California Subject Examinations for Teachers®

TEST GUIDE

SCIENCE SUBTEST II: CHEMISTRY

Sample Questions and Responses and Scoring Information

CS-TG-QR218X-01

Sample Test Questions for CSET: Science Subtest II: Chemistry

Below is a set of multiple-choice questions and constructed-response questions that are similar to the questions you will see on CSET: Science Subtest II: Chemistry. 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)

Lanthanide Series	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
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. The bright-line spectrum of the hydrogen atom is not continuous because electron transitions:

   A. involve discrete amounts of energy.

   B. always involve electron pairs.

   C. are forbidden by the quantum model.

   D. involve random amounts of energy.

2. Which of the following statements about the properties of elements in the periodic table is generally true?

   A. Elements in the same period of the periodic table have the same atomic radius because they have the same number of orbitals in their electron configuration.

   B. Elements in Group 1 (1A) and Group 3 (3B) have similar chemical properties because they have the same number of valence electrons.

   C. Moving down the periodic table, the ionization energies of the elements within a group increase as the number of orbitals in their electron configurations increases.

   D. Elements in the same group of the periodic table have similar chemical properties because they have the same number of valence electrons.

3. A sample of N_2 occupies a volume of 2.50 L at –120°C. To which of the following approximate temperatures should the gas be heated in order to double the volume of the gas without changing its pressure?

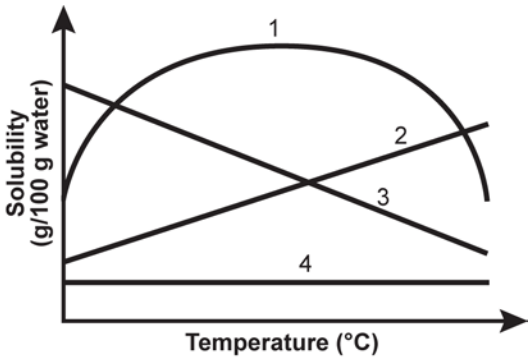
   A. –240°C

   B. –60°C

   C. 33°C

   D. 306°C

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



Which of the lines in the graph above represents the general relationship between solubility and solution temperature for most soluble solids dissolved in water?

A. line 1

B. line 2

C. line 3

D. line 4

5. Thyroid cancer can be treated by giving the patient radioactive iodine-131. Iodine-131 accumulates exclusively in the thyroid gland, thus exposing the cancerous cells to the radiation. If a patient is given a 1.0 g dose of iodine-131 and 0.0625 g remains after 32 days, what is the half-life of iodine-131?

