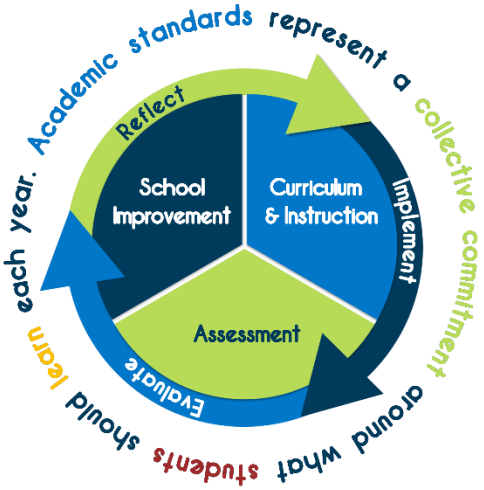
ILLINOIS STATE BOARD OF EDUCATION

SCIENCE

GRADES HIGH SCHOOL

Samples to Success

Sample items provide valuable insight into how students engage with different texts, tasks, and contexts, highlighting the types of opportunities they need for success in the classroom. These items offer a shared reference point for understanding proficiency expectations, complementing the assessment's role in measuring learning.



By analyzing items alongside performance data, educators can gain a deeper understanding of students' strengths and areas for growth. Students thrive in environments rich with diverse materials, challenges that vary in task type, and multiple avenues for demonstrating understanding.

High-quality instruction, aligned with the learning goals, is the most effective way to support students' growth and prepare them for success.

CAT1-A

Evaluating Scientific Arguments and Models with Evidence

For Use with High School Samples to Success

Below Proficient

Passage I

In a particular *playa* (relatively flat, dry desert basin) evidence shows that some large rocks have moved along the surface, leaving shallow trails in the clay sediment, some up to several hundred meters long. Three scientists provided explanations for how these rocks moved.

Scientist 1

In the spring, snowmelt from surrounding mountains runs downhill and collects in the playa. At night, cold temperatures cause this water to freeze around the rocks. When temperatures rise again, the ice begins to melt, leaving a layer of mud on the surface and ice "rafts" around the rocks. The buoyancy of the ice rafts floats the rocks on top of the mud such that even light winds can then push the rocks along the surface. Evidence of this lifting is seen in that the trails left by rocks are both shallow and only about 2/3 as wide as the rocks themselves. Due to the combination of ice, mud, and light winds, the rocks are able to move several hundred meters in a few days.

Scientist 2

Snowmelt from surrounding mountains does collect in the playa during the spring. However, the temperature in the playa does not get cold enough for ice to form. When the playa's surface gets wet, the top layer of clay transforms into a slick, muddy film. In addition, dormant algae present in the dry clay begin to grow rapidly when the clay becomes wet. The presence of mud and algae reduces friction between the rocks and the clay. Even so, relatively strong winds are required to push the rocks along the wet surface, forming trails. Due to the combination of mud, algae, and strong winds, the rocks are able to move several hundred meters in a few hours.

Scientist 3

Water does collect in the playa, producing mud and ice. However, neither mud nor ice is responsible for the rocks' movements. The playa is located along a fault line between tectonic plates. Minor vertical shifts in the plates cause the rocks to move downhill, leaving trails. Due to the combination of tectonic plate movement and strong winds, the rocks are able to move only a few meters over several years.

Sample Item:

According to Scientist 2, friction between the rocks and the clay is reduced by which of the following?

A. Ice only
B. Algae only
C. Ice and mud only
D. Mud and algae only

Passage I

A study was conducted to examine whether female *Blattella germanica* (a species of cockroach) prefer to eat cat food, cheese, ham, or peanuts. First, 200 mg of each of the 4 foods was separately placed into a single box. Then, adult female *B. germanica* were added to the box. Figure 1 shows how the mass, in mg, of each food in the box changed over time after the addition of the *B. germanica*. Table 1 shows the percent by mass of carbohydrates, lipids, proteins, and water, respectively, present in each of the 4 foods tested in the study.

