CSET®

California Subject Examinations for Teachers®

TEST GUIDE

SCIENCE SUBTEST 1: GENERAL SCIENCE

Sample Questions and Responses and Scoring Information

CS-TG-QR215X-01

Sample Test Questions for CSET: Science Subtest I: General Science

Below is a set of multiple-choice questions and constructed-response questions that are similar to the questions you will see on Subtest I of CSET: Science. You are encouraged to respond to the questions without looking at the responses provided in the next section. Record your responses on a sheet of paper and compare them with the provided responses.

Scientific calculators **will be provided** for the examinees taking Science Subtest I: General Science, as well as the specialty subtests of Life Sciences, Chemistry, Earth and Space Sciences, and Physics. Refer to the California Educator Credentialing Examinations website for a list of the calculator models that may be provided. Directions for the use of the calculator will not be provided at the test administration. You will not be allowed to use your own calculator for CSET: Science subtests.

PERIODIC TABLE OF THE ELEMENTS

1 **1A**																	18 **8A**
1 **H** 1.01	2 **2A**											13 **3A**	14 **4A**	15 **5A**	16 **6A**	17 **7A**	2 **He** 4.00
3 **Li** 6.94	4 **Be** 9.01											5 **B** 10.81	6 **C** 12.01	7 **N** 14.01	8 **O** 16.00	9 **F** 19.00	10 **Ne** 20.18
11 **Na** 23.0	12 **Mg** 24.3	3 **3B**	4 **4B**	5 **5B**	6 **6B**	7 **7B**	8	9 **8B**	10	11 **1B**	12 **2B**	13 **Al** 27.0	14 **Si** 28.1	15 **P** 31.0	16 **S** 32.1	17 **Cl** 35.5	18 **Ar** 39.9
19 **K** 39.1	20 **Ca** 40.1	21 **Sc** 45.0	22 **Ti** 47.9	23 **V** 50.9	24 **Cr** 52.0	25 **Mn** 54.9	26 **Fe** 55.8	27 **Co** 58.9	28 **Ni** 58.7	29 **Cu** 63.5	30 **Zn** 65.4	31 **Ga** 69.7	32 **Ge** 72.6	33 **As** 74.9	34 **Se** 79.0	35 **Br** 79.9	36 **Kr** 83.8
37 **Rb** 85.5	38 **Sr** 87.6	39 **Y** 88.9	40 **Zr** 91.2	41 **Nb** 92.9	42 **Mo** 95.9	43 **Tc** (98.9)	44 **Ru** 101.1	45 **Rh** 102.9	46 **Pd** 106.4	47 **Ag** 107.9	48 **Cd** 112.4	49 **In** 114.8	50 **Sn** 118.7	51 **Sb** 121.8	52 **Te** 127.6	53 **I** 126.9	54 **Xe** 131.3
55 **Cs** 132.9	56 **Ba** 137.3	57–71	72 **Hf** 178.5	73 **Ta** 180.9	74 **W** 183.9	75 **Re** 186.2	76 **Os** 190.2	77 **Ir** 192.2	78 **Pt** 195.1	79 **Au** 197.0	80 **Hg** 200.6	81 **Tl** 204.4	82 **Pb** 207.2	83 **Bi** 209.0	84 **Po** (209)	85 **At** (210)	86 **Rn** (222)
87 **Fr** (223)	88 **Ra** (226)	89–103	104 **Rf** (261)	105 **Db** (262)	106 **Sg** (266)	107 **Bh** (264)	108 **Hs** (277)	109 **Mt** (268)	110 **Ds** (271)	111 **Rg** (282)	112 **Cn** (285)	113 **Nh** (286)	114 **Fl** (289)	115 **Mc** (289)	116 **Lv** (293)	117 **Ts** (294)	118 **Og** (294)

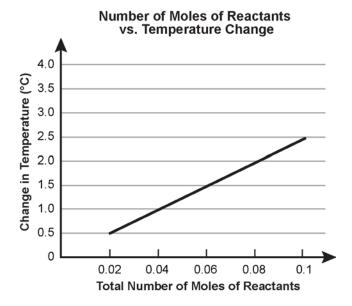|	57 **La** 138.9	58 **Ce** 140.1	59 **Pr** 140.9	60 **Nd** 144.2	61 **Pm** (145)	62 **Sm** 150.4	63 **Eu** 152.0	64 **Gd** 157.3	65 **Tb** 158.9	66 **Dy** 162.5	67 **Ho** 164.9	68 **Er** 167.3	69 **Tm** 168.9	70 **Yb** 173.0	71 **Lu** 175.0
Lanthanide Series															
Actinide Series	89 **Ac** (227)	90 **Th** 232.0	91 **Pa** 231.0	92 **U** 238.0	93 **Np** (237)	94 **Pu** (244)	95 **Am** (243)	96 **Cm** (247)	97 **Bk** (247)	98 **Cf** (251)	99 **Es** (252)	100 **Fm** (257)	101 **Md** (258)	102 **No** (259)	103 **Lr** (262)

1. After studying geologic maps of California, a researcher hypothesizes that the bedrock in a region is offset from similar rocks a hundred miles to the south by movement along a transform fault. Which of the following experiments would provide the strongest evidence to support this hypothesis about the evolution of California's complex geologic history?

   A. a comparative study of mineral assemblages in the two different rocks

   B. an analysis of aerial photographs of the fault taken over the past fifty years

   C. a comparison of current slip rates with the total distance of proposed offset

   D. an investigation of surficial deposits that have been offset along the fault

2. In the early twentieth century, Robert Millikan created electrically charged oil droplets and then determined their electric charge by calculating the magnitude of the electric charge that would suspend them in midair in opposition to gravity. He found that the electric charge on each oil droplet was always an integer multiple of what we now know as the basic unit charge. Millikan's experiment is credited with discovering:

   A. the size of an electron.

   B. the relationship described by Ohm's law.

   C. the charge on a single electron.

   D. the relationship between charge and force.

3. **Use the information below to answer the question that follows.**

A student performs the following neutralization reaction five times using different amounts of reactants. The change in temperature of the reaction mixture for each reaction is shown in the graph.
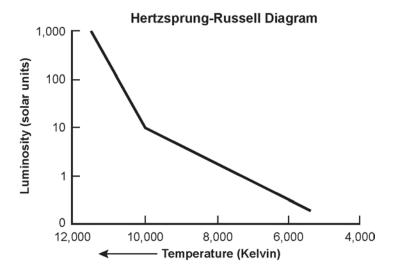
$$NaOH(aq) + HCl(aq) \longrightarrow NaCl(aq) + H_2O(\ell)$$

Number of Moles of Reactants
vs. Temperature Change

Which of the following conclusions is best supported by the data shown in the graph?

