

PHYSICAL SCIENCE:
CHEMISTRY

REGENTS REVIEW
PRACTICE TESTS

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Based on N.Y.S.
Next Generation Learning Standards

WITH ANSWERS AND EXPLANATIONS

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PHYSICAL SCIENCE: CHEMISTRY
Regents Review
Practice Test Book

Answers, Explanations, and Practice Tests Written By:
Jamie Kubiak- Chemistry Teacher

About This Practice Test Book:
The goal of this Practice Test Book is to provide students with an opportunity to practice the new Regents Chemistry curriculum with the June 2026 and August 2026 Chemistry Regents Examinations and two original Practice Tests modeled off these tests.

Each test is accompanied by an answer key as well as explanations of the answers to help guide your review. Use these published exams as well as the two original practice tests to test your grasp of the chemistry concepts in the curriculum. This Practice Test Book is best accompanied by the separate Physical Science: Chemistry Workbook to supplement the foundation required to answer these test questions.

The goal is to meet the performance expectations of Physical Science: Chemistry, where students must be able to: ask questions and define problems, develop and use models, plan and carry out investigations, analyze and interpret data, use mathematical and computational thinking, construct explanations and design solutions, engage in argument from evidence, and obtain, evaluate, and communicate information. The new Chemistry Regents Examination is modeled off these Science and Engineering Practices, requiring students to have a deeper understanding of chemistry to communicate ideas like scientists.

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As the author of these answer keys and practice tests, I know that chemistry is not a passive subject one passively absorbs; instead, chemistry is something you do! I hope this book is a beneficial and worthwhile addition to your studies. No artificial intelligence was used in the creation of this Practice Test Book.

About The Author:
Jamie Kubiak has been teaching in New York City Public Schools since September 2014, where he has taught Regents and non-Regents Chemistry, Living Environment, Science Research, and most recently AP Chemistry. Jamie is a Math for America (M*f*A) Master Teacher II in his second four-year Master Teacher Fellowship, preceded by a four-year Early Career Teaching Fellowship. Currently, Jamie teaches AP Chemistry at The Bronx High School of Science, where he's taught since 2021. Jamie has a love of chemistry, teaching, and making learning accessible and fun for his students.

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Test 1

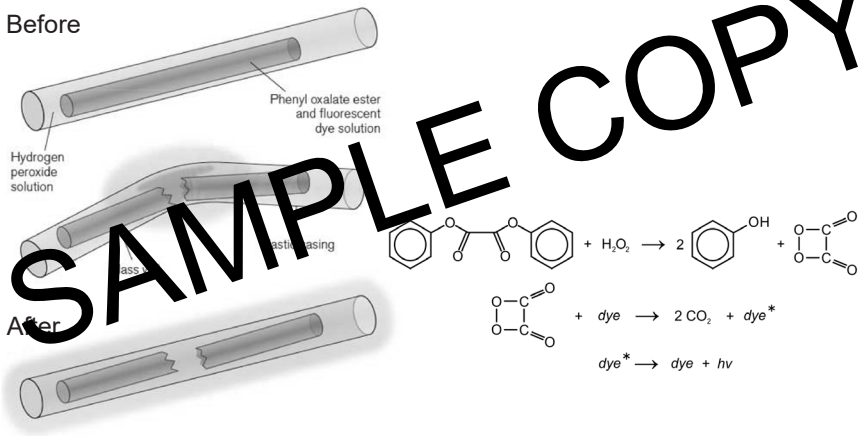
Answer all questions in this part.

***Directions*: Use your knowledge of chemistry to answer all questions in this examination. Throughout this exam, some questions may require the use of the *2025 Edition Reference Tables for Physical Science: Chemistry.* This is provided in the back of this test book.**

Base your answers to questions 1 through 4 on the information below and on your knowledge of chemistry.

Glowstick Reactions

The light from a glowstick comes from a chemical reaction in a process known as chemiluminescence. Typical glowsticks keep the reactants separate with a thin-walled glass vial filled with hydrogen peroxide (H_2O_2). When the glowstick is snapped, the reaction between an oxalate ester and fluorescent dye solution with the hydrogen peroxide begins. A high-energy intermediate reacts with the fluorescent dye, moving to an excited state. The intermediate is a strong electron acceptor, stealing an electron from the dye, producing CO_2 and a radical anion with an unpaired electron. The fluorescent dye captures the unpaired electron and gains energy, moving into an excited state* before relaxing back down to the ground state, producing the characteristic fluorescent glow (*hv*).



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1. Which statement supports the claim that glowsticks glow after the glass vial is broken?
(1) Fluorescent light is produced through the reaction as dye molecules enter the excited state, releasing light energy.
(2) Fluorescent light is produced through the reaction as dye molecules return to the ground state, releasing light energy.
(3) Fluorescent light is absorbed through the reaction as dye molecules enter the excited state, releasing light energy.
(4) Fluorescent light is absorbed through the reaction as dye molecules return to the ground state, releasing light energy. 1 ____

2. Using collision theory, explain why the reaction requires the glowstick to be snapped to occur.

_____

_____

_____

Figure 1 provides information about different glowstick production chemicals.

