SUGGESTED SKILL

✖ *Mathematical Routines*

5.B

Identify an appropriate theory, definition, or mathematical relationship to solve a problem.

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AVAILABLE RESOURCES
- AP Chemistry Lab Manual > **Investigation 3: What Makes Hard Water Hard?**
- Classroom Resource > **Guided Inquiry Activities for the Classroom: Lesson 1**

TOPIC 1.1
Moles and Molar Mass

Required Course Content

LEARNING OBJECTIVE

1.1.A

Calculate quantities of a substance or its relative number of particles using dimensional analysis and the mole concept.

ESSENTIAL KNOWLEDGE

1.1.A.1

One cannot count particles directly while performing laboratory work. Thus, there must be a connection between the masses of substances reacting and the actual number of particles undergoing chemical changes.

1.1.A.2

Avogadro's number ($N_A = 6.022 \times 10^{23}\ \mathrm{mol^{-1}}$) provides the connection between the number of moles in a pure sample of a substance and the number of constituent particles (or formula units) of that substance.

1.1.A.3

Expressing the mass of an individual atom or molecule in atomic mass units (amu) is useful because the average mass in amu of one particle (atom or molecule) or formula unit of a substance will always be numerically equal to the molar mass of that substance in grams. Thus, there is a quantitative connection between the mass of a substance and the number of particles that the substance contains.

EQN: $n = m/M$

TOPIC 1.2
Mass Spectra of Elements

AVAILABLE RESOURCES
- Classroom Resource > **Exploring Atomic Structure Using Photoelectron Spectroscopy (PES) Data**

Required Course Content

LEARNING OBJECTIVE

1.2.A

Explain the quantitative relationship between the mass spectrum of an element and the masses of the element's isotopes.

ESSENTIAL KNOWLEDGE

1.2.A.1

The mass spectrum of a sample containing a single element can be used to determine the identity of the isotopes of that element and the relative abundance of each isotope in nature.

1.2.A.2

The average atomic mass of an element can be estimated from the weighted average of the isotopic masses using the mass of each isotope and its relative abundance.

> *Exclusion Statement: Interpreting mass spectra of samples containing multiple elements or peaks arising from species other than singly charged monatomic ions will not be assessed on the AP Exam.*

TOPIC 1.3

Elemental Composition of Pure Substances

Required Course Content

LEARNING OBJECTIVE

1.3.A

Explain the quantitative relationship between the elemental composition by mass and the empirical formula of a pure substance.

ESSENTIAL KNOWLEDGE

1.3.A.1

Some pure substances are composed of individual molecules, while others consist of atoms or ions held together in fixed proportions as described by a formula unit.

1.3.A.2

According to the law of definite proportions, the ratio of the masses of the constituent elements in any pure sample of that compound is always the same.

1.3.A.3

The chemical formula that lists the lowest whole number ratio of atoms of the elements in a compound is the empirical formula.

TOPIC 1.4
Composition of Mixtures

Required Course Content

LEARNING OBJECTIVE

1.4.A

Explain the quantitative relationship between the elemental composition by mass and the composition of substances in a mixture.

ESSENTIAL KNOWLEDGE

1.4.A.1

Pure substances contain atoms, molecules, or formula units of a single type. Mixtures contain atoms, molecules, or formula units of two or more types, whose relative proportions can vary.

1.4.A.2

Elemental analysis can be used to determine the relative numbers of atoms in a substance and to determine its purity.

SUGGESTED SKILL

✗ *Models and Representations*

1.A

Describe the components of and quantitative information from models and representations that illustrate particulate-level properties only.

TOPIC 1.5
Atomic Structure and Electron Configuration

Required Course Content

LEARNING OBJECTIVE

1.5.A

Represent the ground-state electron configuration of an atom of an element or its ions using the Aufbau principle.

ESSENTIAL KNOWLEDGE

1.5.A.1

The atom is composed of negatively charged electrons and a positively charged nucleus that is made of protons and neutrons.

