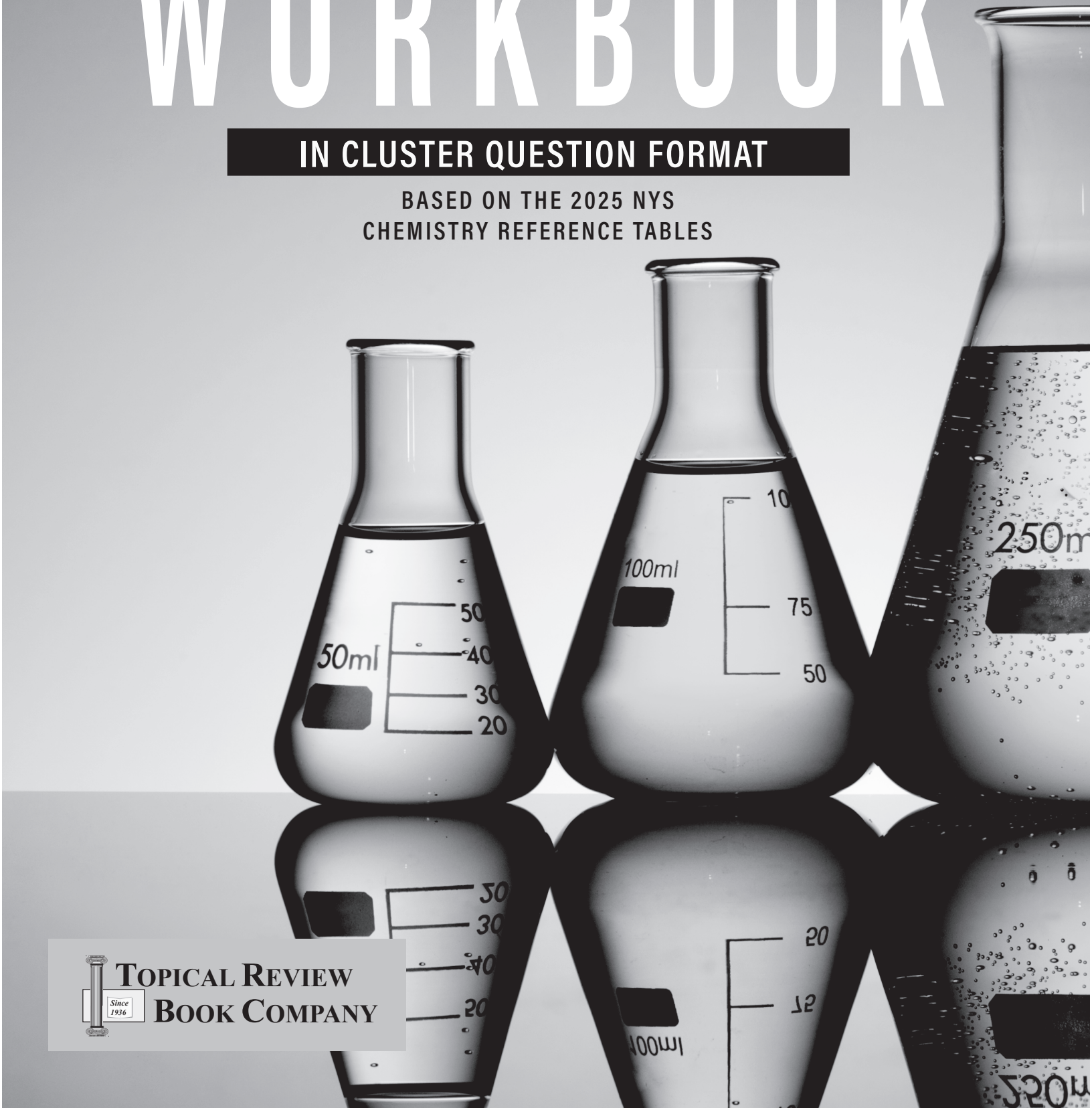
PHYSICAL SCIENCE:

CHEMISTRY WORKBOOK

IN CLUSTER QUESTION FORMAT

BASED ON THE 2025 NYS
CHEMISTRY REFERENCE TABLES



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PHYSICAL SCIENCE: CHEMISTRY WORKBOOK

Based on the NYSSLS Core Testing Topics and 2025 Chemistry Reference Tables

7 CORE SECTIONS:

- Structure and Properties of Matter
- Chemical Reactions
- Energy
- Waves and Electromagnetic Radiation
- Matter and Energy in Organisms and Ecosystems
- Engineering, Technology, and Application of Sciences
  - With Labs included
- NYS 2025 Reference Tables

EACH SECTION INCLUDES:

- **Overview** | Comprehensive summary of core material
- **Diagrams** | Detailed visual guides and analytical descriptions
- **Vocabulary** | Targeted exercises to master key scientific terms
- **Set 1 Cluster Questions** | Guided practice to build confidence
  - Answers and explanations included at the end of each section
- **Set 2 Cluster Questions** | Independent practice to test your knowledge
  - Answers and explanations included only in a separate answer key

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PHYSICAL SCIENCE
CHEMISTRY
Workbook

The Authors:
Jamie Kubiak – Chemistry Teacher
Asia Jackson – Chemistry Teacher

About This Workbook:

The goal of this workbook is to provide students with an overview of the new chemistry curriculum through necessary information, diagrams, vocabulary, and practice test questions to meet the performance expectations of Physical Science-Chemistry. This is by no means a replacement for students' classroom materials and experiences, but a meaningful complement that will connect everyday phenomena with the chemistry that drives our world. This workbook covers six main topics in chemistry that are found in the new curriculum that give important context and relevance to the scientific concepts typically covered in a chemistry course. As authors of this workbook, we know that chemistry is not a subject one passively absorbs but rather requires an active input from students; chemistry is something you do! We hope this workbook is a beneficial and worthwhile addition to your studies. No artificial intelligence was used in the creation of this workbook.

About The Authors:

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.