Figure 1: Information on Glowstick Chemicals

Chemical	Cost	Effects	Glow Time
Oxalate esters	Low	Produces carcinogenic trichlorophenols	30 seconds
Trichloro salicylate oxalate esters (TCSOE)	Medium	Skin and eye irritation if exposed	6 – 12 hours
Butyl benzoate/triethyl citrate	Low	Moderate local irritation, harmful if swallowed	3 – 12 hours
Phthalates	Low	Endocrine disruptors, reproductive toxicity	8 – 24 hours

3. Which statement identifies criteria that supports using trichloro salicylate oxalate esters TCSOE instead of phthalates in the production of glowsticks?
(1) Phthalates are cheaper to use than TCSOE and glow for longer.
(2) TCSOE are cheaper to use than phthalate and glow for longer.
(3) Phthalates are safer than TCSOE and glow for longer.
(4) TCSOE are safer than phthalates and glow for a moderately long time.

3 ____

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4. A chemist wants to extend the glow time of a typical glowstick without opening it. Propose a change in the reaction conditions, other than the use of a different chemical from Figure 1, that could accomplish this goal and explain the effect on the reaction rate.

Proposed change: _____

_____

Effect on reaction rate: _____

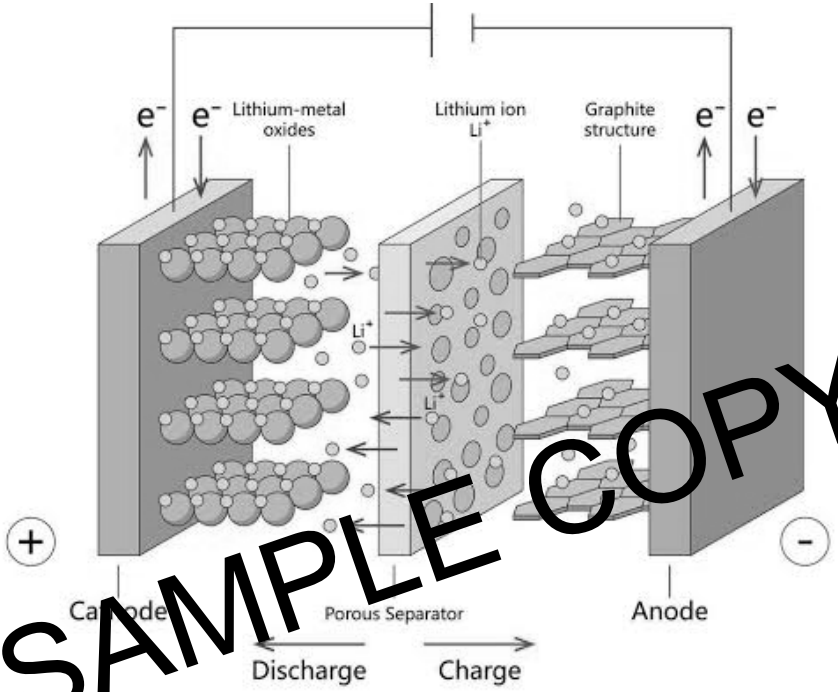
_____

Base your answers to questions 5 through 9 on the information below and on your knowledge of chemistry.

Lithium-Ion Batteries and Alternatives

Lithium has become popular for its use in battery powered devices. Lithium-ion batteries have advantageous size and weight, helping to power everything from mobile phones to laptops to electric vehicles. Figure 1 shows a model of the charging and discharging process within a lithium-ion battery.

Figure 1: Lithium-Ion Battery Charge and Discharge



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Equations 1 and 2 represent the half-reactions occurring during the discharge, which is the draining or use of the battery.

Equation 1: $CoO_2 + Li^+ + e^- \rightarrow LiCoO_2$

Equation 2: $LiC_6 \rightarrow C_6 + Li^+ + e^-$

5. Write a balanced overall reaction to provide evidence that the discharge process moves lithium from the graphite anode to the cobalt oxide cathode.

Reaction: _____

_____

_____

6. Which row provides evidence to support the claim that the discharging process involves a transfer of electrons as an energy conversion occurs within the system?

Row	Half-Reaction at Anode	Half-Reaction at Cathode	Energy Conversion
(1)	$LiC_6 \rightarrow C_6 + Li^+ + e^-$	$CoO_2 + Li^+ + e^- \rightarrow LiCoO_2$	electrical to chemical
(2)	$LiC_6 \rightarrow C_6 + Li^+ + e^-$	$CoO_2 + Li^+ + e^- \rightarrow LiCoO_2$	chemical to electrical
(3)	$CoO_2 + Li^+ + e^- \rightarrow LiCoO_2$	$LiC_6 \rightarrow C_6 + Li^+ + e^-$	electrical to chemical
(4)	$CoO_2 + Li^+ + e^- \rightarrow LiCoO_2$	$LiC_6 \rightarrow C_6 + Li^+ + e^-$	chemical to electrical

6 ____

Some alternatives to lithium-ion batteries are emerging as concerns about their sustainability have arisen. Figure 2 outlines some of the properties of these alternative batteries.