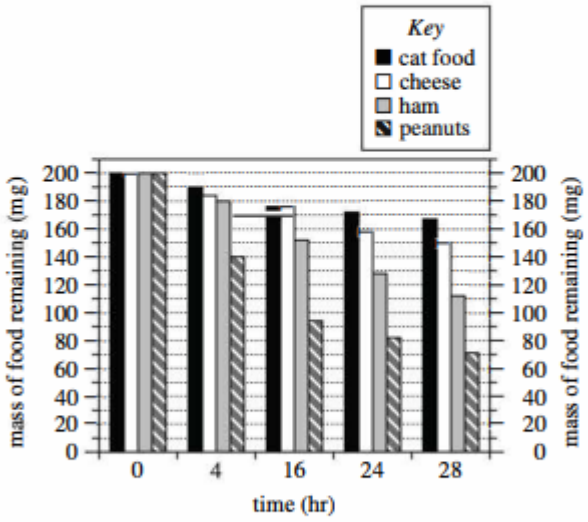


Figure 1

Figure adapted from Prachumporn Lauprasert et al., "Food Preference and Feeding Behavior of the German Cockroach, *Blattella germanica* (Linnaeus)." ©2006 by the Faculty of Science, Chulalongkorn University.

Table 1

Food	Percent by mass			
	carbohydrates	lipids	proteins	water
Cat food	1.2	6.0	16.9	66.2
Cheese	0.5	27.7	20.8	48.4
Ham	0.0	18.2	23.6	57.1
Peanuts	15.8	49.6	26.2	6.4

Table adapted from U.S. Department of Agriculture, *USDA National Nutrient Database for Standard Reference, Release 24*. 2011.

Sample Item:

Consider the statement "The *B. germanica* ate the food between 0 hr and 4 hr, between 4 hr and 16 hr, between 16 hr and 24 hr, and between 24 hr and 28 hr." This statement is consistent with the data in Figure 1 for how many of the 4 foods?

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

CAT1-C

Evaluating Scientific Arguments and Models with Evidence

For Use High School Samples to Success

Proficient

Passage VI

A *phylogenetic tree* shows proposed patterns of descent among groups of organisms. Each *node* (branching point) represents the *most recent common ancestor* (MRCA) of the 2 descendant groups (see the diagram). Groups that are more closely related share a more recent MRCA than do groups that are less closely related.

Three students each analyzed a different type of molecular data—DNA sequence, *protein sequence* (order of amino acids), or RNA sequence—to determine if turtles share a more recent MRCA with *archosaurs* (birds and crocodiles) or with *squamates* (lizards and snakes). Each of the students constructed a phylogenetic tree based on his or her analysis.

Student 1

The length of a particular DNA sequence varies among groups of organisms. As species evolve, new DNA subunits are added. An analysis of DNA sequences from turtles, archosaurs, and squamates indicates that turtles and archosaurs share the greatest number of additions. Therefore, turtles and archosaurs share a more recent MRCA than do turtles and squamates (see Figure 1).

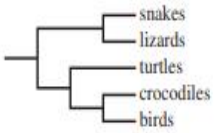


Figure 1

Student 2

The length of a particular protein sequence remains the same among groups of organisms. As species evolve, some amino acids are substituted by different amino acids. An analysis of protein sequences from turtles, archosaurs, and squamates indicates that turtles and crocodiles share the greatest number of substitutions. Therefore, turtles and crocodiles share a more recent MRCA than do either turtles and birds, or turtles and squamates (see Figure 2).

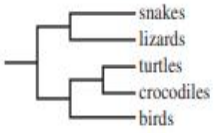


Figure 2

Student 3

The length of a particular RNA sequence varies among groups of organisms. As species evolve, some RNA subunits are deleted. An analysis of RNA sequences from turtles, archosaurs, and squamates indicates that turtles and squamates share the greatest number of deletions. Therefore, turtles and squamates share a more recent MRCA than do turtles and archosaurs (see Figure 3).