Asia Jackson has been teaching in New York City Public and Independent Schools since September 2014, where she taught Regents and non-Regents chemistry, Forensic Science, Living Environment, middle school Physical Science, Independent Science Research, and Chemistry of Cooking. Asia is currently a doctoral candidate at Teachers College, Columbia University, pursuing her Ph.D. in Science Education. She currently teaches various chemistry courses to middle and high school students at Saint Ann's School, where she has taught since 2023. She is passionate about creating accessible, meaningful science education for students of all ages. With a focus on inclusive science education, she aims to reimagine scientific literacy and how students demonstrate their understanding.

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The Overview and Essential Information:
The Overview will introduce you to the overarching ideas within the subtopic of chemistry and provide you with a summary of the topic. In the Essential Information, you'll find a thorough explanation of all relevant content to that chapter, explaining the why and how behind the chemistry. This should deepen your understanding of the chemistry concepts that you'll need to apply with important science and engineering practices in order to demonstrate your knowledge.

Diagrams:
In this section, you'll find common diagrams and figures that are relevant to the chapter's content. Each diagram is accompanied by an explanation that will guide your understanding of the picture or figure, tying it to the relevant information from the bulk of the chapter.

Vocabulary Refresher:
Use this section to test your knowledge on the vocabulary presented throughout the chapter. There are so many new vocabulary words in chemistry, so it's important to practice and understand the definitions of all the different words. It's helpful to note that a lot of vocabulary words will be italicized, but not all. Match the corresponding words with their definitions, looking back to the Essential Information of the chapter to help as needed.

Set 1 and Set 2 Cluster Questions and Answers:
At the end of each chapter, you'll find practice questions that align to the new Regents curriculum for that chapter's topic. Work through these by examining the diagrams, tables, and figures provided in order to apply the concepts of the chapter. Check your answers to Set 1, which are located at the end of the chapter. You'll also find explanations of the answers to help your understanding. Set 2 is another group of practice clusters, except the answers are not in this Workbook, but in a separate answer booklet. See your teacher to check your answers on these questions. An additional set of four full-length practice tests can be found in the Physical Science: Chemistry Practice Tests book.

Reference Tables:
The new Chemistry References Tables are described and explained in detail in this section. Here, you'll find helpful tips and suggestions to navigate the information provided so that you can use the reference information properly in answering the questions in Sets 1 and 2 Cluster Questions, in the Physical Science: Chemistry Practice Tests book, and on the Chemistry Regents Examination.

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Periodic Table of the Elements

	1												13	14	15	16	17	18
1	1 H Hydrogen 1.01	2																2 He Helium 4.00
2	3 Li Lithium 6.94	4 Be Beryllium 9.01											5 B Boron 10.81	6 C Carbon 12.01	7 N Nitrogen 14.01	8 O Oxygen 16.00	9 F Fluorine 19.00	10 Ne Neon 20.18
3	11 Na Sodium 22.99	12 Mg Magnesium 24.31	3	4	5	6	7	8	9	10	11	12	13 Al Aluminum 26.98	14 Si Silicon 28.09	15 P Phosphorus 30.97	16 S Sulfur 32.06	17 Cl Chlorine 35.45	18 Ar Argon 39.95
4	19 K Potassium 39.10	20 Ca Calcium 40.08	21 Sc Scandium 44.96	22 Ti Titanium 47.87	23 V Vanadium 50.94	24 Cr Chromium 52.00	25 Mn Manganese 54.94	26 Fe Iron 55.85	27 Co Cobalt 58.93	28 Ni Nickel 58.69	29 Cu Copper 63.55	30 Zn Zinc 65.38	31 Ga Gallium 69.72	32 Ge Germanium 72.63	33 As Arsenic 74.92	34 Se Selenium 78.97	35 Br Bromine 79.90	36 Kr Krypton 83.80
5	37 Rb Rubidium 85.47	38 Sr Strontium 87.62	39 Y Yttrium 88.91	40 Zr Zirconium 91.22	41 Nb Niobium 92.91	42 Mo Molybdenum 95.95	43 Tc Technetium	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.91	46 Pd Palladium 106.42	47 Ag Silver 107.87	48 Cd Cadmium 112.41	49 In Indium 114.82	50 Sn Tin 118.71	51 Sb Antimony 121.76	52 Te Tellurium 127.60	53 I Iodine 126.90	54 Xe Xenon 131.29
6	55 Cs Cesium 132.91	56 Ba Barium 137.33	57 La Lanthanum 138.91	72 Hf Hafnium 178.49	73 Ta Tantalum 180.95	74 W Tungsten 183.84	75 Re Rhenium 186.21	76 Os Osmium 190.23	77 Ir Iridium 192.22	78 Pt Platinum 195.08	79 Au Gold 196.97	80 Hg Mercury 200.59	81 Tl Thallium 204.38	82 Pb Lead 207.2	83 Bi Bismuth 208.98	84 Po Polonium	85 At Astatine	86 Rn Radon
7	87 Fr Francium	88 Ra Radium	89 Ac Actinium	104 Rf Rutherfordium	105 Db Dubnium	106 Sg Seaborgium	107 Bh Bohrium	108 Hs Hassium	109 Mt Meitnerium	110 Ds Darmstadtium	111 Rg Roentgenium	112 Cn Copernicium	113 Nh Nihonium	114 Fl Flerovium	115 Mc Moscovium	116 Lv Livermorium	117 Ts Tennessine	118 Og Oganesson

Key

50 — Atomic number
Sn — Element symbol
Tin — Element name
118.71 — Average atomic mass

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

Source: CRC Handbook of Chemistry and Physics, 104th ed., 2023–2024, CRC Press

Overview:

Matter is composed of elements, which consist of atoms—the smallest units of an element. The periodic table organizes elements by grouping them according to predictable physical and chemical properties. Element atoms with unstable nuclei undergo radioactive decay, releasing energy to achieve stability through a process governed by the Law of Conservation. Electrostatic forces between molecules in a substance determine the structure, phase, properties, and behaviors. In a solution, a solute dissolves in a solvent to form a homogeneous mixture. Concentration is measured via molarity, parts per million (ppm), or mass percent. Solutions can be unsaturated, saturated, or supersaturated, and their concentration affects colligative properties. Finally, gas behavior is described by the kinetic-molecular theory, in which real gases approximate "ideal" behavior most closely at low pressure and high temperature.