1.5.A.2

Coulomb's law is used to calculate the force between two charged particles.

EQN: $F_{coulombic} \propto \dfrac{q_1 q_2}{r^2}$

1.5.A.3

In atoms and ions, the electrons can be thought of as being in "shells (energy levels)" and "subshells (sublevels)," as described by the ground-state electron configuration. Inner electrons are called core electrons, and outer electrons are called valence electrons. The electron configuration is explained by quantum mechanics, as delineated in the Aufbau principle and exemplified in the periodic table of the elements.

> *Exclusion Statement: The assignment of quantum numbers to electrons in subshells of an atom will not be assessed on the AP Exam.*

LEARNING OBJECTIVE

1.5.A

Represent the ground-state electron configuration of an atom of an element or its ions using the Aufbau principle.

ESSENTIAL KNOWLEDGE

1.5.A.4

The relative energy required to remove an electron from different subshells of an atom or ion or from the same subshell in different atoms or ions (ionization energy) can be estimated through a qualitative application of Coulomb's law. This energy is related to the distance from the nucleus and the effective (shield) charge of the nucleus.

AVAILABLE RESOURCES
- Classroom Resource > **Exploring Atomic Structure Using Photoelectron Spectroscopy (PES) Data**
- The Exam > **2021 Chief Reader Report**

TOPIC 1.6
Photoelectron Spectroscopy

Required Course Content

LEARNING OBJECTIVE

1.6.A

Explain the relationship between the photoelectron spectrum of an atom or ion and:

i. The ground-state electron configuration of the species.

ii. The interactions between the electrons and the nucleus.

ESSENTIAL KNOWLEDGE

1.6.A.1

The energies of the electrons in a given shell can be measured experimentally with photoelectron spectroscopy (PES). The position of each peak in the PES spectrum is related to the energy required to remove an electron from the corresponding subshell, and the relative height of each peak is (ideally) proportional to the number of electrons in that subshell.

TOPIC 1.7
Periodic Trends

Required Course Content

LEARNING OBJECTIVE

1.7.A

Explain the relationship between trends in atomic properties of elements and electronic structure and periodicity.

ESSENTIAL KNOWLEDGE

1.7.A.1

The organization of the periodic table is based on patterns of recurring properties of the elements, which are explained by patterns of ground-state electron configurations and the presence of completely or partially filled shells (and subshells) of electrons in atoms.

> **Exclusion Statement:** *Writing the electron configuration of elements that are exceptions to the aufbau principle will not be assessed on the AP Exam.*

1.7.A.2

Trends in atomic properties within the periodic table (periodicity) can be predicted by the position of the element on the periodic table and qualitatively understood using Coulomb's law, the shell model, and the concepts of shielding and effective nuclear charge. These properties include:

i. Ionization energy
ii. Atomic and ionic radii
iii. Electron affinity
iv. Electronegativity.

1.7.A.3

The periodicity (in 1.7.A.2) is useful to predict/estimate values of properties in the absence of data.

SUGGESTED SKILL

⬟ *Model Analysis*

4.C

Explain the connection between particulate-level and macroscopic properties of a substance using models and representations.

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AVAILABLE RESOURCES

- Classroom Resource >
  Alternative Approaches to Teaching Traditional Topics

TOPIC 1.8
Valence Electrons and Ionic Compounds

Required Course Content

LEARNING OBJECTIVE

1.8.A

Explain the relationship between trends in the reactivity of elements and periodicity.

ESSENTIAL KNOWLEDGE

1.8.A.1

The likelihood that two elements will form a chemical bond is determined by the interactions between the valence electrons and nuclei of elements.

1.8.A.2

Elements in the same column of the periodic table tend to form analogous compounds.

1.8.A.3

Typical charges of atoms in ionic compounds are governed by the number of valence electrons and predicted by their location on the periodic table.