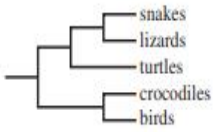


Figure 3

Figures adapted from Naoyuki Iwabe, et al., "Sister Group Relationship of Turtles to the Bird-Crocodilian Clade Revealed by Nuclear DNA-Coded Proteins." ©2004 by Society for Molecular Biology and Evolution.

Sample Item:

The phylogenetic tree constructed by which of the students supports the hypothesis that turtles are more closely related to archosaurs than to squamate?

A. Student 2 only
B. Student 3 only
C. Students 1 and 2 only
D. Students 1 and 3 only

Passage IV

Ammonia (NH_3) can be produced according to the chemical equation

$$N_2 + 3H_2 \rightleftharpoons 2NH_3$$

The *equilibrium arrow* ($\rightleftharpoons$) indicates that this reaction proceeds in both directions until it is at *equilibrium*, so that both the forward reaction (production of NH_3) and the backward reaction (production of N_2 and H_2) occur at the same rate. Equilibrium can be shifted forward or backward by changing the temperature, pressure, or concentration of reactants or products.

Two experiments were done using the following apparatus to produce NH_3.

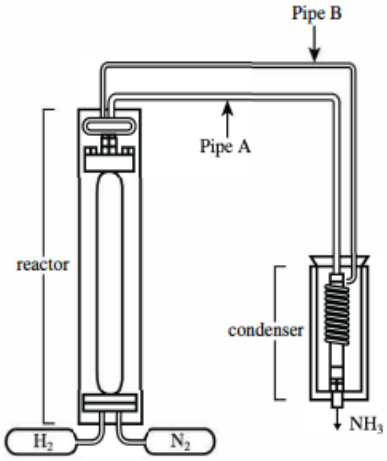


diagram of apparatus

In each trial, Steps 1–4 occurred:

1. A fresh catalyst (Catalyst W, X, Y, or Z), 160 kg of H_2, and 745 kg of N_2 were placed in the reactor.
2. The H_2 and N_2 reacted at a constant temperature and a constant pressure until equilibrium was established.
3. A mixture of NH_3 and any unreacted H_2 and N_2 flowed through Pipe A to a $-50°C$ condenser at 1 atmosphere (atm) of pressure.
4. NH_3 condensed and exited the apparatus. (H_2 and N_2 do not condense at $-50°C$.) Any unreacted H_2 and N_2 flowed into Pipe B, returning to the reactor.

Steps 2–4 reoccurred in cycles until no more H_2 and N_2 returned from the condenser.

Experiment 1

A set of 9 trials was conducted with each of the 4 catalysts. For each set, the pressure was 150 atm; within each set, the temperature was different for each trial. Figure 1 shows, for each trial, the number of cycles of Steps 2–4.

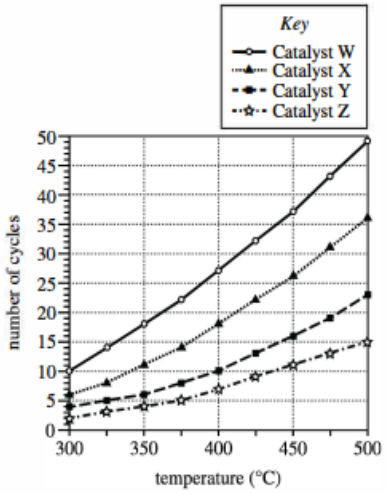


Figure 1

Experiment 2

Four sets of 9 trials each were conducted with Catalyst Z. For each set, the temperature was different; within each set, the pressure was different for each trial. Figure 2 shows, for each trial, the amount of NH_3 produced in the *first* cycle of Steps 2–4.