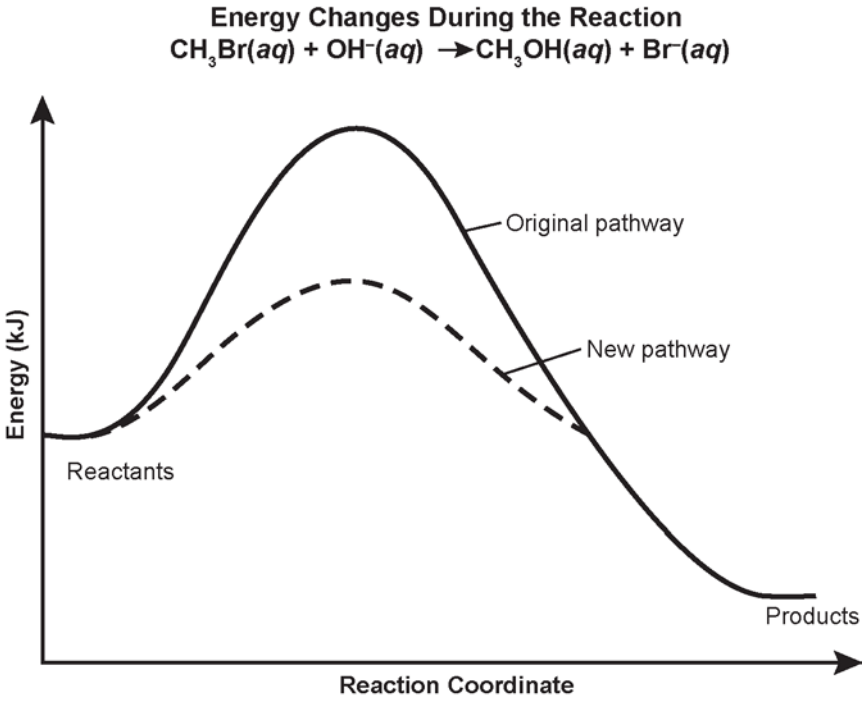
A. 2 days

B. 8 days

C. 17 days

D. 30 days

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



The graph above shows the energy profile for the given reaction. Which of the following actions will result in the new pathway illustrated on the graph?

A. adding a catalyst

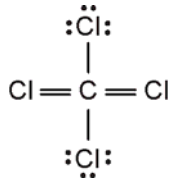
B. adding Br^-

C. adding OH^-

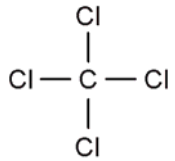
D. increasing the temperature

7. Which of the following is the correct Lewis electron dot structure for CCl_4?

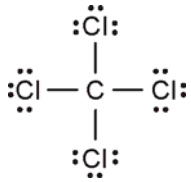
A.



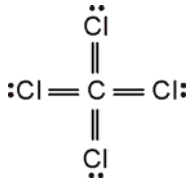
B.



C.



D.



8. According to the valence shell electron pair repulsion (VSEPR) model, what is the molecular geometry of NH_3?

A. tetrahedral

B. square planar

C. T-shaped

D. trigonal pyramidal

9. **Use the chemical equation below to answer the question that follows.**

$CO(g) + 2H_2(g) \longrightarrow CH_3OH(\ell)$

A chemist reacts 35.0 g of CO with 4.04 g of H_2 to produce CH_3OH according to the reaction shown. Assuming that the reaction goes to completion, what mass of CH_3OH can be produced?

A. 32.1 g

B. 35.0 g

C. 40.1 g

D. 64.7 g

10. **Use the chemical equation below to answer the question that follows.**

$Zn(s) + 2HCl(aq) \longrightarrow ZnCl_2(aq) + H_2(g)$

When zinc metal reacts with hydrochloric acid, hydrogen is released according to the equation above. If 54.0 g of Zn reacts with excess HCl, what is the volume of H_2 gas that is formed at STP?

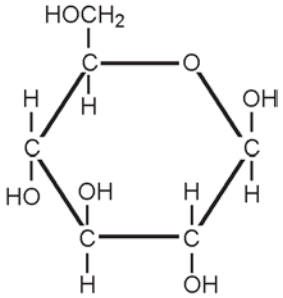
A. 11.9 L

B. 18.5 L

C. 22.4 L

D. 23.9 L

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



The structural formula shown above is the monomer for which of the following types of molecules?

A. polysaccharide

B. polypeptide

C. phospholipid

D. nucleotide polymer

12. A solid aluminum ingot with a mass of 4110 g cools from 660.0°C to 25.0°C. During the process, 2.36×10^6 J of heat are released. What is the specific heat of the aluminum?

A. 0.838 J/(g•°C)

B. 0.870 J/(g•°C)

C. 0.904 J/(g•°C)

D. 23.0 J/(g•°C)

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

Specific heat of water = 4.184 J/(g•°C)
Specific heat of steam = 2.02 J/(g•°C)
ΔH_{fus} = 334 J/g
$\Delta H_{vap} = 2.26 \times 10^3$ J/g

A 25.0 g sample of water is heated from 52.0°C to steam at 140.0°C. How much heat is needed to complete this process?

A. 4.44×10^3 J

B. 6.35×10^4 J

C. 6.57×10^4 J

D. 7.49×10^4 J

14. A complex of large steam-driven geothermal power plants called The Geysers is located in the Mayacamas Mountains north of San Francisco. These power plants use pressurized steam captured from underground wells to generate electricity. Which of the following is the primary source of energy used to produce the underground steam?