Essential Information:

Atoms – Almost all things in the universe are considered matter if it has mass and take up space. The building blocks of matter are called elements. Microscopically, elements are pure substances composed of a single type of particle or atom. Atoms are the smallest possible unit of any element, and when 2 or more atoms combine, they form molecules. Structurally, atoms consist of a small, dense, positively charged nucleus at the center, containing even smaller particles called protons (positively charged) and neutrons (neutral), surrounded by negatively charged electrons in orbitals or energy levels. Electrons in the outermost orbital are called valence electrons and determine how atoms of an element form bonds.

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Protons and neutrons, each with a mass of 1 atomic mass unit (amu), make up the overall mass of an atom, while the mass of an electron is so small in comparison that its mass is considered negligible. The number of protons in the nucleus of an atom of any element is determined by the atomic number and identifies the element. For example, an oxygen atom has 8 protons, while a carbon atom has 6. In a neutral atom, the atomic number also represents the number of electrons. Atoms with a charge are called ions. When atoms lose electrons, they become positively charged ions, cations, while gaining electrons creates negatively charged ions, anions.

Periodic Table – The periodic table is the arrangement of elements based on classification and properties in order of increasing atomic number. Depending on its location on the periodic table, physical and chemical properties can be predicted. Elements can be classified as metals, metalloids, and non-metals. Metals make up about 70% of all elements. With the exception of hydrogen, they are located to the left of the dark staircase on the Reference Table for Physical Science: Chemistry periodic table. In contrast, non-metals are located on the right and metalloids along the staircase. The table is arranged by groups (columns) and periods (rows). Elements in the same group have the same number of valence electrons and share similar chemical characteristics. Group 1 (alkali metals) and Group 2 (alkaline earth metals) have 1 and 2 valence electrons, respectively. Groups 3 through 12 are transition metals and tend to have a range of valence electrons. From Group 13 to 18, the number of valence electrons increases from 3 to 8. Group 17 are halogens, the most reactive non-metals. The last group on the periodic table is the rare, inert noble gases. They are mostly chemically inactive and bond only with more active elements. Elements in the same period have the same number of orbitals. For example, sodium is in period 3 (row 3); therefore, it has 3 principal energy levels (orbitals). Besides atomic structure, placement on the periodic table can also determine an element's properties. For example, the atomic radius or distance from the center of the nucleus to the outermost orbital decreases as you move across a period from left to right, while it increases as you go down a group, adding orbitals. Elements to the bottom left of the periodic table are larger than elements on the upper right side. Other properties include reactivity (an atom's ability to undergo a chemical reaction), electronegativity (an atom's ability to attract electrons), and ionization energy (the energy required to remove an electron from a valence orbital). Both properties increase as you move across a period and decrease as you go down a group. Because group 18 elements are mostly inert and unreactive, the noble gases do not follow the trend.

Nuclear – The number of neutrons in an atom of a given element can vary. For example, carbon can exist as carbon-12, carbon-13, and carbon-14. The number next to the element following the dash represents the atomic mass of that particular atom or isotope of the element. Because the number of protons cannot change, to have different masses, the number of neutrons must differ. To determine the number of neutrons, we subtract the number of protons (atomic number) from the mass number. Continuing the previous example, each carbon isotope has 6 protons but increases in neutron number from 6 to 7 to 8, respectively. The ratio of protons and neutrons in the nucleus of an atom determines the stability of the core. The instability of an atom's nucleus can trigger nuclear reactions that release particles and energy (radiation) to form a more stable nucleus. Elements that emit particles undergo a process called radioactive decay and are radioactive isotopes or radioisotopes. There are 6 possible particles that can be released from the nucleus during a nuclear decay reaction (see Reference Table for Physical Science: Chemistry page 3: Symbols used in Nuclear Chemistry). The radioactive decay process can be shown

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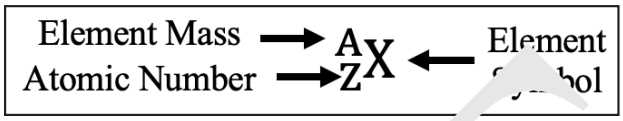
using a nuclear equation or reaction that begins with the radioisotope undergoing nuclear decay, followed by a yield arrow, the released nuclear particle, and the new element. The Law of Conservation states that matter, charge, and energy cannot be created or destroyed. To ensure that the law of conservation is satisfied, the total mass and charge of the reactants must equal those of the products. For example, plutonium naturally decays, releasing an alpha particle and energy as it transmutes into a new element. The nuclear equation is written as shown: $^{239}_{94}\text{Pu} \rightarrow {}^{4}_{2}\alpha + {}^{A}_{Z}\text{X}$

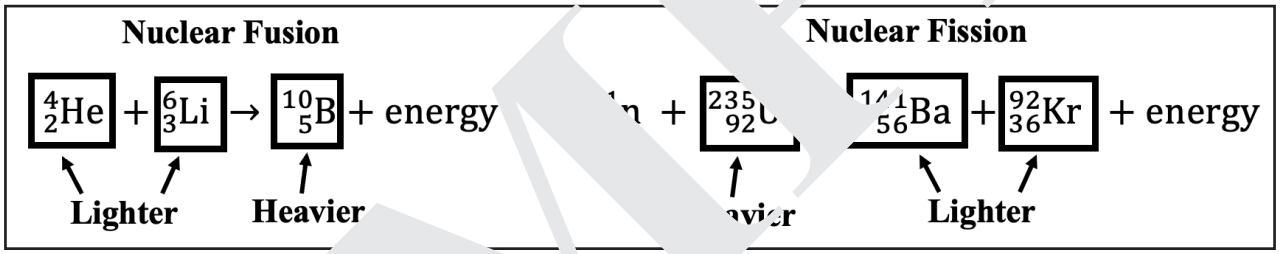


To identify the new element, *X*, the charges or atomic numbers of the reactants are set equal to those of the products using an algebraic equation. With an atomic number of 92, the new element is identified as uranium on the periodic table. The complete nuclear equation for the radioactive decay of plutonium-239 is:

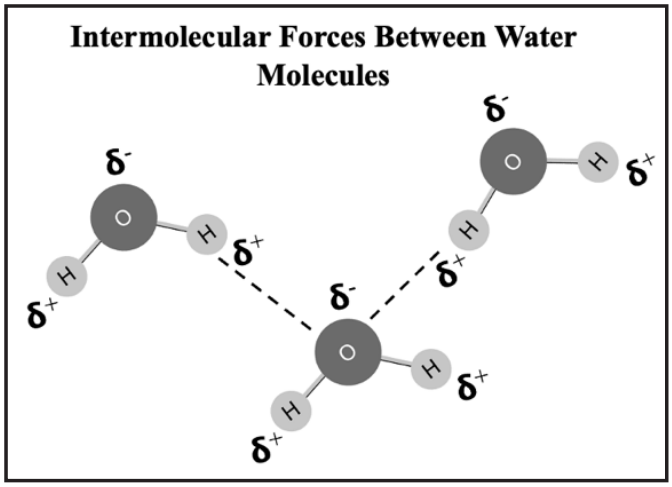
$$^{239}_{94}\text{Pu} \rightarrow {}^{4}_{2}\alpha + {}^{235}_{92}\text{U}$$

Atomic Number	Atomic Mass
94 = 2 + Z	239 =
- 2	- 4 - 4
	A = 235

All nuclear reactions convert mass into energy. Nuclear fusion occurs when lighter radioisotopes combine to form a heavier one, while nuclear fission involves splitting a heavier nucleus into lighter ones.



Forces – Intermolecular forces are the attractive forces within a substance that hold its atoms, molecules, ions, or particles together. For example, water is a polar molecule consisting of two partial positive (δ+) hydrogen atoms and one partial negative (δ-) oxygen atom that are bonded together. The positive and negative charges on different molecules attract each other, holding them together, as shown in the diagram. Molecules without a charged attraction are considered nonpolar. The strength of these forces can determine the phase of matter (solid, liquid, or gas) and properties such as melting and boiling points, vapor pressure, and surface tension. Solids have the strongest attractive electrostatic forces; therefore, their particles are pulled tightly packed together, with little space between them. Liquids have moderate electrostatic forces and some space between the particles, while gases have the weakest electrostatic forces and lots of space between the particles. The stronger the forces, the harder it will be to separate the molecules from one another. Therefore, substances with strong forces will have higher melting and boiling points and surface tension.



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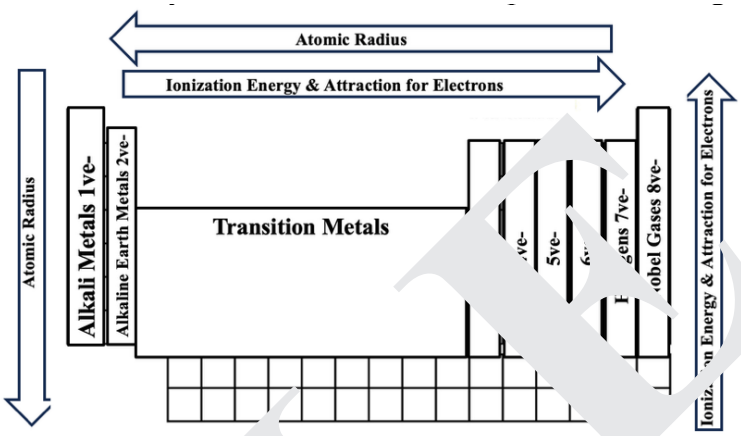
Diagrams:

1. **Periodic Table with Valence Electrons, group name, trend arrows**
   – This diagram shows the names of different groups on the periodic table and the number of valence electrons for each. The arrow shows how different elemental properties change. As you move to the left of a period and up a group, the ionization energy and attraction for electrons increase. As you move to the left in a period down a group, the atomic radius increases.



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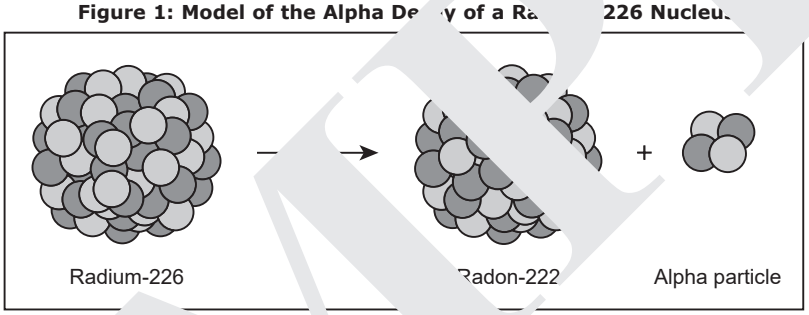
2. **Nuclear Decay** – The figure is a visual representation of the decay of a radioisotope's nucleus. In this example, radium-226 releases an alpha particle and results in the formation of a radon-222 atom.



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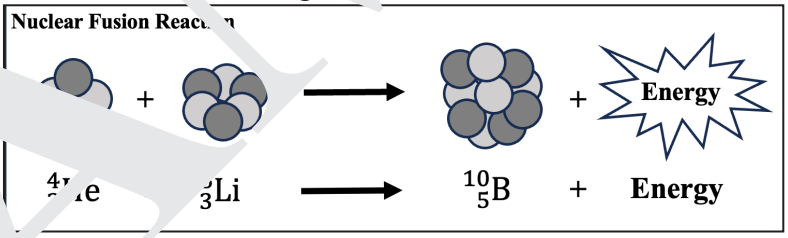
3. **Nuclear Fusion** – The image illustrates a nuclear fusion reaction by showing two lighter nuclei that combine to form a new element with a greater mass. Mass is converted to energy, which is released.