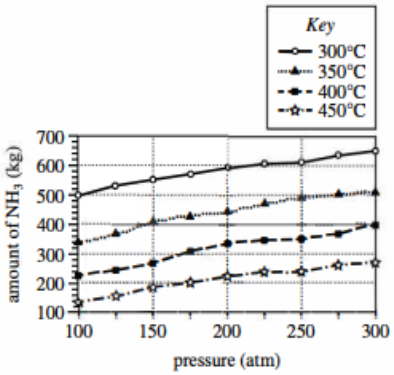


Figure 2

Sample Item:

Consider the trial in Experiment 2 that produced 550 kg of NH_3. Based on Figure 1, the number of cycles that were needed to complete the reaction in this trial was most likely:

A. less than 5.
B. between 5 and 10.
C. between 10 and 15.
D. greater than 15.

CAT2-A

Interpretation of Data

For Use with High School Samples to Success

Below Proficient

A study was conducted to examine whether female *Blattella germanica* (a species of cockroach) prefer to eat cat food, cheese, ham, or peanuts. First, 200 mg of each of the 4 foods was separately placed into a single box. Then, adult female *B. germanica* were added to the box. Figure 1 shows how the mass, in mg, of each food in the box changed over time after the addition of the *B. germanica*. Table 1 shows the percent by mass of carbohydrates, lipids, proteins, and water, respectively, present in each of the 4 foods tested in the study.

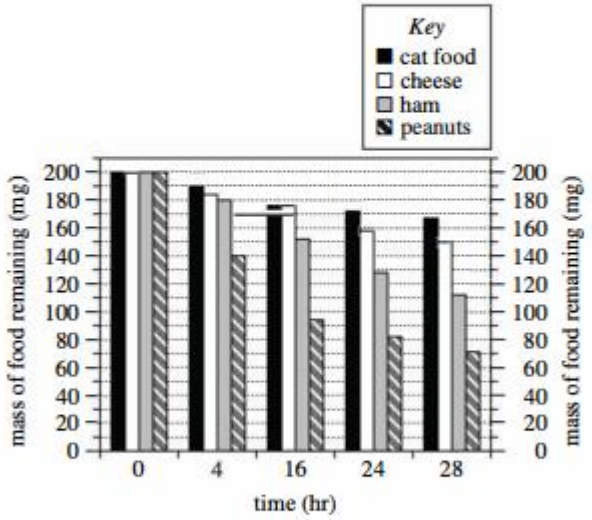


Figure 1

Figure adapted from Prachumporn Lauprasert et al., "Food Preference and Feeding Behavior of the German Cockroach, *Blattella germanica* (Linnaeus)." ©2006 by the Faculty of Science, Chulalongkorn University.

Table 1

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Table adapted from U.S. Department of Agriculture, *USDA National Nutrient Database for Standard Reference, Release 24*. 2011.

Sample Item:

According to Figure 1, the mass of cheese remaining at 4 hr was closest to which of he following values?

A. 140 mg
B. 176 mg
C. 185 mg
D. 190 mg

Figure 1 is a diagram of an *RLC circuit*. The circuit has a power supply and 3 components: a resistor (R), an inductor (L), and a capacitor (C).

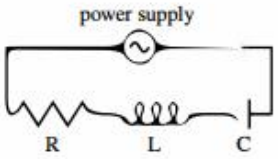


Figure 1

Electric current can flow through the circuit either clockwise (positive current) or counterclockwise (negative current). Figure 2 shows how the electric current in the circuit, I (in amperes, A), and the power supply voltage, V_S (in volts, V), both changed during a 20-millisecond (msec) time interval.

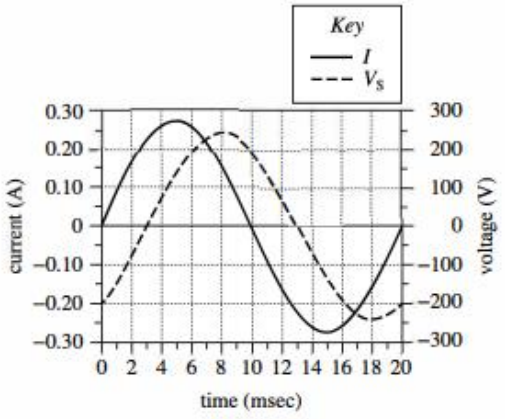


Figure 2

Figure 3 shows how the voltages across the components—V_R, V_L, and V_C, respectively—each changed during the same 20 msec time interval.