A. An increase in the amount of reactants used in the reaction leads to an increase in the percent yield of the reaction.

B. There is a linear relationship between the volume of the reactants used and the amount of energy absorbed during the reaction.

C. An increase in temperature leads to an increase in the rate at which the neutralization reaction occurs.

D. Doubling the number of moles of reactants leads to a twofold increase in the temperature change caused by the reaction.

4. **Use the graph below to answer the question that follows.**

Hertzsprung-Russell Diagram

The graph shows the relationship between the temperature and luminosity of main-sequence stars as depicted on a Hertzsprung-Russell diagram. Which of the following statements best describes the change in luminosity that occurs as the temperature increases above 10,000 Kelvin?

A.   The change in luminosity decreases exponentially.

B.   The change in luminosity decreases logarithmically.

C.   The change in luminosity per unit temperature increases.

D.   The change in luminosity per unit temperature decreases.

5. **Use the table below to answer the question that follows.**

Substance	Phase	Mass	Volume
1	liquid	6 g	8 cm³
2	liquid	9 g	9 cm³
3	liquid	20 g	5 cm³
4	solid	5 g	4 cm³
5	solid	8 g	9 cm³

The mass and volume of five substances are measured and recorded in the table shown. Which of the following is a valid conclusion that can be drawn from the data in the table?

A. Substance 4 will float in substance 2 when both are in the liquid phase.

B. Substance 4 will float in substance 1.

C. Substance 3, in solid form, will float in the liquid form of substance 3.

D. Substance 5 will float in substance 2.

6. A laboratory procedure requires the use of a 0.25 M NaOH solution. If according to the lab procedure, 2.00 g of NaOH should be dissolved in 200 mL of distilled water to prepare this solution, which of the following mathematical expressions could be used determine the number of formula units of NaOH used?

A. $2.00 \text{ g NaOH} \left(\dfrac{1 \text{ mol NaOH}}{40.0 \text{ g NaOH}} \right) \left(\dfrac{6.022 \times 10^{23} \text{ NaOH formula units}}{1 \text{ mol NaOH}} \right)$

B. $2.00 \text{ g NaOH} \left(\dfrac{1 \text{ mol NaOH}}{40.0 \text{ g NaOH}} \right) \left(\dfrac{1 \text{ mol NaOH}}{6.022 \times 10^{23} \text{ NaOH formula units}} \right)$

C. $2.00 \text{ g NaOH} \left(\dfrac{40.0 \text{ g NaOH}}{1 \text{ mol NaOH}} \right) \left(\dfrac{1 \text{ mol NaOH}}{6.022 \times 10^{23} \text{ NaOH formula units}} \right)$

D. $2.00 \text{ g NaOH} \left(\dfrac{40.0 \text{ g NaOH}}{1 \text{ mol NaOH}} \right) \left(\dfrac{6.022 \times 10^{23} \text{ NaOH formula units}}{1 \text{ mol NaOH}} \right)$

7. A team of climate scientists is planning a yearlong research project in Antarctica to drill several hundred meters into an ice sheet to retrieve ice cores. A previous drilling project in the same area had limited success because of the failure of the drilling equipment after several months, so the team has contracted an engineering company to design a specialized drill. Which of the following factors will be the primary constraint on any design solution that the engineering company develops?

   A. the time needed to design and manufacture new drilling equipment

   B. the physical conditions where the drilling equipment will be used

   C. the ability of the drilling equipment to be reused on future projects

   D. the protection of ice cores retrieved by the new drilling equipment

8. A civil engineer has been contracted to develop a prototype for an inexpensive temporary retaining wall that could be installed quickly when a landslide occurs and small debris flows toward busy roadways. The engineer comes up with several possible designs that, in theory, will do the job and be relatively easy to install. Before choosing which design should be developed into a prototype, it is most important that the engineer:

   A. determine the weakness in each design that might cause failure in extreme conditions.

   B. compare each design's theoretical effectiveness to its estimated development cost.

   C. build physical models of each design and test them under realistic field conditions.

   D. identify the conditions and settings in which each design would be least effective.

9. **Use the table below to answer the question that follows.**

Time (s)	Speed of Ball Rolling Down Inclined Plane (m/s)
0	2.0
1	7.5
2	13.0
3	18.5

The table shows some data for the speed of a ball rolling down an inclined plane. Which of the following types of mathematical equations best represents the underlying pattern in the relationship between time and speed of the ball rolling down the inclined plane?

A. $s(t) = at^2$

B. $s(t) = at + b$

C. $s(t) = at^2 + bt + c$

D. $s(t) = a \log(t) + b$

Use the chemical equation below to answer the two questions that follow.

$$6CO_2 + 12H_2O + \text{light} \longrightarrow C_6H_{12}O_6 + 6O_2 + 6H_2O$$

The production of glucose by photosynthesis is summarized in the equation shown. This one chemical equation actually comprises two distinct sets of reactions; the light-dependent reactions and the light-independent reactions.

10. The production of carbohydrates from carbon dioxide and water that occurs during photosynthesis begins with the absorption of photons by plant pigments and the transfer of this energy to chlorophyll A. This initial step is particularly important to the process because it leads directly to the:

    A. release of carbon dioxide through the stomata.

    B. synthesis of water from hydrogen and oxygen.

    C. breakdown of carbohydrate molecules.

    D. production of the energy used to drive the overall reaction.

11. The main function of the light-independent reactions (or Calvin cycle) during photosynthesis is to produce:

    A. adenosine triphosphate (ATP) from chlorophyll.

    B. carbohydrates from carbon dioxide.

    C. oxygen from water.

    D. pyruvate from NADPH.

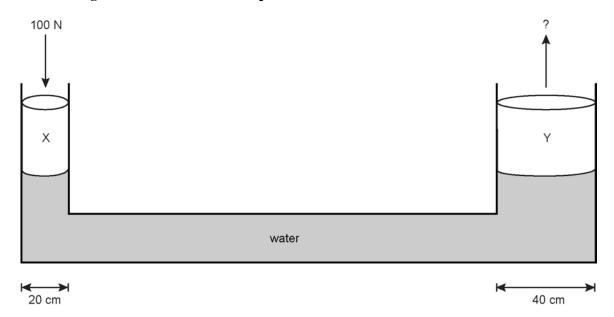12. **Use the valence shell electron configuration below to answer the question that follows.**

    $3s^23p^5$

    The valence electrons for an element have the electron configuration shown. This element is most likely to be located in which of the following groups and periods of the periodic table?