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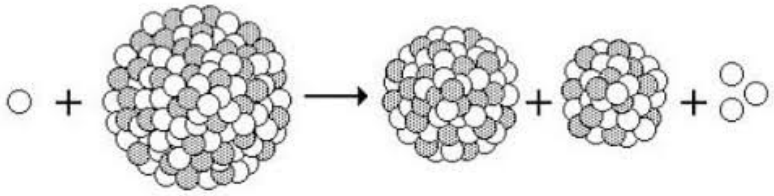
4. **Nuclear Fission** – The image illustrates nuclear fission by showing a heavy nucleus splitting into two lighter nuclei. Mass is converted to energy, which is released.



$$^{1}_{0}n + {}^{235}_{92}U \rightarrow {}^{144}_{56}Ba + {}^{92}_{36}Kr + 3{}^{1}_{0}n + \text{Energy}$$

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Vocabulary Refresher

Directions - Match the correct definition for the following terms:

1. _____Valence Electrons
2. _____Atoms
3. _____Volume
4. _____Solution
5. _____Concentration
6. _____Orbitals
7. _____Molecules
8. _____Nucleus
9. _____Fusion
10. _____Solute
11. _____Electronegativity
12. _____Mass
13. _____Solvent
14. _____Ionization Energy
15. _____ Intermolecular Forces
16. _____Fission
17. _____ Atomic Radius

A. location of electrons in an atom

B. amount of matter

C. the substance that is dissolved in a solution

D. amount of space a substance takes up

E. single particles that are the smallest unit of any given element

F. central portion of an atom that contains protons and neutrons

G. two or more atoms chemically combined through bonds

H. outermost electrons found in the last orbital

I. energy required to remove a valence electron from an atom

J. an atom's ability to attract electrons

K. the distance from the center of the nucleus to the outermost orbital

L. lighter radioisotopes nuclei combine to form a heavier nucleus resulting in the release of energy

M. attractive forces within a substance that hold its atoms, molecules, ions, or particles together

N. the substance that is doing the dissolving in a solution

O. splitting a heavier nucleus into lighter nuclei resulting in the release of energy

P. a homogenous mixture of two or more substances that consist of a solute and solvent

Q. the amount of solute dissolved in a given amount of solution expressed in ppm, molarity, and mass percent

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Set 1 – Chemical Reactions

Base your answers to questions 1 through 5 on the information below and on your knowledge of chemistry. Some questions may require the use of the ***2025 Edition Reference Tables for Physical Science: Chemistry***.

Alkaline Water Beverages and pH

Several drink companies sell alkaline water, claiming it's beneficial for your health because it neutralizes acidic foods and drinks. Alkaline water has a pH that is higher than 7. Naturally occurring alkaline water has a higher pH because of minerals found within, such as magnesium, calcium, and potassium carbonates, which ionize in solution to produce hydroxide (OH^-) ions through the following reactions, for example:

Equation 1: $CaCO_3(s) \rightleftharpoons Ca^{2+}(aq) + CO_3^{2-}(aq)$

Equation 2: $CO_3^{2-}(aq) + H_2O(\ell) \rightleftharpoons HCO_3^-(aq) + OH^-(aq)$

Artificial alkaline water is produced by adding similar minerals to water, with most manufacturers advertising a pH around 8 or 9, with beverages above a pH of 11 having potential harm to the mouth, gums, and tongue. The companies claim that acidic foods are bad and drinking alkaline water will counteract the effects, with no scientific evidence to support the claims.

1. Cite evidence from the Equations that supports the claim that the minerals containing carbonates produce an alkaline solution in water.

Evidence: _____

_____

2. A beverage company plans to produce an alkaline water with a pH of 12. Which of the following correctly summarizes why this beverage would not be advised to be consumed?
(1) A beverage with a pH of 12 is 1,000 times more acidic than alkaline water with pH of 9, causing potential harm to the mouth.
(2) A beverage with a pH of 12 is 1,000 times more basic than alkaline water with a pH of 9, causing potential harm to the mouth.
(3) A beverage with a pH of 12 is three times more basic than alkaline water with a pH of 9, causing potential harm to the mouth.
(4) A beverage with a pH of 12 is three times more acidic than alkaline water with a pH of 9, causing potential harm to the mouth. 2_____

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Figure 1: Information on Bottled Alkaline Water Brands

Brand	pH level	Cost per 32 fl. oz	Electrolyte Concentration (ppm)
Pure Ionized Alkaline Super	9.5	$2.69	50 - 60 ppm
Alkaline Plus	11.5	$4.23	100 ppm
Natural Spring Clean	8.1 - 8.2	$1.95	75 ppm

3. A consumer wants to purchase an alkaline water with the following criteria:

Criterion 1: Low cost

Criterion 2: Minimize health impacts to the mouth

Select the brand of bottled alkaline water that best meets these criteria by evaluating the information in Figure 1, and justify the selection by citing evidence.

Bottled alkaline water: _____

Justification for Criterion 1: _____

_____

Bottled alkaline water: _____

Justification for Criterion 2: _____

_____

4. Construct a mathematical representation, using appropriate calculations, that could be used to determine the mass of electrolytes found in 1000 grams of solution for the Alkaline Plus water. Show all work.

Mathematical Representation

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Human bodies are already equipped to keep pH levels stable in several ways. Carbonic anhydrase is an enzyme found in the mouth and gives carbonated water its unique, tangy flavor. The enzyme is found on the surface of the tongue in the sour sensing cells where the tingly sensation comes from nerve receptors being activated.

Carbonic anhydrase catalyzes the conversion of carbonic acid $H_2CO_3(aq)$, to hydrogen carbonate, $HCO_3^-(aq)$, and hydrogen ions, $H^+(aq)$, according to the reactions seen below.

Equation 3: $H_2CO_3(aq) \rightleftharpoons H^+(aq) + HCO_3^-(aq)$

Equation 4: $H^+(aq) + HCO_3^-(aq) \rightleftharpoons CO_2(aq) + H_2O(\ell)$

5. When drinking carbonated water that contains excess $CO_2(aq)$, which statement describes the produced effect?

(1) The added CO_2 increases the rate of production of $H_2O(\ell)$, giving the drink its tangy flavor.
(2) The added CO_2 decreases the rate of production of $H_2O(\ell)$, giving the drink its tangy flavor.
(3) The added CO_2 increases the rate of production of $H^+(aq)$ and $HCO_3^-(aq)$, giving the drink its tangy flavor.
(4) The added CO_2 decreases the rate of production of $H^+(aq)$ and $HCO_3^-(aq)$, giving the drink its tangy flavor.