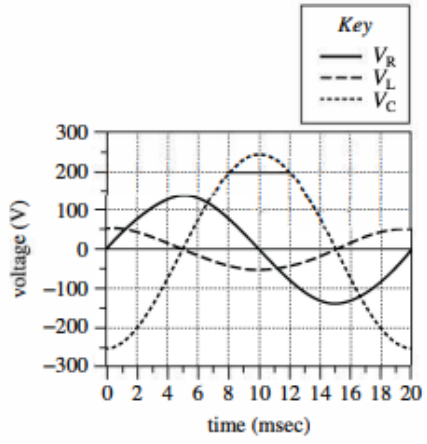


Figure 3

Sample Item:

According to Figure 2, the maximum positive value of V_s was approximately?

A. 125 V.
B. 200 V.
C. **250 V.**
D. 275 V.

Solar time is determined by the position of the Sun relative to a *meridian* (an imaginary line that passes through the northernmost and southernmost points of the horizon, dividing the visible sky into 2 equal halves). At *solar noon*, the Sun appears to cross the meridian. A *solar day* is the period between one solar noon and the next. Because the Sun's apparent motion is not uniform, a solar day is generally not the same length as a *mean day*, which is exactly 24 hrs (1,440 min). See Figure 1.

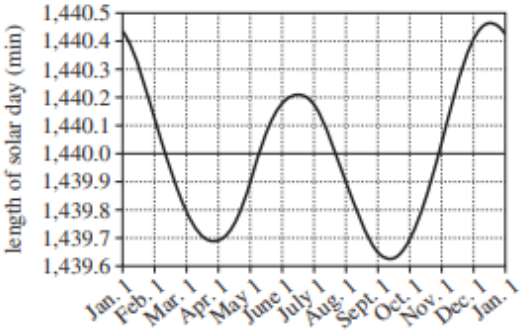
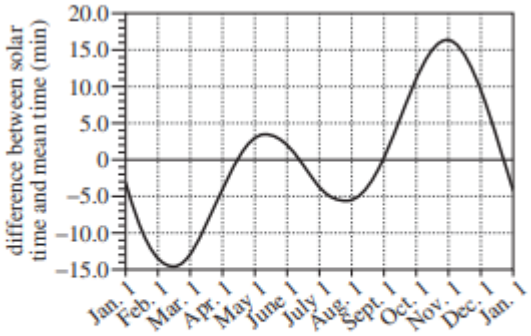


Figure 1

Figure 2 shows how the difference between solar time and *mean time* (time as indicated by a clock) varies throughout the year.



Note: If the difference between solar time and mean time is positive, solar time is ahead of mean time; if the difference is negative, solar time is behind mean time.

Figure 2

Sample Item:

According to Figure 2, in a given year, solar time is ahead of mean time for approximately how many months in total?

A. 3.5
B. 5.5
C. 7.5
D. 9.5

Figure 1 is a diagram of an *RLC circuit*. The circuit has a power supply and 3 components: a resistor (R), an inductor (L), and a capacitor (C).

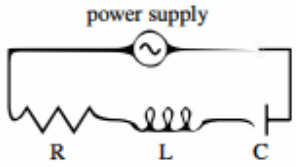


Figure 1

Electric current can flow through the circuit either clockwise (positive current) or counterclockwise (negative current). Figure 2 shows how the electric current in the circuit, I (in amperes, A), and the power supply voltage, V_S (in volts, V), both changed during a 20-millisecond (msec) time interval.

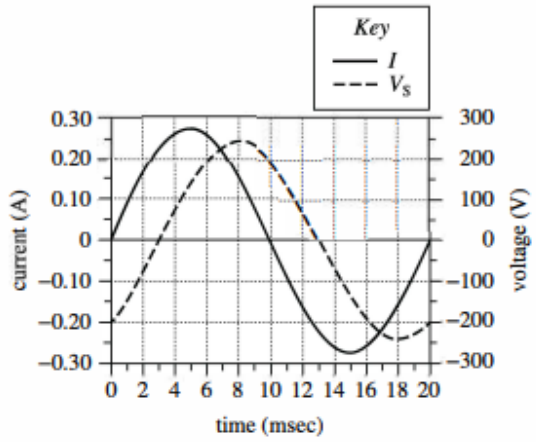


Figure 2

Figure 3 shows how the voltages across the components—V_R, V_L, and V_C, respectively—each changed during the same 20 msec time interval.