    A. Group 14, Period 2

    B. Group 15, Period 5

    C. Group 16, Period 7

    D. Group 17, Period 3

13. Increasing the temperature of a reaction usually leads to an increase in reaction rate because it:

    A. decreases the minimum amount of energy needed for the reaction to proceed.

    B. increases the likelihood that the reactants are in a molecular orientation that favors reactivity.

    C. decreases the strength of the intramolecular bond energies of the reactants.

    D. increases the frequency and energy of the collisions between reactant molecules.

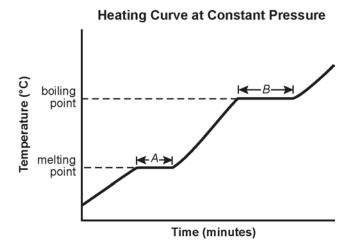14.   **Use the diagram below to answer the question that follows.**

A force of 100 N is applied to piston X as shown in the diagram.
What is the upward force applied by piston Y?

A.   200 N

B.   400 N

C.   800 N

D.   1000 N

15. When light strikes a conducting metal, electrons are ejected from the metal. Scientists were puzzled in their efforts to explain this effect using the theories available at the time. Finally, Albert Einstein proposed an explanation by suggesting that light consists of quanta that have discrete values of energy. This explanation provided evidence for which of the following characteristics of light?

    A. Light can be polarized.

    B. Light is composed of particles.

    C. Light is an electromagnetic wave.
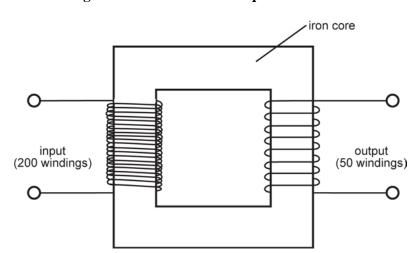
    D. Light travels at a constant speed.

16. In the early nineteenth century, Thomas Young directed a beam of coherent light at a barrier that had two slits cut into it. He then observed the pattern of light produced on the other side of the barrier. This was one of the most important experiments in research related to:

    A. understanding the nature of polarized light.

    B. determining the speed of light.

    C. understanding the wave nature of light.

    D. determining the relationship between frequency and color.

17.   **Use the graph below to answer the question that follows.**

Heating Curve at Constant Pressure

The graph shows the heating curve of a substance. Which of the following statements best explains why section *B* of the graph is longer than section *A*?

A.   The energy required to change the substance from liquid to gas is greater than the energy required to change it from solid to liquid.

B.   The average kinetic energy of the molecules increases as the temperature increases.

C.   The entropy increases more when the substance changes from solid to liquid than when it changes from liquid to gas.

D.   The volume of the substance and the time required to heat it increase as the substance changes phase.

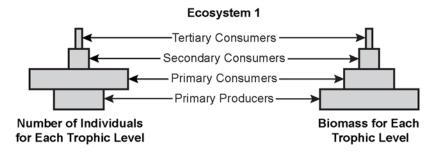18. **Use the diagram below to answer the question that follows.**

The device in the diagram consists of two windings of wire wrapped around an iron core. The windings are separate from each other, and neither is in direct contact with the other. There are 200 windings of wire on the input side and 50 windings of wire on the output side. The device most likely performs which of the following functions?

A.   increasing voltage

B.   decreasing voltage

C.   converting alternating current to direct current

D.   converting direct current to alternating current

19. In most plants, the stomata on the leaves are closed at night and open during the day. Which of the following explains this general pattern?

    A. The stomata are light sensitive and function only in the presence of solar radiation.

    B. High concentrations of potassium in the nearby guard cells force the stomata closed.

    C. The stomata close at night to reduce water loss at a time when a plant does not need carbon dioxide.

    D. Evaporative cooling through transpiration would be excessive if continued through the night.

20. **Use the diagrams below to answer the question that follows.**
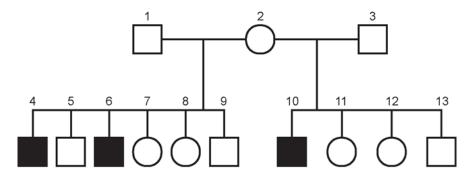
Trophic Pyramids for Two Ecosystems

Ecosystem 1

Tertiary Consumers

Secondary Consumers

Primary Consumers

Primary Producers

Number of Individuals for Each Trophic Level

Biomass for Each Trophic Level

Ecosystem 2

Tertiary Consumers

Secondary Consumers

Primary Consumers

Primary Producers

Number of Individuals for Each Trophic Level
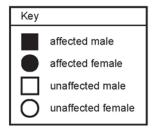
Biomass for Each Trophic Level

The diagrams show two types of trophic pyramids for two different ecosystems. One type of pyramid shows the number of individual organisms that make up each trophic level, while the other shows the total biomass of all organisms at each trophic level. Which of the following is the most likely explanation for the difference in the number of individuals at each trophic level between the two ecosystems?

A.   The individual producers in ecosystem 1 are larger than the individual producers in ecosystem 2.

B.   The productivity of ecosystem 1 is greater than the productivity of ecosystem 2.

C.   The individual producers in ecosystem 1 are smaller than the individual producers in ecosystem 2.

D.   The productivity of ecosystem 1 is less than the productivity of ecosystem 2.

21. Which of the following best describes the accepted model of DNA replication?

    A.   the dispersive model, in which a parental DNA molecule replaces segments of its double helix with new genetic material, making the original segments available to assemble new DNA molecules

    B.   the conservative model, in which the parental DNA remains intact while providing a template for an identical double helix to be synthesized adjacent to it

    C.   the semiconservative model, in which the two strands of the parental double helix separate, and each provides the template for building a new strand that attaches to the parental strand

    D.   the additive model, in which nucleotide chains assemble into double helix configurations, and the segments are linked to correspond to the parental DNA sequence

22. **Use the pedigree chart below to answer the question that follows.**

A rare phenotype appears in the offspring of individuals 1, 2, and 3, all of whom exhibit a normal phenotype. Based on the frequencies in the chart above, which of the following is the most likely mechanism for the inheritance of this trait?