Figure 2: Comparison of Lithium-Ion Battery Alternatives

Type	Lifespan (charges)	Cost ($/kWh)	Safety	Uses	Environmental Impact
Lithium-ion	2,000 – 5,000	$55 – $90	Good stability, but internal heat generation can exceed dissipation, causing explosion	Consumer electronics, portable power, long-range electric vehicles	Resource extraction requires large amounts of water, degrades local ecosystems, lithium is scarce. Vehicles with these batteries emit fewer greenhouse gases
Sodium-ion	10,000	$1[illegible] $[illegible]	Superior thermal stability, retains 90-94% capacity at below -20 °C	Short-range electric vehicles, stationary grid storage	Easily derived from table salt, extraction requires minimal water
Solid-state	10,000 +	$300 – $600	Replaces flammable liquid electrolytes	Luxury and long-range electric vehicles	High manufacturing complexity and scaling challenges, but low carbon footprint
Flow	5,000 – 10,000	$350 – $800	Non-flammable water-based electrolyte; some leak risk	Large-scale utility grids	Lower toxicity of metals used

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7. Use the patterns of outermost electrons to describe how sodium could substitute for the lithium in lithium-ion batteries.

Base your answers to questions 42 through 45 on the information below and on your knowledge of chemistry.

Cold Pack Chemistry

If someone injures themselves in a sporting event, they're often given ice or an instant cold pack to put on the acute injury to stop swelling and lessen pain. A common cold pack includes ammonium nitrate, which has a specific heat capacity of 4.184 J/g°C in solution with water with a total mass of approximately 150.0 grams of solution inside. Figure 1 shows a model of an instant cold pack.

Figure 1: Instant Cold Pack Diagram



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42. Which statement describes the flow of energy when an ice pack is put onto the body because of a sports injury?
(1) The energy exits the system from the surroundings, and the temperature of the surroundings decreases.
(2) The energy exits the system from the surroundings, and the temperature of the surroundings increases.
(3) The energy enters the system from the surroundings, and the temperature of the surroundings increases.
(4) The energy enters the system from the surroundings and the temperature of the surroundings decreases. 42 ____

43. What amount of energy is transferred when the temperature of the ammonium nitrate solution inside of a common instant ice pack decreases from 25.0°C to 10.0°C?
(1) 3.14×10^3 J
(2) 6.28×10^3 J
(3) 9.41×10^3 J
(4) 1.57×10^4 J 43 ____

Ice packs can be made with different compounds to produce the same cold effect. Commercial ice packs are often made with a concentration of 2.50 *M*. Figure 2 provides data for the alternate ice packs.

Figure 2: Selected Ice Pack Compounds and Heats of Solution

Ice Pack Compound	Heat of Solution, ΔH (kJ/mol)
Ammonium nitrate (NH_4NO_3)	+25.6
Urea ($CO(NH_2)_2$)	+15.3
Ammonium chloride (NH_4Cl)	+14.8
Sodium thiosulfate ($Na_2S_2O_3$)	+48.8

44. Make a claim about which ice pack compound would result in the lowest solution temperature when applied to the body and justify this claim using evidence, assuming equal molar concentrations and initial temperatures.

Claim: _____

Evidence: _____

_____

_____

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45. A student prepares 150. mL of an ice pack solution with ammonium chloride (NH_4Cl) to test in the lab. How many grams of solute are required to make the solution with the same concentration as a commercial ice pack?

(1) 20.1 g
(2) 891.7 g
(3) 7.01×10^{-3} g
(4) 3.21 g

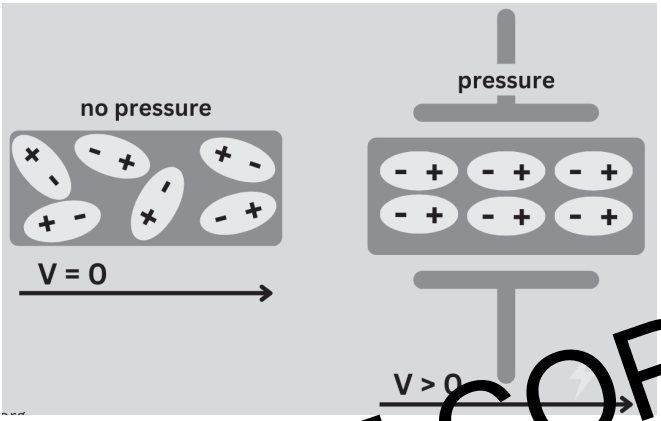
45 ____

Base your answers to questions 46 through 48 on the information below and on your knowledge of chemistry.

Piezoelectrics

Piezoelectric materials generate electricity from applied pressure. Crystals of some compounds are piezoelectric because they have charges that can shift when compressed, creating regions of positive and negative charge that generate a voltage. Figure 1 shows a model of how piezoelectrics generate a voltage.

Figure 1: Model of Piezoelectric Materials



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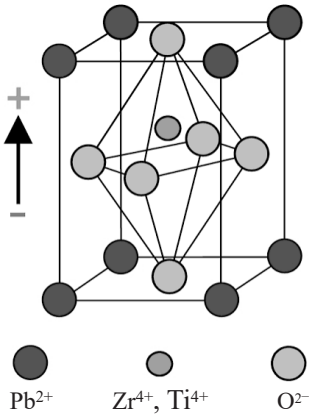
46. Which row describes how the electrical forces and voltage change as pressure is applied to the piezoelectric material?