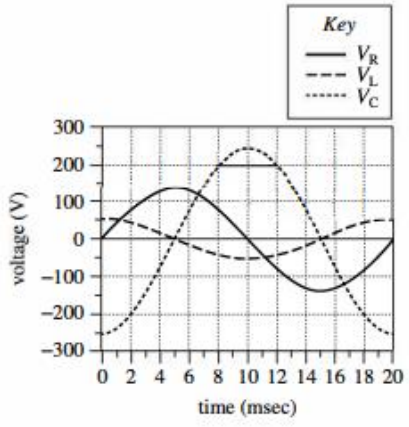


Figure 3

Sample Item:

Based on Figure 2, at which of the following times was the current in the circuit flowing counterclockwise?

A. 0 msec
B. 5 msec
C. 10 msec
D. **15 msec**

Passage I

Radon (Rn) is a naturally occurring radioactive gas. Scientists conducted a study to measure the Rn concentration in *soil gas* (the gases present between soil particles) following a major earthquake that occurred in May 2008.

Study

In June 2008, 8 sites (Sites 1–8) were selected along the fault line of the earthquake. Site 1 was approximately 25 km to the northeast from the epicenter of the earthquake, and each successive site was 25 km to 50 km farther to the northeast than the previous site. The vertical displacement of the ground due to the earthquake was measured at each site (see Figure 1).

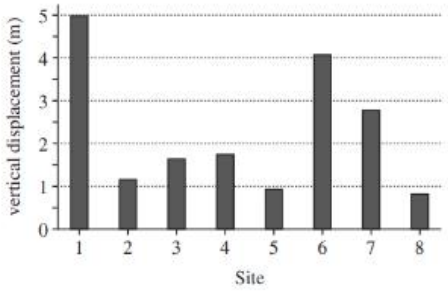


Figure 1

At each site, 4 pairs of 2.3 cm diameter holes were drilled 0.80 m deep in the soil. A rigid Teflon tube was placed in each hole and then covered with an airtight cap fitted with a length of flexible tubing (see Figure 2).

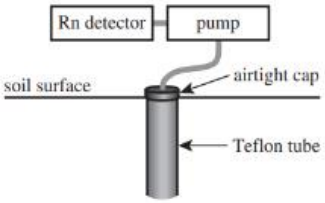


Figure 2

At each hole, the soil gas was pumped out of the tube and into an Rn detector at a flow rate of 1 L/min. Three successive readings were taken with the Rn detector, each lasting 5 min, and the average Rn concentration, in kilobecquerels per cubic meter (kBq/m^3), was determined. At each of the holes, the Rn measurements were repeated in December 2008 and again in July 2009. Figure 3 shows the average Rn concentration at each of the 8 sites on each of the 3 dates that readings were taken.

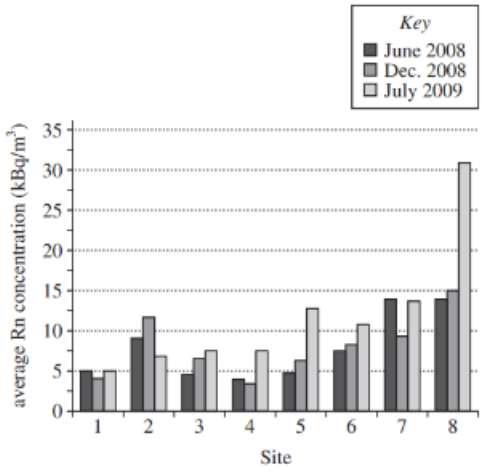


Figure 3

Figures 1 and 3 adapted from X. Zhou et al., DOI: 10.1186/1467-4866-11-5.

Sample Item:

Which of the following expressions best shows the direction of the flow of soil gas through the apparatus shown in Figure 2?