    A. decay of radioactive substances in the core of the earth

    B. friction from the movement of tectonic plates

    C. pressure from the mass of overhead rock

    D. combustion of nearby underground pockets of methane gas

15. During glycolysis and the citric acid cycle, molecules of nicotinamide adenine dinucleotide (NAD^+) and flavin adenine dinucleotide (FAD^+) are reduced to NADH and $FADH_2$. These molecules play a major role in the production of adenosine triphosphate (ATP) in cells. Which of the following best describes the role of NADH and $FADH_2$ in producing ATP?

    A. phosphorylating adenosine diphosphate (ADP) into ATP

    B. hydrolyzing water into oxygen and hydrogen

    C. converting glucose into pyruvate

    D. donating electrons to the electron transport chain complex

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.

16. **Complete the exercise that follows.**

Both covalent and hydrogen bonds are responsible for important properties of water.

Using your knowledge of these two types of chemical bonds and the properties of water (H_2O):

- compare the covalent bonds and the hydrogen bonds found in a sample of liquid water; and
- explain how hydrogen bonding influences two characteristic properties of water.

17. **Complete the exercise that follows.**

Alkanes and alkenes are two types of organic compounds having similar physical properties.

Using your knowledge of organic chemistry:

- describe the chemical structure of each type of molecule and explain how the structure relates to chemical reactivity;
- identify the type of reaction that occurs and the type of compound produced in a reaction between an alkene and Br_2; and
- draw a mechanism that shows the reaction between an alkene and Br_2.

18. **Complete the exercise that follows.**

Landfill gas, which is primarily methane, is produced when bacteria decompose landfill waste. This renewable source of gas can be captured, treated, and used as an energy source to produce electricity. In one method of producing electricity, outside air and landfill gas combust to produce heated gases. These heated gases pass through a turbine, which spins a generator that produces electricity.

Using your knowledge of energy transfer and the influence of science and engineering on society:

- describe two energy transfers that take place in the combustion turbine system;
- explain at the molecular level why gases expand when heated; and
- describe one benefit to society from the production of electricity from landfill gas.

Annotated Responses to Sample Multiple-Choice Questions for CSET: Science Subtest II: Chemistry

1. **Correct Response: A.** (SMR Code: 1.1a) Electron transitions from one orbit to another result in specific amounts of energy being released or absorbed. These quanta of energy appear as characteristic lines on the spectrum for each element. Since the released or absorbed energy is not continuous over a range of values, the bright-line spectrum also is not continuous.

2. **Correct Response: D.** (SMR Code: 1.1d) Valence electrons occupy the outermost energy level of an atom and are primarily responsible for determining an element's chemical properties. Elements with the same number of valence electrons belong to the same group, or column, of the periodic table. For example, the elements in Group 1 (IA) have one valence electron and are highly reactive, whereas the elements in Group 18 (VIIIA) have eight valence electrons that fill the outermost level, making these elements chemically unreactive.

3. **Correct Response: C.** (SMR Code: 1.2c) According to Charles's law, the volume of a fixed amount of gas at a constant pressure is directly proportional to the gas's absolute temperature. Therefore, doubling the absolute temperature of the sample of N_2 gas will double its volume. The gas's starting absolute temperature is –120°C + 273 = 153 K. Doubling the absolute temperature gives 306 K, or 33°C.

4. **Correct Response: B.** (SMR Code: 1.3b) The solubility of many solids in water increases as the temperature increases, as represented by line 2 on the graph. As the temperature of the solution increases, there is more energy available to overcome ionic or intermolecular forces in the solid.

5. **Correct Response: B.** (SMR Code: 1.4d) The half-life of a radioactive isotope is the time it takes for half of a sample of the isotope to decay. In this example, since 0.0625 g is one-sixteenth of the original 1.0 g of iodine-131, the iodine must have undergone four half-lives during the 32 days, since $\frac{1}{16} = \frac{1}{2} \times \frac{1}{2} \times \frac{1}{2} \times \frac{1}{2}$. Therefore, the half-life of iodine-131 is 32 ÷ 4 = 8 days.