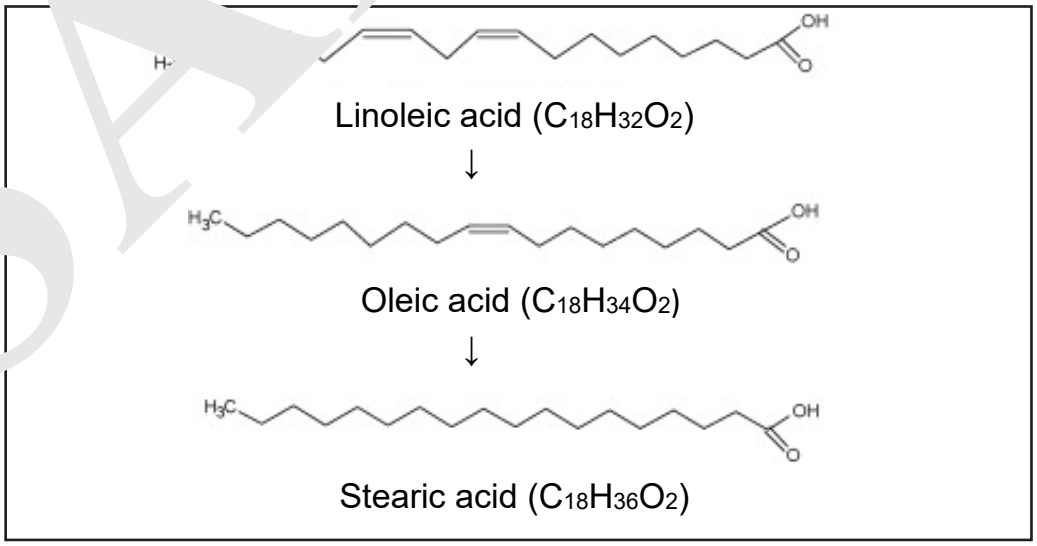
5_____

Base your answers to questions 6 through 10 on the information below and on your knowledge of chemistry. Some questions may require the use of the **2025 Edition Reference Tables for Physical Science: Chemistry.**

Candle Chemistry

Humans have been burning candles for centuries, using many different materials, including animal fat, wax, beeswax, and more. Waxes are organic substances that are typically solid at room temperature but malleable enough to shape. Some waxes derived from vegetable oil must be hydrogenated to become waxy. Hydrogenation is a reaction between hydrogen (H_2) and hydrocarbons, where the double and triple bonds are removed as hydrogen atoms are added. This process can produce stearic acid, a main component in soy wax, as seen in Figure 1.

Figure 1: Hydrogenation of Linoleic Acid to Stearic Acid



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Set 1 — Waves and Electromagnetic Radiation

Base your answers to questions 1 through 4 on the information below and on your knowledge of chemistry. Some questions may require the use of the ***2025 Edition Reference Tables for Physical Science: Chemistry***.

Blacklights and UV Light

Blacklights are commonly used in forensics to help detect materials not immediately visible to the naked eye. They get their name from their emission of light that is "black", which we can't see. Blacklights function by giving off radiation in the ultraviolet (UV) range of the electromagnetic spectrum while also giving off purplish light that we can see. Some substances and materials appear different colors under black light because they are able to absorb one wavelength of light in the UV range and emit a different wavelength in the visible range. This is called fluorescence.

UV light is composed of three categories: UVA, UVB, and UVC. Blacklights make use of UVA radiation, which is the closest in wavelength to visible violet light. Prolonged exposure to blacklights can be harmful to our eyes. The UVB light from the sun is what causes sunburns, eye damage, and potentially skin cancer while UVC light helps sterilize medical instruments as well as surfaces, since it is high energy enough to kill viruses and bacteria.

1. Which statement supports the claim that fluorescence is observed under a blacklight?

   (1) Radiation that was absorbed in the visible range is released in the form of UV light as electrons jump to the excited state.
   (2) Radiation that was absorbed in the UV range is released in the form of visible light as electrons return to a lower energy state.
   (3) Radiation that is released in the UV range is absorbed in the form of visible light as electrons return to their ground state.
   (4) Radiation that is released in the visible range is absorbed in the form of UV light as electrons jump to the excited state. 1_____

2. What is the approximate wavelength range that blacklights would most likely operate in?
   (1) 100 to 200 nm (2) 200 to 300 nm (3) 300 to 400 nm (4) 400 to 500 nm 2_____

3. Which of the following matches the type of UV radiation with its relative frequency and energy compared to the other types of UV light?

Row	Type of UV Radiation	Relative Frequency	Relative Energy
(1)	UVA	lowest	lowest
(2)	UVB	lowest	highest
(3)	UVB	highest	highest
(4)	UVC	highest	lowest