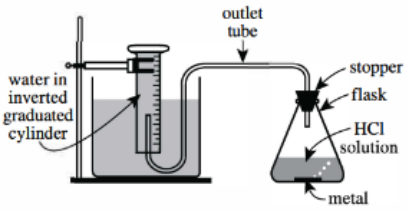
A. Teflon tube -> pump > Rn detector
B. Teflon tube -> Rn detector -> pump
C. Pump -> Rn detector->Teflon tube
D. Pump->Teflon tube-> Rn detector

Passage III

When a solid metal (M) such as iron (Fe), nickel (Ni), or zinc (Zn) is placed in an aqueous hydrochloric acid (HCl) solution, a reaction that produces H_2 gas occurs:

$$M + 2HCl \rightarrow MCl_2 + H_2$$

Two experiments were conducted to study the production of H_2 in this reaction. The apparatus shown in the diagram below was used to collect the H_2 gas produced in each trial.



diagram

As H_2 was produced in the stoppered flask, it exited the flask through the outlet tube and displaced the water that had been trapped in the inverted graduated cylinder. (This displacement occurred because the H_2 did not dissolve in the water.) The volume of water displaced equaled the volume of gas (H_2 and water vapor) collected.

In each trial of the experiments, Steps 1–3 were performed:

1. The apparatus was assembled, and 25 mL of a 4 moles/L HCl solution was poured into the empty flask.
2. A selected mass of Fe, Ni, or Zn was added to the flask, and the stopper was quickly reinserted into the flask.
3. When H_2 production ceased, the volume of water that was displaced from the graduated cylinder was recorded.

The apparatus and its contents were kept at a selected temperature throughout Steps 2 and 3. The atmospheric pressure was 758 mm Hg throughout all 3 steps.

Experiment 1

In each trial, a selected mass of Fe, Ni, or Zn was tested at 30°C (see Figure 1).

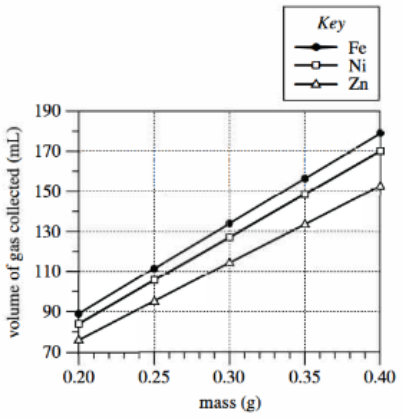


Figure 1

Experiment 2

In each trial, 0.30 g of Fe, Ni, or Zn was tested at a selected temperature (see Figure 2).

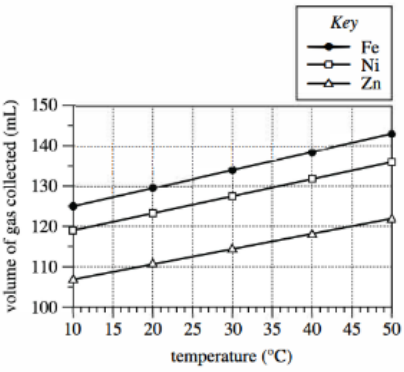


Figure 2

Sample Item:

How many temperatures were tested in Experiment 1, and how many temperatures were tested in Experiment 2?

	Experiment 1	Experiment 2
A.	1	1
B.	**1**	**5**
C.	5	1
D.	5	5

Passage III

Three studies examined the effects of *compost* (organic matter) on 3 physical properties of soil.

Five soil mixtures (Mixtures 1–5) were prepared (see Table 1).

Table 1

Mixture	Percent by volume of: compost	soil
1	5	95
2	25	75
3	50	50
4	75	25
5	95	5

Study 1

A 1.5 L pot was prepared by placing 500 g of Mixture 1 into the pot, after which the pot was stored at 30°C for 72 hr. The pot and its contents were then baked in a 105°C oven for 24 hr. After cooling, the mixture's *bulk density* (the dry mass of the mixture per unit volume) was determined.

These procedures were repeated for each of Mixtures 2–5 (see Table 2).

Table 2

Mixture	Bulk density (mg/mL)
1	104
2	159
3	213
4	255
5	302

Study 2

Another 1.5 L pot of Mixture 1 was prepared, stored, and baked as in Study 1.