Row	Electrical Forces	Voltage
(1)	Decrease	Decrease
(2)	Decrease	Increase
(3)	Increase	Decrease
(4)	Increase	Increase

46 ____

While some natural piezoelectric materials exist, such as quartz (SiO_2) and Rochelle salt (potassium sodium tartrate tetrahydrate), scientists have created synthetic materials that have piezoelectric properties. One of the most common is lead zirconate titanate. However, the presence of the toxic metal lead has caused scientists to search for alternatives. Figure 2 shows the crystal structure of lead zirconate titanate.

Figure 2: Crystal Structure of Lead Zirconate Titanate



47. Based on patterns of outermost electrons, propose a replacement for the toxic lead (Pb^{2+}) ions found in the crystal structure of lead zirconate titanate and justify the replacement with evidence.

Replacement for Lead: _____

Justification: _____

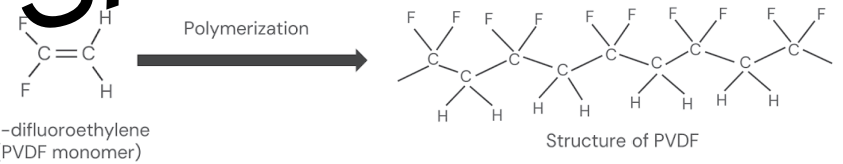
_____

_____

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Another piezoelectric material is polyvinylidene fluoride (PVDF), which is a flexible plastic polymer. Figure 3 shows the structure of PVDF made from repeating monomer units of 1,1-difluoroethylene.

Figure 3: Polymerization of PVDF from Monomers



48. Which row describes how the C–C bond strength in a PVDF polymer affects the flexibility when compared to the PVDF monomer?

Row	C-C Bond Strength	Flexibility
(1)	Increases	Decreases
(2)	Increases	Increases
(3)	Decreases	Increases
(4)	Decreases	Decreases

48 ____

August 2026

Answer all questions in this part.

***Directions*: Use your knowledge of chemistry to answer all questions in this examination. Throughout this exam, some questions may require the use of the *2025 Edition Reference Tables for Physical Science: Chemistry.* This is provided in the back of this test book.**

Base your answers to questions 1 through 5 on the information below and on your knowledge of chemistry.

Electricity Generation in New York State

New York State uses several types of energy sources to generate electricity. Data from 2021 indicate a large percentage of electrical energy in New York State is generated by natural gas plants and nuclear power plants. Burning natural gas primarily composed of methane (CH_4) produces carbon dioxide, which is a major contributor to climate change.

Figure 1 represents a distribution of energy sources of electricity in New York State. Equations 1 and 2 represent reactions that produce energy, which are used to generate electricity

Figure 1: Sources of Electricity Generation in New York (2021)

Energy Sources	Percentage of Electricity Generation* (%)
Natural gas (CH_4)	45.6
Nuclear (U-235)	24.9
Hydropower	22
Wind	3.0
Biomass, solar, and other	4

*The percentages do not add up to 100, due to rounding.

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Equation 1: $CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g) + \text{energy}$

Equation 2: $^{235}_{92}\text{U} + {}^{1}_{0}\text{n} \rightarrow {}^{89}_{36}\text{Kr} + {}^{144}_{56}\text{Ba} + 3{}^{1}_{0}\text{n} + \text{energy}$

1. Which row correctly compares the relative amount of energy released to the changes that occur at the atomic level in Equations 1 and 2 when an equal number of moles of the fuel source are used?

Row	Equation 1	Equation 2
(1)	Small magnitude of energy released; involves formation of different atoms	Large magnitude of energy released; involves rearrangement of atoms
(2)	Small magnitude of energy released; involves rearrangement of atoms	Large magnitude of energy released; involves formation of different atoms
(3)	Large magnitude of energy released; involves formation of different atoms	Small magnitude of energy released; involves rearrangement of atoms
(4)	Large magnitude of energy released; involves rearrangement of atoms	Small magnitude of energy released; involves formation of different atoms

1 ____

2. Which statement describes the flow of energy in Equation 1?
(1) The energy enters the system from the surroundings, and the temperature of the surroundings decreases.
(2) The energy enters the system from the surroundings, and the temperature of the surroundings increases.
(3) The energy exits the system to the surroundings, and the temperature of the surroundings decreases.
(4) The energy exits the system to the surroundings, and the temperature of the surroundings increases. 2 ____

3. Calculate the volume in liters of the gas produced in Equation 1, which is a major contributor to climate change, when 25.0 g of methane has completely reacted at STP. [1] _____ L

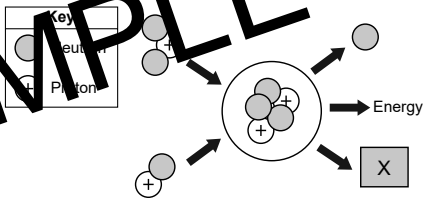
Uranium-235 naturally decays by several steps, known as a decay series. In the first step, U-235 emits an alpha particle, producing Th-231. In the next step, Th-231 undergoes beta decay. Nuclear fission and the products of the decay series can pose serious health risks.