A. The abnormal phenotype depends on autosomal transmission.

B. The X chromosome carries the recessive allele.

C. The abnormal phenotype occurs only by mutation.

D. The Y chromosome carries the recessive allele.

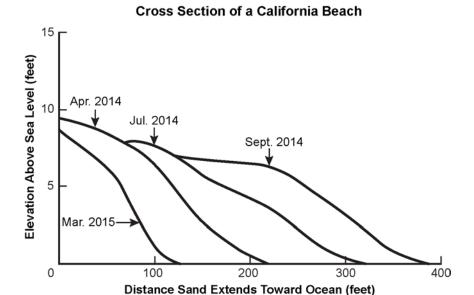23. **Use the information below to answer the question that follows.**

    Darwin made two distinct claims when proposing his theory of evolution. Darwin's first claim was that all modern species have evolved from ancestral forms. The second claim was that natural selection is the main mechanism for evolutionary change.

    Which of the following observations best supports Darwin's claim that all modern species have evolved from ancestral forms?

    A. Similar complex structures, such as the eye, are present in a wide variety of unrelated organisms.

    B. Early embryos of all vertebrate groups, such as mammals, reptiles, and fish, are very similar.

    C. Variation occurs in all species, and this variation may help determine the survival of an individual.

    D. All species appear to be well adapted to the environment in which they live.

24. Which of the following statements best describes the most widely accepted theory of the solar system's evolution?

    A. A small star grew as it consumed comets, eventually becoming large enough to ignite fusion reactions and attract planetary bodies.

    B. A star existing within the Milky Way galaxy pulled in comets and interstellar dust traveling through its gravitational field.

    C. A spinning cloud of interstellar dust and gas shrank under the force of gravity, producing a central star and revolving planetesimals.

    D. The remnant elements of the explosion of a massive star coalesced, forming planets that circled the hydrogen core of the exploded star.

25. Jupiter and the sun have some similar characteristics, but they have developed very differently primarily because Jupiter:

    A. has a lower average density.

    B. is composed of a greater variety of elements.

    C. contains much less overall mass.

    D. has a core and a gaseous atmosphere.

26. **Use the diagram below to answer the question that follows.**

Cross Section of a California Beach

The diagram shows a cross section of a beach with typical changes in the contour and form of beach sand along California's coastline between April 2014 and March 2015. Which of the following explanations best describes the likely events responsible for the changes in the contour and form of the beach?

A.   Large swells during the summer provided abundant sand, while less sediment was available during the winter months.

B.   The small waves during the summer deposited sand on the beach, while the storm waves of winter cut back the beach.

C.   Sediment that built up during the dry summer months was eroded by heavy winter rains and washed into the ocean.

D.   The finer sediment deposited during the summer became compacted and was more stable than the easily eroded coarse winter deposits.

27. Which of the following statements best describes the underlying principle that allows radiometric dating to be used as an absolute dating technique?

    A. The decay rate of naturally occurring radioactive elements into other elements is predictable.

    B. The strength of the electric charge of radioactive elements is a measure of how long they have been radioactive.

    C. The proportions of beta and alpha particles emitted from rock change as a consequence of age and temperature.

    D. The half-life of radioactive elements can be determined by the magnetic field created in the surrounding rocks.

28. Which of the following processes is primarily responsible for generating the different petrologic characteristics of oceanic and continental crustal plates?

    A. segregation of minerals and rocks of different densities as they are recycled at plate boundaries through volcanism and continental accretion

    B. separation of the distinct rocks and minerals that form at different temperatures during thermal fractionation in magma bodies

    C. erosion and sedimentation processes that continually separate the denser minerals in igneous rocks from lighter minerals

    D. formation of high-density igneous rocks as magma is erupted into the high-pressure conditions of oceanic spreading centers

29. Which of the following statements best describes the process of fossil fuel formation?

    A. Fossil fuels formed millions of years ago in massive deposits during an unusually warm period and are not currently forming.

    B. Fossil fuels form over hundreds of years from the rapid decay of organic matter in shallow oxygen-rich ponds and swamps.

    C. Fossil fuel formation is ongoing and involves the burial and slow transformation of carbonate rocks under high-pressure conditions.

    D. Fossil fuels form over millions of years from the buried remains of organic matter deposited in low-oxygen aqueous environments.

30. When groundwater is pumped from an unconfined sand-and-gravel aquifer, sometimes the amount of groundwater withdrawn exceeds the recharge of the aquifer. Which of the following is the most likely consequence of withdrawing more water from this kind of aquifer than is naturally recharged?

    A. Groundwater supply will remain constant, but water quality will be reduced as water is increasingly pulled from the pore spaces of the aquifer sediments.

    B. The water table will drop, but the supply of groundwater will remain undiminished as water is drawn upward into the aquifer from bedrock sources.

    C. Groundwater will be pulled from greater distances, but the water table near the point of withdrawal will remain at the same level.

    D. The water table will be lowered, and water from streams, lakes, and wetlands will move downward into the aquifer in response to the decrease in groundwater elevation.

Constructed-Response Assignment Directions

For each constructed-response assignment in this section, you are to prepare a written response.

Read each assignment carefully before you begin your response. Think about how you will organize your response. You may use the erasable notebooklet to make notes, write an outline, or otherwise prepare your response. ***However, your final response must be either:***

1) typed into the on-screen response box,
2) written on a response sheet and scanned using the scanner provided at your workstation, or
3) provided using both the on-screen response box (for typed text) and a response sheet (for calculations or drawings) that you will scan using the scanner provided at your workstation.

Instructions for scanning your response sheet(s) are available by clicking the "Scanning Help" button at the top of the screen.

Your responses will be evaluated based on the following criteria.

