect because the prediction is wrong, since electromagnetic waves should speed up when entering a vacuum and mechanical waves should go no farther. Choice (B) is incorrect because the prediction is wrong, since different media affect the speed of electromagnetic waves, causing them to bend through refraction. Choice (D) is incorrect because this question cannot be answered here, since a liquid medium is not used. Choice (F) is incorrect because this question cannot be answered here, since a liquid medium is not used; the prediction is also incorrect since mechanical waves can travel through a liquid.

Item	Standard/ Element	DOK Level	Correct Answer	Explanation
12	SPS7d	3	D, B	The correct answer for Part A is choice (D) Solid acetic acid is being converted from a solid to a liquid by absorbing heat energy from the surroundings. There is no temperature increase, which indicates a phase change between points X and Y. This is the lower of the two phase changes, which means acetic acid is changing from a solid to liquid. Choices (A) and (C) are incorrect because no temperature increase occurs between these two points so the liquid acetic acid molecules are not becoming warmer. Choice (B) is incorrect because the second horizontal segment represents boiling. The correct answer for Part B is choice (B) More heat energy is required to vaporize a gram of water than to vaporize a gram of acetic acid. The graph shows that acetic acid boils at a higher temperature than water does. However, moving along the upper horizontal line indicating boiling (vaporization), acetic acid starts boiling at about 500 joules added and has converted completely to vapor at about 1,400 joules added, so about 900 joules were required to vaporize the acetic acid. Water started vaporizing at about 800 joules added but didn't completely vaporize until about 3,000 joules added, or 2,200 joules required to vaporize, so more energy was required to vaporize water than vaporize acetic acid. Choice (A) is incorrect because according to the graph, more heat energy is required to melt a gram of water than a gram of acetic acid. Choice (C) is incorrect because the slope of the line segment representing the heating of liquid water is shallower than that of the liquid acetic acid, so the temperature of a gram of liquid acetic acid will increase at a faster rate. Choice (D) is incorrect because the rate at which acetic acid vapor cools is actually faster than that of water based on the slope of the line segments corresponding to cooling vapor.
13	SPS4a	3	A, D	The correct answers are choices (A) and (D). The krypton isotope and the barium isotope represent the two nuclei that account for all the nuclear particles in the nuclear fission reaction. Choice (B) is incorrect because this isotope cannot be added to any of the other isotopes to account for all the nuclear particles in the nuclear fission reaction. Choice (C) is incorrect because a reaction involving alpha decay is not generally considered a nuclear fission reaction. Choice (E) is incorrect because a larger atomic nucleus occurs in a fusion reaction not a fission reaction. Choice (F) is incorrect because a reaction involving beta decay is not generally considered a nuclear fission reaction.

Item	Standard/ Element	DOK Level	Correct Answer	Explanation
14	SPS6b	3	D, B	The correct answer for Part A is choice (D) 30 minutes, because the larger diameter of crystals decreases the total surface area of the solute exposed to the solvent, increasing the length of exposure to the solvent. Choices (A), (B), and (C) are incorrect because a larger crystal size means it would take longer than 20 minutes to dissolve. The correct answer for Part B is choice (B) Keep the diameter of crystals at 1.0 mm. Keep the temperature at 20°C. Stir the solution. Choice (A) is incorrect because the larger crystal size requires more time. Choice (C) is incorrect because the larger crystal size requires more time and the lower temperature provides less exposure to the solvent. Choice (D) is incorrect because you are changing 2 variables, temperature and stirring.

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