3_____

4. Explain why UVA radiation is considered less harmful to humans than UVB and UVC radiation.

_____

_____

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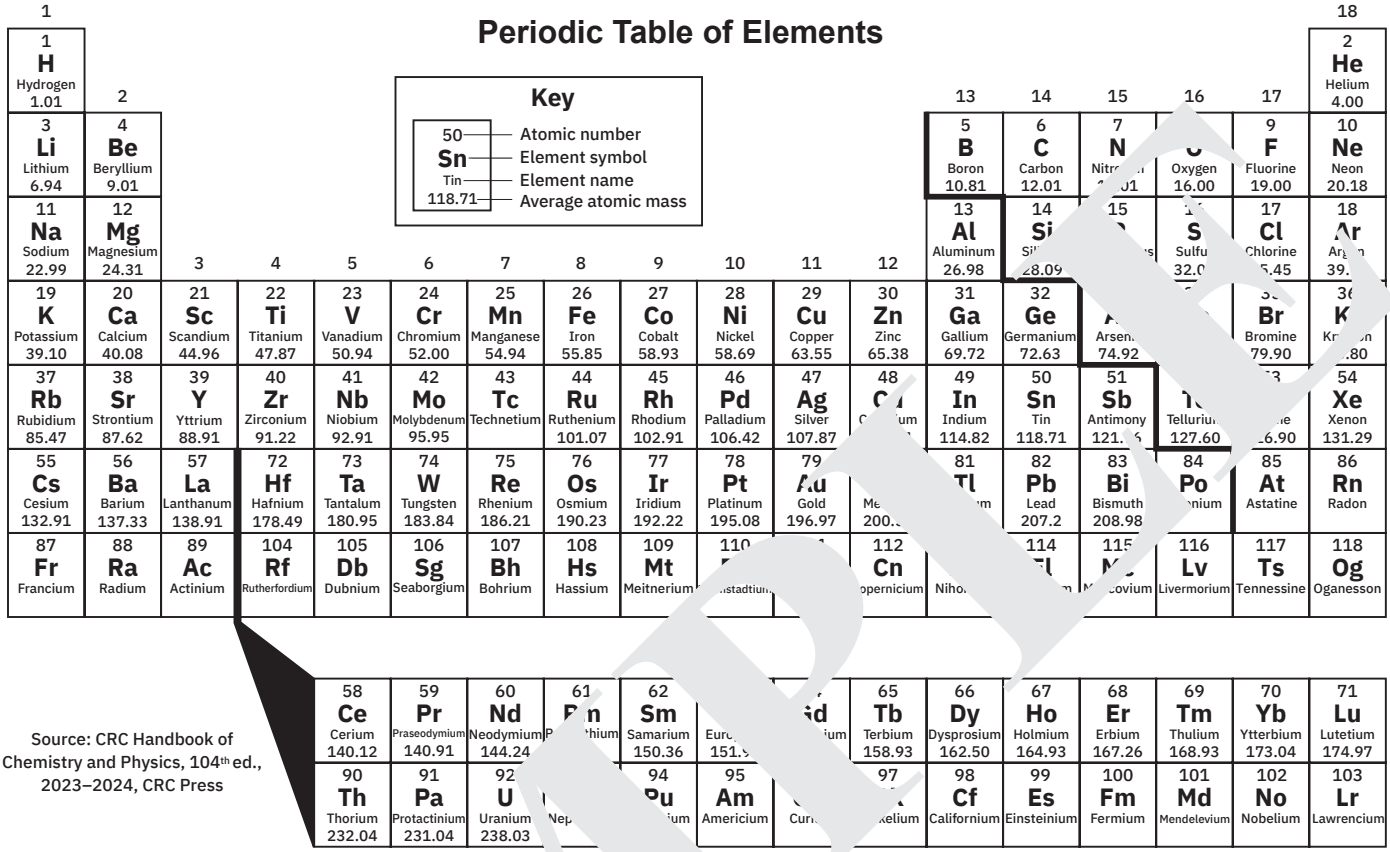
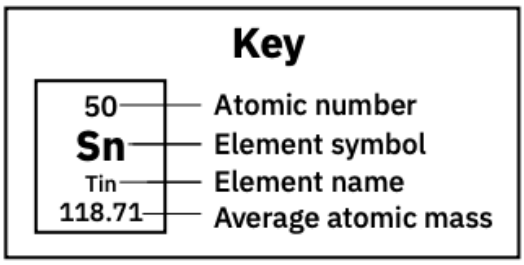
Periodic Table of Elements



Source: CRC Handbook of Chemistry and Physics, 104th ed., 2023–2024, CRC Press

"Periodic Table of the Elements" Explanation – The Periodic Table of the Elements shows all 118 elements, which are arranged into 18 groups (columns) and 7 periods (rows), which are labeled on the top and left of the table. The elements are arranged by atomic number, which is the number of protons in the nucleus.



When examining the key, the atomic number of each element is listed above the element symbol, the one or two letters that distinguish the element from the others. Below the symbol is the name of the element. At the bottom is the average atomic mass, which represents the average mass of one atom of the element in atomic mass units (amu) as well as the mass of one mole of atoms of that element in grams.

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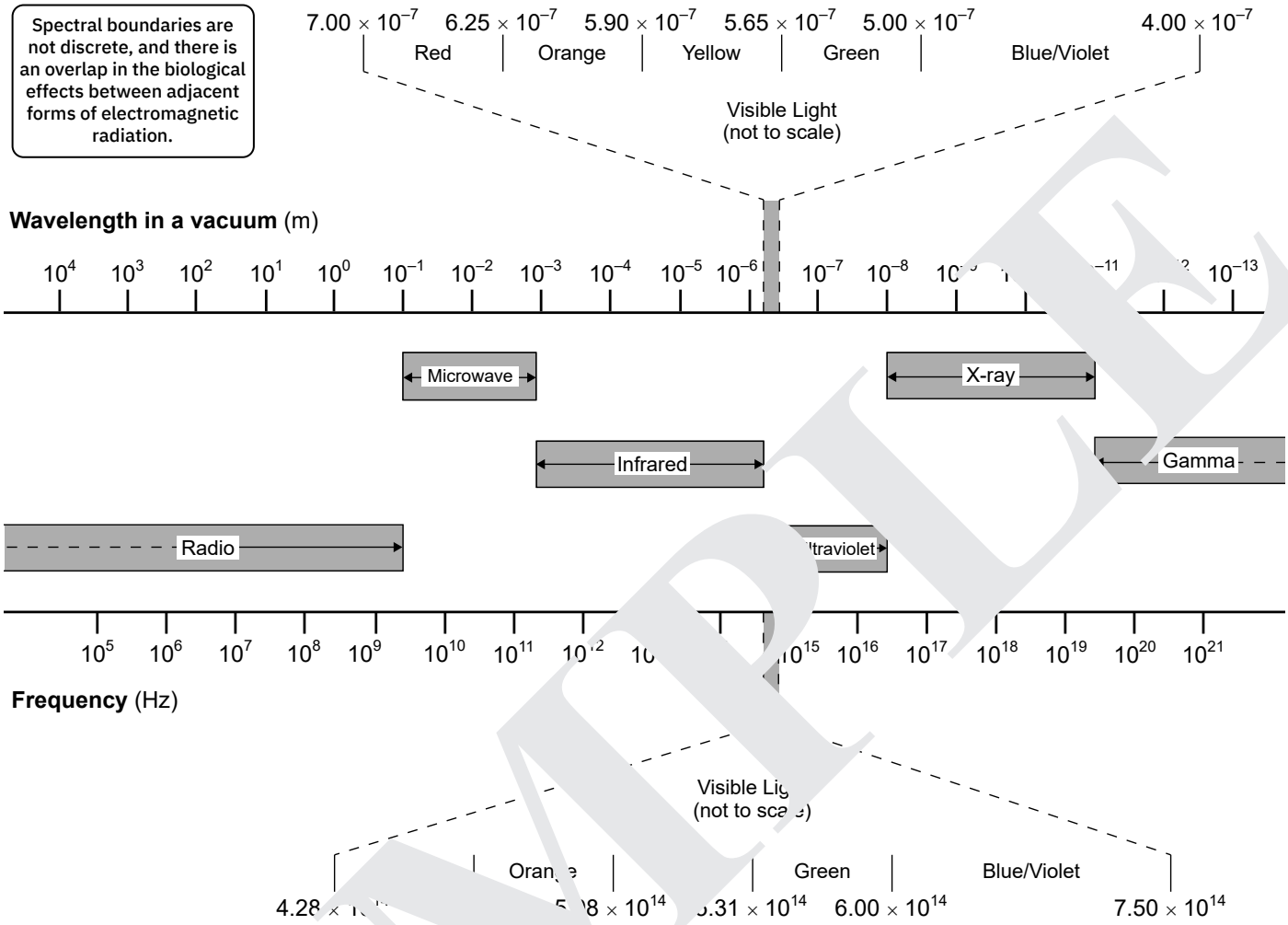
The Electromagnetic Spectrum