PURPOSE: the extent to which the response addresses the constructed-response assignment's charge in relation to relevant CSET subject matter requirements

SUBJECT MATTER KNOWLEDGE: the application of accurate subject matter knowledge as described in the relevant CSET subject matter requirements

SUPPORT: the appropriateness and quality of the supporting evidence in relation to relevant CSET subject matter requirements

The assignments are intended to assess subject matter knowledge and skills, not writing ability. Your responses, however, must be communicated clearly enough to permit a valid judgment of your knowledge and skills. Your responses should be written for an audience of educators in the field.

Your responses should be your original work, written in your own words, and not copied or paraphrased from some other work. Please write legibly when using the response sheets. You may not use any reference materials during the testing session. Remember to review your work and make any changes you think will improve your responses.

Any time spent responding to an assignment, including scanning the response sheet(s), is part of your testing time. Monitor your time carefully. When your testing time expires, a pop-up message will appear on-screen indicating the conclusion of your test session. Only response sheets that are scanned before you end your test or before time has expired will be scored. Any response sheet that is not scanned before testing ends will NOT be scored.
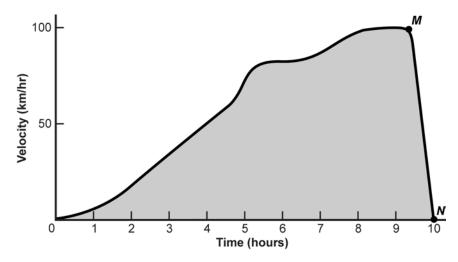
31. **Complete the exercise that follows.**

A chemist wants to engineer a chemical compound that has wet-adhesive properties comparable to the substance marine mussels use to attach themselves to rocks in intertidal zones.

Using your knowledge of the engineering design process:

• define the problem to be solved, specify the goals or criteria for the design, and identify any constraints on or limitations of the design;

• describe two types of data that would be useful in evaluating the performance of any prototype compounds; and

• explain how these data should be used to optimize the design of the chemical compound.

32. **Use the graph below to complete the exercise that follows.**

The velocity vs. time graph shown represents a trip made by a train heading north.

Using your knowledge of motion and graphs:

- explain the significance of the shaded area in the velocity vs. time graph;

- explain the significance of the slope of the velocity vs. time graph; and

- describe the acceleration between points *M* and *N* on the graph.

33. **Complete the exercise that follows.**

   A series of steps is required to complete the process of protein synthesis.

   Using your knowledge of structure and function and the transmission of genetic information and protein synthesis in eukaryotes:

   • describe the processes of transcription and translation in protein synthesis, including the roles of DNA, mRNA, and tRNA;

   • explain how the 20 amino acids found in proteins are formed by only four nucleotide bases; and

   • describe how the structure of tRNA is related to its function.

34. **Complete the exercise that follows.**

   Using your knowledge of the water cycle and cause-and-effect relationships:

   • draw and label a diagram of the water cycle that includes all the pathways of the cycle and the physical processes involved;

   • describe the transfer of energy between water and the environment as water evaporates and condenses; and

   • describe how sustained increases in global atmospheric temperatures are likely to affect the water cycle.

Annotated Responses to Sample Multiple-Choice Questions for CSET: Science Subtest I: General Science

1. **Correct Response: A.** (SMR Code: 1.1c) Transform faults are found where adjacent plates slide horizontally past each other. With this type of movement, there is no subduction of either plate and no new crust is created. Strong similarities in the mineral assemblages of the bedrock in the two regions would provide supporting evidence that the bedrock originally formed under the same conditions and very likely in the same location and at the same time. The bedrock was separated over time through the movement of the plates relative to one another along the fault.

2. **Correct Response: C.** (SMR Code: 1.1c) Each electron carries an electrical charge approximately equal to -1.60×10^{-19}. Robert Millikan discovered this experimentally by showing that the oil droplets had an electrical charge equal to some whole-number multiple of this number. After measuring the charge of thousands of oil droplets, he calculated the charge for a single electron by noting the smallest possible difference in charge found between the oil droplets.

3. **Correct Response: D.** (SMR Code: 1.1e) According to the graph, as the number of moles of reactants increases, the temperature change increases. Checking several data points reveals that doubling the number of moles of reactants leads to a twofold increase in the temperature change. For example, when the number of moles of reactants is 0.02, the change in temperature is 0.5°C; when the number of moles of reactants is doubled to 0.04, the change in temperature is 1.0°C.

4. **Correct Response: C.** (SMR Code: 1.1e) The Hertzsprung-Russell diagram plots the luminosity of stars as a function of their surface temperature. The luminosity increases upward on the vertical axis, while the temperature decreases left to right on the horizontal axis. The increased steepness of the graphed line above 10,000 Kelvin indicates that the change in luminosity per unit temperature increases at that point.

5. **Correct Response: D.** (SMR Code: 1.1e) A substance, whether solid or liquid, will float on another liquid substance if the density of the first substance is less than the density of the second. Only response choice D definitively meets this criterion. Density (d) is defined as the mass (m) per unit volume (V) of a material, shown by the formula $d = m/V$. The density of Substance 5 equals 0.9 g/cm^3, while the density of Substance 2 equals 1 g/cm^3. Therefore, Substance 5 will float in Substance 2.

6. **Correct Response: A.** (SMR Code: 1.1f) The unit factor method can be used to convert from grams to formula units. Grams can be converted to moles, and moles can be converted to formula units (or molecules). 2.00 grams of NaOH is converted to moles by dividing the mass by the formula weight of NaOH, which is 40.0 g/mole. This value is then multiplied by Avogadro's number (the number of particles, or formula units, of NaOH in 1 mole) in order to determine the number of formula units of NaOH used.

7. **Correct Response: B.** (SMR Code: 1.2a) An engineering constraint is a restriction placed upon a design. In this scenario, the physical conditions where the drilling equipment will be used will be the primary constraint, because the equipment must be designed so that it functions in the harsh, extreme cold conditions of Antarctica.

8. **Correct Response: C.** (SMR Code: 1.2c) As part of the engineering design process, it is important for the civil engineer to consider each possible solution in terms of the design requirements. In this case, small-scale models of potential structures can be created, tested, and evaluated. Once the best potential solution (model) is selected, a prototype can be developed so that the engineer can continue on the path of test and redesign needed to create the final product.