6. **Correct Response: A.** (SMR Code: 2.1b) Adding a catalyst will result in the new pathway indicated on the graph. Catalysts increase the rate of reaction, almost always by lowering the amount of activation energy needed to initiate the reaction. The catalyzed reaction will follow a path requiring less energy than if the catalyst had not been present.

7. **Correct Response: C.** (SMR Code: 2.2b) Lewis electron dot structures are used to represent and track the valence electrons of atoms. Each valence electron of an atom is represented as a single dot. Atoms have a tendency to lose, gain, or share electrons so they end up with eight valence electrons. In this example, before bonding, each Cl atom has seven valence electrons and the C atom has four valence electrons. To complete a valence shell of eight electrons for each atom, the single unpaired electron from each Cl atom and one of the four valence electrons from C create a single bond, represented by a single line connecting them. The remaining three pairs of nonbonding electrons surround each Cl atom and are represented as dots.

8. **Correct Response: D.** (SMR Code: 2.2c) The VSEPR model predicts the molecular geometry of a molecule. It is based on the number of electron pairs surrounding the molecule's central atom, which can be determined from the molecule's Lewis structure. In the molecule NH_3, the central N atom shares three pairs of electrons in bonds with the H atoms and has a nonbonding pair of electrons. To minimize repulsions among the electron domains, each H atom and the free electron pair will occupy space furthest from every neighbor. Since molecular geometry considers only the arrangement of the atoms and not the electron domains, the molecular geometry for NH_3 will be trigonal pyramidal.

9. **Correct Response: A.** (SMR Code: 2.3b) The mass of CH_3OH that will be produced upon the reaction's completion is calculated by determining which is the limiting reactant. The moles of each reactant must first be calculated. The amount of CO the reaction begins with is 35.0 g ÷ 28.0 g/mol = 1.2 mol, while the amount of H_2 the reaction begins with is 4.04 g ÷ 2.02 g/mol = 2.0 mol. From the equation, 1 mole of CO is needed for every 2 moles of H_2. Therefore, H_2 is the limiting reactant. To calculate the mass of CH_3OH, use the molecular weights of H_2 and CH_3OH to perform a unit conversion. Solving for the mass gives:

$$4.04 \text{ g } H_2 \bullet \frac{1.0 \text{ mol } H_2}{2.02 \text{ g } H_2} \bullet \frac{1.0 \text{ mol } CH_3OH}{2.0 \text{ mol } H_2} \bullet \frac{32.1 \text{ g } CH_3OH}{1.0 \text{ mol } CH_3OH} = 32.1 \text{ g } CH_3OH.$$

10. **Correct Response: B.** (SMR Code: 2.3b) The number of moles of zinc reacted is calculated by dividing the molar mass of zinc into the mass used, 54.0 g ÷ 65.4 g/mol = 0.826 moles. Since the coefficients for Zn and H_2 in the balanced reaction are both 1, 0.826 moles of H_2 gas must be formed. The ideal gas equation can be used to determine the volume of H_2 at STP. Solving for volume gives $V = \frac{nRT}{P}$. The known values can be inserted into the equation, giving $V = \frac{(0.826 \text{ mol})(0.08206 \text{ L•atm/K•mol})(273 \text{ K})}{1 \text{ atm}} =$ 18.5 L.

11. **Correct Response: A.** (SMR Code: 2.4e) The structural formula represents a glucose monomer. When many of these monomers chemically join together, they form a polysaccharide, such as cellulose or glycogen.

12. **Correct Response: C.** (SMR Code: 3.1c) The heat transfer relationship is given by the equation $q = mc\Delta T$, where q = heat transfer, m = mass, c = specific heat, and ΔT = change in temperature. Inserting the known quantities and solving gives 2.36×10^6 J = (4110 g)(c)(635°C), or c = 0.904 J/(g•°C).

13. **Correct Response: B.** (SMR Code: 3.1c) The heating process can be divided into three distinct segments.