A nuclear power plant on the Hudson River, Indian Point, was closed by New York State on April 30, 2021, as a result of ongoing safety issues. With the loss of electricity generated by this power plant, production from other energy sources had to be increased.

Scientists are researching methods to utilize a controlled nuclear fusion reaction, as illustrated by Figure 2. This could be a useful alternative to generate electricity in the future, addressing both environmental and health concerns.

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Figure 2: Model of Nuclear Fusion



4. Using the key provided in Figure 2, draw a model of the nucleus, labeled *X*. [1]

5. Which isotopic notation represents the product of the nuclear decay of the ^{231}Th?
(1) $^{231}_{89}Ac$ (2) $^{231}_{91}Pa$ (3) $^{227}_{89}Ra$ (4) $^{231}_{90}Th$ 5 ____

Base your answers to questions 6 through 9 on the information below and on your knowledge of chemistry.

The Fruit Industry in New York State

New York State is the third largest producer of grapes and the second largest producer of apples in the United States. Factors that affect the growth of grapes include temperature, soil pH, humidity, rainfall, and wind. The optimal conditions for growing grapes include a soil pH of 5.5 to 6.5 and a temperature range between 25°C and 32°C. Apples grow in a wide variety of soil types, but do best in well-drained soil at a pH of 6.0 to 7.0.

6. Make a claim that compares the hydronium ion concentration of the optimal soil conditions to grow grapes to the hydronium ion concentration of the optimal soil conditions to grow apples. [1]

_____

_____

_____

The sugars produced by grape plants and apple trees include glucose, fructose ($C_6H_{12}O_6$), and sucrose ($C_{12}H_{22}O_{11}$). Glucose is first produced, which can transform to fructose, a molecule with the same molecular formula but a different structure. These two simple sugars chemically combine to produce water and sucrose, which are transported to the other parts of the plant.

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7. Select components from the options provided and complete the model, including energy, to correctly demonstrate the production of glucose in grapes and apples. [1]

Components for Model			
H_2O_2	C_6H_{12}	CO_2	Light
O_2	H_2O	$C_6H_{12}O_6$	Nuclear

Model:

_____ + _____ + _____ → _____ + _____

8. Which equation best demonstrates the conservation of matter in the synthesis of sucrose in apples?

(1) $C_6H_{12}O_6 + C_6H_{12}O_6 + H_2O \rightarrow C_{12}H_{24}O_{13}$

(2) $C_6H_{12}O_6 + C_5H_{10}O_5 + H_2O \rightarrow C_{11}H_{22}O_{10}$

(3) $C_6H_{12}O_6 + C_6H_{12}O_6 \rightarrow C_{12}H_{22}O_{11} + H_2O$

(4) $C_6H_{12}O_6 + C_5H_{10}O_5 \rightarrow C_{11}H_{20}O_{10} + H_2O$ 8 ____

Grapes and apples can be made into jellies. Grape jelly can be made from grape juice in a process that involves boiling and dissolving additional sugars. During heating, soluble substances called pectins are released and help thicken the jelly.

9. Which claim identifies the relationship between the boiling points of grape juice and jelly?
(1) The jelly has the same boiling point as the juice because they both contain the same concentration of dissolved particles.
(2) The juice has a lower boiling point than the jelly because the juice contains a lower concentration of dissolved particles.
(3) The jelly has a higher boiling point than the juice because the jelly contains a lower concentration of dissolved particles.
(4) The juice has a higher boiling point than the jelly because the juice contains a greater concentration of dissolved particles. 9 ____

Base your answers to questions 10 through 13 on the information below and on your knowledge of chemistry.

The Great American Solar Eclipse

On April 8, 2024, most people in New York State were able to see some portion of a total solar eclipse. During a solar eclipse the moon passes between the Sun and Earth, blocking the Sun's rays.

The Sun's energy is emitted as electromagnetic radiation produced by fusion. More than half the energy from the Sun that reaches Earth's surface is in the infrared range. Nearly as much energy is in the visible range and less than 5% is in the ultraviolet (UV) range, which is damaging when absorbed by the human body.

When the Sun's energy is blocked by the moon, the outer layer of hot magnetized plasma, called the corona, becomes visible. The corona is always present but is only visible in daylight during an eclipse. During the brief time of total Sun blockage in an eclipse, scientists can study the emission spectra of the corona. In 2019 during a solar eclipse, scientists in Chile recorded spectral lines associated with iron at wavelengths 530.3 nm, 637.4 nm, and 789.2 nm.

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10. Which types of electromagnetic radiation correspond to the spectral lines of iron reported in the Sun's corona during a solar eclipse?
(1) visible light, infrared, and ultraviolet
(2) visible light and infrared
(3) ultraviolet and visible light
(4) ultraviolet and infrared 10 ____

PHYSICAL SCIENCE: CHEMISTRY

ANSWERS AND EXPLANATIONS

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Test 1

1. Answer: 2

   Explanation: When atoms or molecules return to the ground state from an excited state, they release energy in the form of light. The fluorescent dye molecules undergo a reaction that puts them into the excited state and when they relax back to the ground state, they give off the glow stick light.