9. **Correct Response: B.** (SMR Code: 1.3a) As shown in the data table above, the acceleration of the ball is constant—the speed increases by 5.5 m/s for every consecutive second. The equation $s(t) = at + b$ describes how the speed of the ball changes linearly (the acceleration is constant) as a function of time and describes an object for which the initial speed (b) is a non-zero value.

10. **Correct Response: D.** (SMR Code: 1.3e) A photon is a particle of light, which provides the energy for photosynthesis. The absorption of photons by plant pigments represents the first step in converting light energy into chemical energy. As the energy is transferred to chlorophyll, electrons become excited and enter an electron transport chain, which powers the production of adenosine triphosphate (ATP).

11. **Correct Response: B.** (SMR Code: 3.2d) During the light-independent reactions, or Calvin cycle, carbon from CO_2 molecules is incorporated into organic molecules in a process called carbon fixation. The fixed carbon is reduced to carbohydrates through the addition of electrons. NADPH, which acquired electrons in the light reactions of photosynthesis, provides the electrons; and the chemical energy that drives the Calvin cycle is provided by ATP, which was also generated during the light reactions. The processes of the Calvin cycle do not require light directly, and thus are considered light independent, but they are dependent on products of the light-dependent reactions of photosynthesis.

12. **Correct Response: D.** (SMR Code: 2.1c) In this electron configuration, the 3 indicates electrons in the third electron shell; elements in the third row, or period, of the periodic table, have valence electrons in that shell. Since there are 2 valence electrons in the *s* orbital, and 5 in the *p* orbital, for a total of 7 valence electrons, this element is located in Group 17, where elements with 7 valence electrons are located.

13. **Correct Response: D.** (SMR Code: 2.2c) Increasing the temperature of a reaction will generally lead to an increase in reaction rate. For reactions to occur, the reactants must come in contact with each other at the proper orientation and with the required activation energy. As a system is heated, the particles in it begin to move faster, therefore increasing the likelihood that they will collide with other particles or molecules with enough energy to react.

14. **Correct Response: B.** (SMR Code: 2.3d) Pascal's law states that pressure applied to an enclosed fluid is transmitted equally throughout the liquid and container walls. Therefore, when 100 N of force is applied to piston X, the pressure of the enclosed water increases throughout the container and exerts a force on piston Y equal to the ratio of the areas of the two pistons. Since the area of piston Y is four times that of piston X, the upward force of piston Y is four times 100 N, or 400 N.

15. **Correct Response: B.** (SMR Code: 2.4d) Einstein's theory that light was composed of particles provided an explanation for characteristics of the photoelectric effect that other theories about light (e.g., the wave nature of light) could not explain. Specifically, the theory posits that light energy is contained in discrete quanta or units (photons), which transfer energy to individual electrons, causing them to be ejected from the metal.

16. **Correct Response: C.** (SMR Code: 2.4d) Thomas Young's experiment provided evidence of the wave-like nature of light. When a beam of light of a single color was directed through two slits, Young observed alternating light and dark bands where the light passing through the two slits recombined. Young interpreted these findings as an interference pattern characteristic of waves, in which two colliding wave crests enhance each other, while a crest and trough cancel each other out.

17. **Correct Response: A.** (SMR Code: 2.5g) Section B of the graph is longer than section A because more energy is required to vaporize the substance than to melt it. During a phase change, energy is used to rearrange molecules in a melting solid or to spread molecules apart in a vaporizing liquid. For this reason, the substance stays at a steady temperature until the phase change is complete, at which time the applied energy begins increasing the substance's temperature again.

18. **Correct Response: B.** (SMR Code: 2.6c) This device is a step-down transformer used to decrease voltage. Each output-side winding receives the same voltage, induced magnetically from the alternating current in the input windings. The voltages of the output windings simply add together: more windings give a proportionate increase in voltage, fewer windings give a proportionate decrease. Thus, if more input than output windings are present, the voltage will drop.

19. **Correct Response: C.** (SMR Code: 3.2d) Stomata permit plants to take up CO_2 and release O_2 during the day as they photosynthesize. Plants, however, also lose water through the stomata. At night, when photosynthesis stops and the plant does not need CO_2, the stomata close, preventing water loss.

20. **Correct Response: A.** (SMR Code: 3.3c) A biomass pyramid reflects the total weight of living matter at each trophic level, while a numbers pyramid reflects the total number of individual organisms at each trophic level. To have the situation shown for ecosystem 1, where the number of individual producers is smaller than the next higher trophic level yet the biomass is larger, the biomass of individual organisms must be large. This type of pattern might be found in a forest. In ecosystem 2, the large biomass of producers is the result of more, yet smaller, organisms. This would be typical of a grassland ecosystem.

21. **Correct Response: C.** (SMR Code: 3.4b) Watson and Crick predicted that DNA replicated by creating two daughter molecules, each having one new strand and one strand from the original DNA. According to this model, the two strands of the parental double helix separate, each becoming a template for building a new strand, resulting in two identical molecules of DNA. Later experimental evidence supported this method of replication, called the semiconservative model because each new DNA molecule conserves half of the parent molecule.

22. **Correct Response: B.** (SMR Code: 3.4g) Since none of the parents display the rare phenotype, yet three of the offspring do, it can be concluded that the rare phenotype is caused by a recessive allele. Also, since the rare phenotype occurs in offspring of both partners of the female parent, she is the likely carrier of the recessive allele. It cannot be definitively ruled out that the trait is transmitted autosomally; however, it is unlikely, since all three parents would have to be carriers of this rare phenotype. Also, since the trait appears only in male offspring, it is most likely sex-linked (i.e., the allele is on the X chromosome). Each male offspring receives either an $X^R Y$ or $X^r Y$ combination from his parents, with r representing the recessive allele. Since males have only one X chromosome, the rare phenotype would appear in all males inheriting the X^r chromosome from the mother.

23. **Correct Response: B.** (SMR Code: 3.5a) Research has shown that widely different organisms have strong similarities at the embryonic stage. For example, embryos of fish, reptiles, birds, and mammals all exhibit developing gills and tails at an early stage, and only later take their characteristic forms. This evidence supports the theory that these organisms evolved from common ancestral forms.