The dried mixture was ground into powder and passed through a screen with 2 mm diameter openings. Five grams of the screened powder were then mixed with 5 mL of H_2O, and the pH of the powder-H_2O suspension was determined.

These procedures were repeated for each of Mixtures 2–5 (see Table 3).

Table 3

Suspension of H_2O and Mixture:	pH
1	6.5
2	6.2
3	6.7
4	7.0
5	7.2

Study 3

Another 1.5 L pot of Mixture 1 was prepared, stored, and baked as in Study 1. The dried mixture was then ground and screened as in Study 2.

Fifty grams of the screened powder were mixed with 5 mL of H_2O to form a soil paste, and the paste was placed on a filter. Suction was then applied to the filter, and the *extract* (the clear, colorless liquid that passed through the filter) was collected. The electrical conductivity of the extract was determined.

These procedures were repeated for each of Mixtures 2–5 (see Table 4).

Table 4

Extract from Mixture:	Electrical conductivity (dS/m*)
1	2.40
2	2.56
3	3.45
4	2.15
5	1.86

*decisiemens per meter

Sample Item:

Based on the results of Study 1, if a mixture with 60% by volume of compost had been tested in Study 1, the bulk density of this mixture would most likely have been:

A. less than 159 mg/mL.

B. between 159 mg/mL and 213 mg/mL.

C. between 213 mg/mL and 255 mg/mL.

D. greater than 255 mg/mL.

Passage IV

The horseshoe bat *Rhinolophus mehelyi* emits calls and uses the reflected sound waves for a variety of purposes, including determining orientation, detecting food, and communicating. Two studies were done to examine call frequency and mate choice in *R. mehelyi*.

Study 1

Ninety *R. mehelyi* were collected from a single cave. A recording of each bat's call was made when the bat was stationary. Each call was analyzed with an ultrasound detector to determine its *peak frequency* (the frequency at which the call is the loudest). Then the mass of each bat was determined and plotted versus its peak frequency, in kilohertz (kHz). Figure 1 shows the best-fit line obtained from that plot.

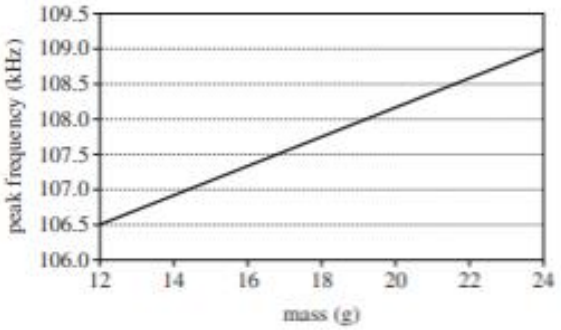


Figure 1

Study 2

A 1 m^3 box was divided into 2 equal compartments, each containing a speaker. A female *R. mehelyi* was placed on a listening perch in the box at a position equidistant from each speaker (see Figure 2).

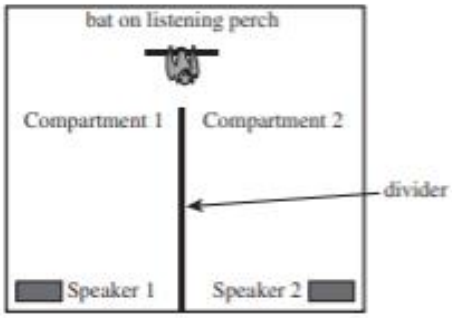


Figure 2

Figures 1 and 2 adapted from Sebastien J. Puechmaille et al., "Female Mate Choice Can Drive the Evolution of High Frequency Echolocation in Bats: A Case Study with *Rhinolophus mehelyi*." ©2014 by PLOS ONE.

Sample Item:

In Study 1, which of the following procedures was likely performed to ensure that a given peak frequency measurement was not influenced by the Doppler effect?

A. Measuring the mass of each bat
B. Collecting bats from a single cave
C. Placing the bat equidistant from 2 speakers
D. **Recording bats while they were stationary**