Spectral boundaries are not discrete, and there is an overlap in the biological effects between adjacent forms of electromagnetic radiation.



"The Electromagnetic Spectrum" Explanation – The electromagnetic spectrum is composed of several bands of differing types of radiation: radio waves, microwaves, infrared radiation, visible light, ultraviolet radiation, x-rays, and gamma rays. The visible light spectrum is composed of the wavelengths of light that humans can observe with their eyes, ranging from 4.00×10^{-7} to 7.00×10^{-7} meters (m), or 400 to 700 nanometers (nm).

The relative wavelengths and frequencies of the other bands of electromagnetic radiation are shown in the middle of the figure, demonstrating the inverse relationship between wavelength and frequency; as wavelength increases, the frequency decreases and vice versa. Typically wavelength is measured in meters and frequency is measured in Hertz (Hz) or inverse seconds (s^{-1}).

The boundaries between the different types of electromagnetic radiation are not discrete, so there may be some overlap in the effects of each type of radiation.

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"Symbols Used in Nuclear Chemistry" Explanation – This table lists the most common particles that appear in nuclear chemistry by name and their notation, similar to that of isotopic notation. The number that appears in the upper left of each notation represents the mass of the particle, which is typically the total sum of any protons and neutrons that appear in the particle. The number on the bottom left is the charge of the particle (since a proton has a +1 charge, each proton contributes 1 to the overall charge).

Symbols Used in Nuclear Chemistry	
Name	**Notation**
alpha	${}^{4}_{2}\text{He}$ or ${}^{4}_{2}\alpha$
beta	${}^{0}_{-1}\text{e}$ or ${}^{0}_{-1}\beta$
gamma	${}^{0}_{0}\gamma$
neutron	${}^{1}_{0}\text{n}$
positron	${}^{0}_{+1}\text{e}$ or ${}^{0}_{+1}\beta$
proton	${}^{1}_{1}\text{H}$ or ${}^{1}_{1}\text{p}$

An alpha particle, represented by ${}^{4}_{2}\text{He}$ or ${}^{4}_{2}\alpha$, is a helium nucleus with two protons and two neutrons. It can be written with the symbol for helium, He, or with the Greek letter alpha, α. Alpha particles have low penetrating power.

A beta particle, represented by ${}^{0}_{-1}\text{e}$ or ${}^{0}_{-1}\beta$, is essentially an electron with no mass and a –1 charge. It can be written with "e" or the Greek letter beta, β. Beta particles have low to medium penetration power, depending on the substance.

A gamma ray, represented by ${}^{0}_{0}\gamma$, has no mass and no charge. It is essentially just pure electromagnetic energy with high penetrating power and the ability to affect biological cells.

A neutron, represented by ${}^{1}_{0}\text{n}$, has a mass of 1 but no electrical charge. It has the same mass as a proton and is used to trigger and is often a product of several nuclear reactions. It is written with an "n" for neutron.

A positron, represented by ${}^{0}_{+1}\text{e}$ or ${}^{0}_{+1}\beta$, is a particle with the same mass as an electron but an opposite charge of +1. It can be written with an "e" or the Greek letter beta, β. It's important to note that an "e" or beta symbol written without the +1 charge is considered a beta particle or electron, not a positron. A positron uses the same symbol because it's the antiparticle of an electron.

A proton, represented by ${}^{1}_{1}\text{H}$ or ${}^{1}_{1}\text{p}$, is a particle with a mass of 1 and a charge of +1. It is essentially the nucleus of the most common isotope of a hydrogen atom, having no neutrons. It's written with either the symbol for hydrogen, H, or with a "p" for proton.

"Selected Ions Forming Aqueous Solutions" Explanation – This table lists common ions that form aqueous solutions when combined with other ions in ionic compounds. An aqueous solution is one that is made by dissolving a solid substance (the solute) into water (the solvent), creating a homogenous mixture where the particles are uniformly distributed in the solution. An aqueous solution is designated with the phase notation of "(aq)". All of the ions in this table will dissolve completely into water, dissociating or breaking into their respective ions in solution.

Selected Ions Forming Aqueous Solutions	
Name	**Formula**
Group 1 metals	Li^+, Na^+, etc.
ammonium	NH_4^+
acetate	$C_2H_3O_2^-$
chlorate	ClO_3^-
hydrogen carbonate	HCO_3^-
nitrate	NO_3^-

Group 1 metals form cations (positively charged ions) when combined with other ions. For example, lithium chloride, LiCl, will dissolve into Li^+(aq) and Cl^-(aq) ions in solution. Any ionic compound with a Group 1 metal cation (found in the first column of the Periodic Table), will follow this same pattern.

The same is true of compounds that feature ammonium, acetate, chlorate, hydrogen carbonate, and nitrate ions.

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