24. **Correct Response: C.** (SMR Code: 4.1e) Astronomers theorize that the solar system formed from a cloud of gas and dust that contracted under its own gravity and began to spin. Most of the cloud gravitated toward the center of this spinning disk, forming the sun. Smaller amounts of matter spun in separate eddies, creating nuclei around which evolving planetesimals formed.

25. **Correct Response: C.** (SMR Code: 4.1e) Although the Sun and Jupiter are both gaseous and composed largely of hydrogen and helium, the Sun is classified a star while Jupiter is a planet. A major difference between stars and planets is that stars have sufficient mass and heat to carry out nuclear fusion, and planets do not.

26. **Correct Response: B.** (SMR Code: 4.2b) In general, the stronger the wave action on a beach, the steeper the beach profile. From April through September 2014, the relatively small waves permitted the deposition of sand, which as the summer went on extended the beach further into the ocean. By March 2015, the large waves of winter storms had eroded the sand that had been deposited the previous summer, leaving a steep cross-sectional profile.

27. **Correct Response: A.** (SMR Code: 4.2c) Decay rates for many radioactive isotopes have been precisely measured and do not change under normal conditions on or near Earth's surface. A radioactive element in organic or inorganic material has decayed at the same rate since the material's formation. The date of the material can thus be calculated from the proportion of the original isotope to its stable end product currently found in the material.

28. **Correct Response: A.** (SMR Code: 4.3a) Oceanic crust tends to consist of dense basalt, while continental crust consists of less dense rocks, such as granite. When oceanic and continental crusts converge, subduction occurs as the denser oceanic crust moves below the continental crust. During this process, sediment from the submerging oceanic plate may be scraped off and added, or accreted, to the continental landmass. Volcanism can also occur at the subduction zones, and the lava recycles minerals and molten rock from the mantle. The materials in the lava may separate based on differences in density.

29. **Correct Response: D.** (SMR Code: 4.5a) Fossil fuels take millions of years to form from organic material deposited in low-oxygen aquatic environments, such as swamps and certain marine settings. The lack of oxygen inhibits decomposition by microorganisms, and sediments cover the remains and partially preserve them. As the organic material is buried deeper, the increasing pressure causes chemical reactions to take place, transforming the material into carbon-rich coal, natural gas, and oil.

30. **Correct Response: D.** (SMR Code: 4.5d) Unconfined sand-and-gravel aquifers are very permeable, permitting easy movement of water from the surface into the aquifer. When the amount of groundwater drawn from such an aquifer exceeds its recharge rate, the water table surrounding the well will drop to form a conical depression with the lowest point being at the well's uptake. Since streams, lakes, and wetlands overlying an unconfined aquifer are surface expressions of the elevation of the aquifer, the elevation of the water in these water bodies will also drop as they drain downward in response to the drop in elevation of the water table.

Examples of Strong Responses to Sample Constructed-Response Questions for CSET: Science Subtest I: General Science

Question #31 (Score Point 3 Response)

The problem the chemist is trying to solve: the creation of an incredibly strong adhesive resistant to failure in moist environments. The criteria for the design will include:

1. minimizing the amount of alteration or preparation the surface to which the adhesive will be applied requires before application.
2. optimizing the curing conditions so that the adhesive will set/finish hardening quickly under any circumstances.
3. ensuring that the adhesive is flexible enough to allow cushioning of violent impact and absorption of pressure, allowing it to resist sheering from stress.
4. resisting reactivity to organic or inorganic solvents so that the adhesive will withstand weathering and the addition of any corrosive or normally reactive materials.
5. Toxicity must also be considered.

Therefore, constraints/limitations on the design include:

1. a compound that does not harden into something completely rigid and stiff, requiring the adhesive to maintain some fluidity or rubbery qualities
2. a compound that doesn't require much preparation of the surface is more likely to be highly reactive to that surface, and most compounds that are highly reactive tend to be toxic.

Two types of data that would be useful in evaluating the performance of any prototype compounds:

1. Chemical composition of the adhesive including but not limited to both the active adhering components and any/all additional vehicles or additives necessary to ensure the function of the adhesive.
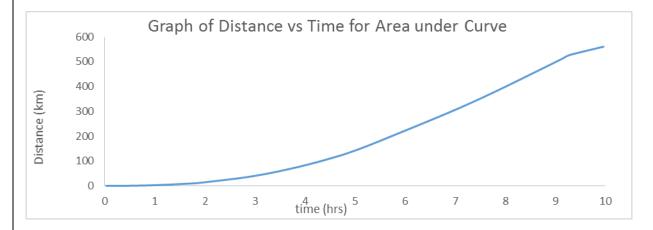2. Tensile strength and flexibility of the dried adhesive.

Question #31 (Score Point 3 Response) (continued)

These data should be used to optimize the design of the chemical compound:

1. By allowing prediction of reactivity of the adhesive based upon the molecular structures of all of the ingredients. Knowledge of chemical composition allows a knowledge of chemical reactions to predict how the adhesive would react to any solvents, as well as how it would hold up to environmental changes such as weathering.

2. Allowing toxicology to be determined based upon the nature of all of the included ingredients. A lot of toxicology data has been gathered over the years, and therefore can be directly applied to a list of ingredients.

3. Evaluating the potential for the adhesive to resist stress from the surrounding environment. Knowing both the tensile strength and the stiffness/flexibility of the adhesive would allow a direct prediction of how it would respond to various stresses placed upon it.
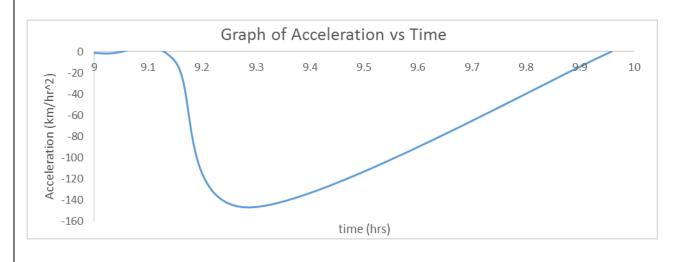
Question #32 (Score Point 3 Response)

Due to the fact that $velocity = \frac{distance}{time}$, and the area under the curve is calculated by $velocity \times time$, this means that the area under the graph is distance. The graph of the area under the curve vs time would look like:

Graph of Distance vs Time for Area under Curve

The total area under the curve of velocity vs time becomes the total distance covered by the train.