    1) heating the liquid water from 52°C to 100°C
       using the equation $q = mc\Delta T$
       q = (25.0 g)(4.184 J/(g•°C))(48°C) = 5.02×10^3 J
    2) the phase change from liquid to vapor at 100°C
       using the equation phase change energy = $m\Delta H_{vap}$
       phase change energy = (25.0 g)(2.26×10^3 J/g) = 5.65×10^4 J
    3) heating the steam from 100°C to 140°C
       using the equation $q = mc\Delta T$
       q = (25.0 g)(2.02 J/(g•°C))(40°C) = 2.02×10^3 J

    The total energy for this heating process is the sum of the energy for all the segments.
    (5.02×10^3 J) + (5.65×10^4 J) + (2.02×10^3 J) = 6.35×10^4 J

14. **Correct Response: A.** (SMR Code: 3.2b) Geothermal energy takes advantage of heat continuously produced deep in the earth through the decay of naturally radioactive materials. This heat is brought up to the crust through convective currents, where it interacts with groundwater to produce pressurized steam.

15. **Correct Response: D.** (SMR Code: 3.2d) NADH and $FADH_2$ are energy-storing molecules that trap electrons in bonds with hydrogen. These electrons are then released into the enzymatic reactions of the electron transport chain. Some of these enzymatic reactions are responsible for the production of ATP.

Examples of Strong Responses to Sample Constructed-Response Questions for CSET: Science Subtest II: Chemistry

Question #16 (Score Point 3 Response)

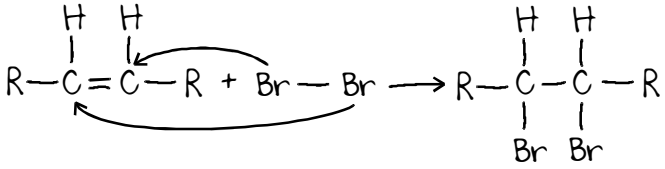
Covalent bonds between hydrogen and oxygen in a water molecule involve a sharing of a pair of electrons. This type of bond is much stronger than the hydrogen bonds between hydrogen and oxygen in separate molecules. The hydrogen bond occurs because of the high polarity of each water molecule, with the negative dipole of the oxygen being attracted to the positive dipole of a hydrogen atom on a nearby water molecule.

Several properties of water are influenced by hydrogen bonding. Water is liquid at room temperature, not a gas like many compounds of similar molecular weight and polarity, because of the strong hydrogen bonding between molecules. Also, it has a fairly high heat of vaporization because of the additional energy needed to overcome the hydrogen bonds.

Question #17 (Score Point 3 Response)

Alkanes are hydrocarbons in which the carbon atoms form only single covalent bonds to the other carbon atoms in the chain, and to the hydrogen atoms (or halogens) attached. Alkenes, on the other hand, are unsaturated with one or more double bonds between carbon atoms. This causes more reactivity than the single-bonded alkanes.

The double bond of alkenes reacts by addition. For example, bromine reacts with an alkene to form an alkyl bromide. This halogenation occurs when the double bond is broken to form single bonds with bromine atoms:



Question #18 (Score Point 3 Response)

In a combustion turbine system, the burning of natural gas releases the potential energy within natural gas molecules and transfers that potential energy from the bonds of the natural gas into thermal/kinetic energy of the air within the chamber. As the air expands, it presses on the turbine and causes it to spin. The pressure of the gas on the turbine and spinning of that turbine translates the thermal/kinetic energy of the gas into work energy of the spinning turbine.

At the molecular level, when gases are heated this causes the addition of thermal energy to a gas (or compound in general). This causes the individual molecules to move faster and collide more frequently. As they collide more frequently, they push each other further apart, resulting in the macroscopic expansion of the gas.

Landfills are a pervasive method of solid waste disposal. Once the land has been allocated for waste storage, it is unlikely to have any other safe purposes. The natural processes of decay that occur within landfills provide a large quantity of natural gas that is readily available in a known and established shape. Utilizing landfills for natural gas and turning otherwise unusable land for energy production permits land to be reallocated for energy production and conserve other property for nontoxic uses.

Scoring Information for CSET: Science Subtest II: Chemistry

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 three constructed-response questions in Subtest II: Chemistry 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 20).

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 II: Chemistry

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

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 II: Chemistry

Scores will be assigned to each response to the constructed-response questions on CSET: Science Subtest II: Chemistry 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.**