2. Answers include but are not limited to: No collisions can occur when the glass vial has not been broken, so no reaction occurs
   or Without particles colliding due to the separation of reactants, no reaction can happen
   or The reaction cannot occur until the glass vial has been snapped, then collisions of reactant particles can start, triggering the reaction

   Explanation: A typical glowstick separates the hydrogen peroxide from the oxalate ester with a glass vial. Once that vial is broken with the glowstick snap, the reactant particles can mix and collide, causing the reaction to occur. Until the glowstick is snapped, there are no collisions.

3. Answer: 4

   Explanation: Trichloro salicylate oxalate esters (TCSOE) can cause skin and eye irritation if exposed, but it is unlikely unless the glowstick breaks open. So, they are safer than phthalates which can cause endocrine and reproductive problems. While phthalates glow for a longer time (8 – 24 hours), TCSOE still glow for 6 – 12 hours, which is moderately long in comparison.

4. Answers include but are not limited to:

Proposed Change:	*Effect on reaction rate:*
Put glowstick in colder environment	Reaction slows down, lasts for longer
Cool down glowstick	Reaction rate is lower
Lower the temperature	Slower

   Explanation: Lowering the temperature will cause the reactant particles to move more slowly, colliding less frequently. This will slow the reaction down, extending the glow of the glowstick.

5. Answer: Reaction: $CoO_2 + LiC_6 \rightarrow LiCoO_2 + C_6$

   Explanation: The discharging process involves the two half-reactions listed in Equations 1 and 2. Combining these Equations yields the overall reaction seen below:

   $$CoO_2 + LiC_6 + Li^+ + e^- \rightarrow LiCoO_2 + C_6 + Li^+ + e^-$$

   Here, the "$Li^+ + e^-$" can be removed from both sides of the equation, giving the overall net-ionic equation above.

6. Answer: 1

Row	Half-Reaction at Anode	Half-Reaction at Cathode	Energy Conversion
(1)	$LiC_6 \rightarrow C_6 + Li^+ + e^-$	$CoO_2 + Li^+ + e^- \rightarrow LiCoO_2$	electrical to chemical

   Explanation: During the discharge process, Equation 1 represents the reduction half-reaction taking place because electrons are gained in the reactants, which occurs at the cathode. Equation 2 represents the oxidation half-reaction taking place because electrons are lost in the products, which occurs at the anode. This process converts electrical energy from the use of the battery to chemical energy (the movement of lithium ions across the porous separator).

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38. Answer: 1

Explanation: Silver atoms are held together by mobile electrons that allow for light to be reflected off of the atoms, providing a luster ideal for mirrors.

39. Answer: 2

Explanation: Formaldehyde vapors can be inhaled, causing potential cancer, according to the information given.

40. Answer: 3

Explanation: The element that can tarnish silver mirrors is sulfur. Oxygen has the same number of outermost electrons, has a higher ionization energy because it has a smaller atomic radius and therefore a stronger attraction to its outermost electrons, making it harder to remove the outermost electrons than in sulfur, with a larger atomic radius.

41. Answers include, but are not limited to:
Metal: Aluminum

Justification for Criterion 1: Aluminum has a low potential for tarnish because it has a natural oxide layer.
or Aluminum has a low chance of oxidation and tarnish.

Justification for Criterion 2: Aluminum has the lowest cost of all the metals with less than $0.01/g.
or Aluminum has a low cost of $0.0003 per gram.

Explanation: Aluminum has a low potential for tarnish and oxidation because it has a natural oxide layer. While gold has no potential and rhodium is resistant to corrosion, both metals cost over $100/gram and aluminum is the lowest cost. So, it is the metal that best meets the criteria.

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42. Answer: 4

Explanation: When an ice pack is applied to the skin for an injury, heat is transferred from the surroundings (the body) to the system (the ice pack), which absorbs heat energy. Therefore, energy enters the system from the surroundings and the temperature of the surroundings decreases and the temperature of the body decreases.

43. Answer: 3

Explanation: Using the $q = mc\Delta T$ equation on Page 4 of the Reference Table, with a mass of 150.0 g, a specific heat capacity of 4.184 J/g°C, and a temperature change of 15.0°C, the amount of energy transferred is:
$q = (150.0\text{ g}) \bullet (4.184\text{ J/g°C}) \bullet (15.0\text{°C}) = 9.41 \times 10^3\text{ J}$

44. Answers include, but are not limited to:

Claim: Sodium thiosulfate
or $Na_2S_2O_3$

Evidence: Answers include, but are not limited to:
Sodium thiosulfate has the highest heat of solution (+48.8 kJ/mol), so it will result in the largest temperature difference and therefore the lowest solution temperature.
or $Na_2S_2O_3$ has a heat of solution of +48.8 kJ/mol which is the largest of the compounds listed. Therefore, it will have the greatest temperature difference and the lowest temperature.

Explanation: ΔH (heat of solution) represents the energy change of the dissolution of each compound in water. A positive ΔH indicates an endothermic dissolution. For an endothermic heat of solution, the dissolving of the substance absorbs heat energy from the surrounding water, thus decreasing the water temperature. When the magnitude (number) of the ΔH is greater, it results in a larger temperature difference. So, sodium thiosulfate results in the greatest temperature decrease of the water with a ΔH value of +48.8 kJ/mol because it is the most positive.