The $Slope = \frac{rise}{run} = \frac{\Delta v}{\Delta t}$. The definition of $\frac{\Delta v}{\Delta t}$ is acceleration. Therefore, the slope of the graph of velocity vs time is the acceleration.

The acceleration between points M (t = 9hr) and N (t = 10hr) is primarily a negative acceleration (also known as deacceleration). This graph would look like:

Graph of Acceleration vs Time

Question #33 (Score Point 3 Response)

Transcription occurs within the nucleus. During transcription, double helical DNA is unwound at the site of the promoter for the gene of interest, and transcription factors recruit an RNA polymerase. As the RNA polymerase proceeds along the template strand of the DNA, a messenger RNA molecule (mRNA) is assembled by complementary base pairing between RNA nucleotides with the DNA template sequence. As the RNA polymerase travels down the DNA molecule, the DNA rewinds. Upon completion of transcription and any post-transcription processing, the mRNA travels to the cytoplasm.

Translation initiates when the mRNA binds to the ribosome. The ribosome attaches to the 5' end of the mRNA and begins to translate the mRNA sequence to a protein through complementary base pairing between the codon (3 bases on the mRNA) to the anticodon (3 bases on the tRNA). The polymerization of the protein occurs through the formation of peptide bonds between each amino acid as the ribosome traverses down the mRNA and each successive tRNA enters the ribosome to translate nucleotide codons into amino acids. When the ribosome reaches the termination codon on the mRNA, translation ends and the peptide is released from the ribosome.

Triplet nucleotide codons translate to amino acids. Since there are four types of nucleotides that can be arranged in combinations of three, there are $4^3 = 64$ possible different codons. Each codon codes for a specific amino acid, and as there are only 20 amino acids – there may be more than one codon that codes for an amino acid, while each codon itself can only specify one amino acid.

The function of the tRNA is to translate the language of nucleotides into the language of amino acids and ensure that when peptide bonds form, the sequence of amino acids corresponds to the blueprint provided by the mRNA. The structure of tRNA is such that one end of the molecule contains the high-energy bond attachment to the specified amino acid, while the other end contains the anticodon. The anticodon is a sequence of 3 nucleotides that will hydrogen-bond with the specific 3-nucleotide codon on the mRNA that codes for the amino acid produced (1 of 20 possible). Due to the presence of the high-energy bond to the amino acid at the other end of the tRNA – when the codon and anticodon recognize one another within the ribosome, the ribosome catalyzes the formation of a peptide bond between amino acids, driving the polymerization of the peptide.

Question #34 (Score Point 3 Response)

Hydrologic Cycle

condensation

cloud

cloud

solar energy

transpiration

precipitation

evaporation

land

river

groundwater

ocean

Water absorbs and stores heat energy from the sun as it is evaporates, through the energy of phase transition (i.e. the latent heat of evaporation). As water vapor (atmospheric moisture) is transported around the globe, this transports stored energy in the water vapor. The energy is released when the water vapor condenses into precipitation (i.e. latent heat of condensation), thus warming the surrounding atmosphere.

Sustained increases in global atmospheric temperatures are likely to increase the carrying capacity of atmospheric humidity, and thus increase the potential of the atmosphere to transport larger volumes of stored energy in the form of more intense storms. These large storm systems transport large volumes of atmospheric water vapor, and thus greater atmospheric heat that is released via precipitation, to higher latitudes. This creates feedback loops in higher latitudes, which are warmed via the advection of heat (i.e. atmospheric water vapor and eventual precipitation) from evaporative centers. In this manner, heat energy is redistributed around the globe and over continental land masses. The water cycle is directly affected via increased volumes of evaporation, atmospheric water transport, and larger volumes of precipitation.

Scoring Information for CSET: Science Subtest I: General Science

Responses to the multiple-choice questions are scored electronically. Scores are based on the number of questions answered correctly. There is no penalty for guessing.

There are four constructed-response questions in Subtest I of CSET: Science. Each of these constructed-response questions is designed so that a response can be completed within a short amount of time—approximately 10–15 minutes. Responses to constructed-response questions are scored by qualified California educators using focused holistic scoring. Scorers will judge the overall effectiveness of your responses while focusing on the performance characteristics that have been identified as important for this subtest (see below). Each response will be assigned a score based on an approved scoring scale (see page 39).

Your performance on the subtest will be evaluated against a standard determined by the Commission on Teacher Credentialing based on professional judgments and recommendations of California educators.

Performance Characteristics for CSET: Science Subtest I: General Science

The following performance characteristics will guide the scoring of responses to the constructed-response questions on CSET: Science Subtest I: General Science.

PURPOSE	The extent to which the response addresses the constructed-response assignment's charge in relation to relevant CSET subject matter requirements.
SUBJECT MATTER KNOWLEDGE	The application of accurate subject matter knowledge as described in the relevant CSET subject matter requirements.
SUPPORT	The appropriateness and quality of the supporting evidence in relation to relevant CSET subject matter requirements.

Scoring Scale for CSET: Science Subtest I: General Science

Scores will be assigned to each response to the constructed-response questions on CSET: Science Subtest I: General Science according to the following scoring scale.

SCORE POINT	SCORE POINT DESCRIPTION
3	**The "3" response reflects a command of the relevant knowledge and skills as defined in the subject matter requirements for CSET: Science.** • The purpose of the assignment is fully achieved. • There is an accurate application of relevant subject matter knowledge. • There is appropriate and specific relevant supporting evidence.
2	**The "2" response reflects a general command of the relevant knowledge and skills as defined in the subject matter requirements for CSET: Science.** • The purpose of the assignment is largely achieved. • There is a largely accurate application of relevant subject matter knowledge. • There is acceptable relevant supporting evidence.
1	**The "1" response reflects a limited or no command of the relevant knowledge and skills as defined in subject matter requirements for CSET: Science.** • The purpose of the assignment is only partially or not achieved. • There is limited or no application of relevant subject matter knowledge. • There is little or no relevant supporting evidence.
U	**The "U" (Unscorable) is assigned to a response that is unrelated to the assignment, illegible, primarily in a language other than English, or does not contain a sufficient amount of original work to score.**
B	**The "B" (Blank) is assigned to a response that is blank.**