45. Answer: 1

Explanation: A commercial ice pack has a solution concentration of 2.50 *M*, so for a student to produce 150 mL of a solution (0.150 L) with ammonium chloride, it would require 0.375 moles of ammonium chloride, as seen in the calculation below. Then, this should be converted to grams of ammonium chloride, which has a molar mass of 53.5 g/mol.

$$n = MV$$

$$n = (2.50\ M) * (0.150\ L) = 0.375\ mol\ NH_4Cl$$

$$0.375\ mol\ NH_4Cl * \frac{53.5\ g\ NH_4Cl}{1\ mol} = 20.1\ g\ NH_4Cl$$

46. Answer: 4

Explanation: As pressure is applied, the electrical forces of the particles increase as they shift, which increases the voltage.

47. Answers include, but are not limited to:

Replacement for Lead: M^{2+}
or Be^{2+}
or Ca^{2+}
or Sr^{2+}
or Ba^{2+}
or Any metal cation with a +2 charge (except radium, which is radioactive)

Justification: This metal has the same number of outermost electrons as lead, so they will both form cations with a charge of +2.
or Both have the same number of outermost electrons and will form +2 cations.

Explanation: Because lead forms a +2 cation in this crystal structure, it must lose two outermost electrons to form the ion. Therefore, a replacement should have the same number of outermost electrons to lose, which is any Group 2 metal, except radium which is radioactive.

48. Answer: 3

Explanation: As the polymer is formed, the C=C double bonds in the monomer become C–C single bonds in the polymer. This decreases the bond strength and increases the flexibility of the molecule, which can bend and twist more than a rigid double bond.

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1. Answer: 2

   Explanation: Equation 1 represents a chemical reaction, where the relative amount of energy released per mole of reactants is several orders of magnitude lower than in a nuclear reaction like in Equation 2. Chemical reactions involve the rearrangement of atoms to produce new substances (elements and/or compounds) while nuclear reactions involve the formation of entirely different atoms because they can change the number of protons in the nucleus.

2. Answer: 4

   Explanation: In Equation 1, the energy term is seen on the right side of the chemical equation (on the right side of the arrow). This indicates an exothermic reaction, where energy is released in the form of heat from the reaction system to the surroundings. So, the temperature of the surroundings increases as they absorb heat.

3. Answer(s): 34.9 L or any value between 34.89 and 35.84 L

   Explanation: Using stoichiometry, the molar ratio of methane (CH_4) to the gas produced in Equation 1 (CO_2), and the given value of 25.0 grams of CH_4, the volume of gas can be calculated using the setup below:

   $$25.0\ \text{g}\ CH_4 \times \frac{1\ \text{mol}\ CH_4}{16.05\ \text{g}\ CH_4} \times \frac{1\ \text{mol}\ CO_2}{1\ \text{mol}\ CH_4} \times \frac{22.4\ \text{L}\ CO_2}{1\ \text{mol}\ CO_2} = 34.9\ \text{L}\ CO_2$$

4. Answers include but are not limited to:

   Explanation: The particle diagrams for nuclear reactions obey the law of conservation of matter, where the total mass of the reactants should equal the total mass of the products, and have the same total number of protons and same total number of neutrons from beginning to end. In this reaction, there are a total of two protons and three neutrons that enter the reaction as two separate particles (one with one proton and one neutron and the other with one proton and two neutrons). So, there should be two protons and three neutrons in the products (just as there are in the intermediate shown in the circle at the center of Model 2). Because one product shown is a single neutron, two protons and two neutrons remain, giving the contents of the missing product *X*.

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5. Answer: 1

   Explanation: According to the reading, Th-231 undergoes beta decay. So, the overall nuclear reaction would proceed as follows:

   $$^{231}_{90}\text{Th} \rightarrow {}^{231}_{91}\text{Pa} + {}^{0}_{-1}\beta$$

   When a nucleus undergoes beta decay, it converts a neutron to a proton. This keeps the same total mass (231) but increases the atomic number of the nucleus by 1, thus giving $^{231}_{91}\text{Pa}$ as the major product, and a beta particle ($^{0}_{-1}\beta$) as the other.

6. Answers include, but are not limited to:
   The optimal soil conditions for grapes have a greater $[H_3O^+]$ than for apples.
   or The optimal soil conditions for apples have a lower hydrogen ion concentration than for grapes.

   Explanation: The optimal soil conditions to grow grapes is with a pH of 5.5 to 6.5, while the optimal soil conditions to grow apples is with a pH of 6.0 to 7.0. Therefore, grapes require a lower pH than apples. The pH and the hydronium ion concentration of the soil are inversely related; thus, a lower pH has a higher hydronium ion concentration and vice versa. So, the soil required for grapes must have a higher hydronium ion concentration than the soil required for apples.

7. Answers include, but are not limited to: Light + CO_2 + H_2O → $C_6H_{12}O_6$ + O_2
or $6CO_2 + 6H_2O$ + energy → $C_6H_{12}O_6 + 6O_2$

   Explanation: To produce glucose in grapes and apples, photosynthesis must occur. Photosynthesis requires light energy (from the sun), carbon dioxide, and water as reactants (on the left of the arrow) to produce glucose and oxygen (on the right of the arrow). The equation can be balanced properly with the correct coefficients, or simply list the correct identity of the substances and light (energy).

8. Answer: 3

   Explanation: According to the reading, glucose ($C_6H_{12}O_6$) and fructose ($C_6H_{12}O_6$) chemically combine to produce water (H_2O) and sucrose ($C_{12}H_{22}O_{11}$). Equation 3 is the only one that properly demonstrates conservation of matter (where there are the same number of each type of atom on both sides of the equation) with 12 carbon atoms, 24 hydrogen atoms, and 12 oxygen atoms on both sides of the equation.

9. Answer: 2

   Explanation: Since grape juice is used to make grape jelly by boiling and dissolving additional sugars, the relative concentration of dissolved particles increases with the jelly. As the juice is boiled, some of the water will evaporate, leaving behind a smaller volume of liquid, thus increasing the concentration of the dissolved sugars. Adding additional sugars also increases the concentration of the dissolved particles in the jelly. When a mixture has a higher concentration of dissolved particles, it will have a higher boiling point.

10. Answer: 2

    Explanation: The wavelengths of the recorded spectral lines of iron were 520.3 nm, 637.4 nm, and 789.2 nm. These values, when converted to meters are 5.203×10^{-7} m, 6.374×10^{-7} m, and 7.892×10^{-7} m, respectively. According to the Reference Tables, the first two lines appear in the visible range of light, and the last wavelength of light appears in the infrared, since it has a higher wavelength just outside of the visible range. Visible light spans from approximately 400 nm (4.00×10^{-7} m) to approximately 700 nm (7.00×10^{-7} m).

11. Answer: 1

    Explanation: Radiation with a wavelength of 10^{-4} m appears in the middle of the infrared range. So, when compared to UV radiation, the wavelength is longer, the frequency is shorter, and the radiation is less damaging to living cells than UV radiation.

12. Answers include, but are not limited to: During the day, look through eclipse glasses. If you see anything then the glasses are counterfeit.
    or Look through the eclipse glasses. If visible light is transmitted, the glasses are counterfeit.
    or Look through the eclipse glasses. If objects can be seen easily, the glasses are counterfeit.
    or Shine a light source through the glasses. If light is seen on the other side, the glasses are not eclipse glasses.

    Explanation: Solar eclipse glasses should block 99.9997% of all light from reaching the eyes, so a consumer could test their glasses to see if sunlight or any visible light is transmitted. If light is transmitted, the glasses are counterfeit. If light is not, then they are not fake.

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13. Answers include, but are not limited to: The chemical bonds absorb UV light and the molecule undergoes a transformation.
or absorbs damaging energy and the structure changes

Explanation: When the organic molecule reactant in Figure 2 is exposed to UV light, the molecule changes its structure, demonstrating that it absorbed the UV light into the bonds between atoms.

14. Answer: 4

Explanation: Tin (Sn) has a band gap energy of 0.00 eV, which indicates that it is a good conductor. Elements with band gap energies above 3 eV are considered insulators. Tin has the largest atomic radius of these Group 14 elements because it has five electron shells (it is furthest down the group). All elements in Figure 1 have the same number of outermost electrons.

15. Answers include, but are not limited to:

Claim: As first ionization energy increases, conductivity decreases.
or Conductivity increases as first ionization energy decreases.

Evidence: Tin has 0 eV of band gap energy and is the best conductor of the selected Group 14 elements.
or Carbon (diamond) has the highest band gap energy of the selected Group 14 elements.
or Carbon is an insulator and has the greatest ionization energy.

Explanation: Going down Group 14 as in Figure 1, the elements become more conductive because their band gap energy, the energy needed to excite an electron of an atom in a crystal so the electron becomes mobile and can conduct energy, decreases. This means that less energy is required to excite electrons in tin (Sn) than in carbon (C). First ionization energy is the energy required to remove an electron and decreases down a group because the outermost electrons are farther away from the positive nucleus, less attracted to the nucleus, and therefore easier to remove. So, as first ionization decreases, conductivity increases and vice versa.

16. Answer: 2

Explanation: Gallium has an oxidation state of +3 because in the given semiconductor compound, GaAs (gallium arsenide), gallium loses its three outermost electrons to arsenic, giving arsenic an oxidation state of –3. In silicon carbide (SiC), Si has an oxidation state of +4 and C has an oxidation state of –4. In lead telluride (PbTe), Pb has an oxidation state of +2 while Te has an oxidation state of –2. In bismuth selenide (Bi_2Se_3), Bi has a +3 oxidation state and Se has an oxidation state of –2. So, the element with an oxidation state of +3 in the answer choices is gallium.

17. Answer: 1

Explanation: An n-type semiconductor requires an extra electron that is provided by the added atom. If silicon is the lattice with four outermost electrons, the added atom in an n-type semiconductor must have five outermost electrons, like with Sb (antimony). A p-type semiconductor has a "hole" created by the added atom that has one fewer electron. So, the added atom in a p-type semiconductor must have three outermost electrons, like with B (boron).

18. Answer: 3

Explanation: The atoms in the partial vacuum casing must be absorbing some of the heat energy from the liquid, cooling it down. Then, that heat energy must transfer to the metal outer casing.

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