Part B: Unit Study Notes and Exam Questions

Unit 2 Chemical Reactions and Radioactivity

By the end of this unit, you should be able to:

1. Differentiate between atoms, ions, and molecules using knowledge of their structure and components
   This includes being able to:
   - ☐ demonstrate knowledge of the three subatomic particles, their properties, and their location within the atom (e.g., by creating models)
   - ☐ define and give examples of *ionic bonding* (e.g., metal and non-metal) and *covalent bonding* (e.g., two non-metals, diatomic elements)
   - ☐ with reference to elements 1 to 20 on the periodic table, draw and interpret Bohr models, including protons, neutrons, and electrons, of
     - atoms (neutral)
     - ions (charged)
     - molecules—covalent bonding (e.g., O_2, CH_4)
     - ionic compounds (e.g., $CaCl_2$)
   - ☐ identify valence electrons using the periodic table (excluding lanthanides and actinides)
   - ☐ distinguish between paired and unpaired electrons for a single atom
   - ☐ draw and interpret Lewis diagrams showing single bonds for simple ionic compounds (e.g., NaCl, MgO, $BaBr_2$) and covalent molecules (e.g., H_2O, CH_4, NH_3)
   - ☐ distinguish between lone pairs and bonding pairs of electrons and molecules
2. Classify substances as acids, bases, or salts, based on their characteristics, name, and formula
   This includes being able to:
   - ☐ identify acids and bases using indicators (e.g., methyl orange, bromothymol blue, litmus, phenolphthalein, indigo carmine)
   - ☐ explain the significance of the pH scale, with reference to common substances
   - ☐ differentiate between acids, bases, and salts with respect to chemical formulas and properties
   - ☐ recognize the names and formulas of common acids (e.g., hydrochloric, sulfuric, nitric, acetic)
   - ☐ use the periodic table to
     - explain the classification of elements as metals and non-metals
     - identify the relative reactivity of elements in the alkali metal, alkaline metal, halogen, and noble gas groups
     - distinguish between metal oxide solutions (basic) and non-metal oxide solutions (acidic)
   - ☐ use the periodic table and a list of ions (including polyatomic ions) to name and write chemical formulas for common ionic compounds, using appropriate terminology (e.g., Roman numerals)
   - ☐ convert names to formulas and formulas to names for covalent compounds, using prefixes up to "deca"
3. Distinguish between organic and inorganic compounds
   This includes being able to:
   - ☐ define *organic compounds* and *inorganic compounds*

   - ☐ distinguish between organic and inorganic compounds, based on their chemical structures
   - ☐ recognize a compound as organic or inorganic from its name, from its chemical formula, or from a diagram or model
4. Analyze chemical reactions, including reference to conservation of mass and rate of reaction
   This includes being able to:
   - ☐ define and explain the law of conservation of mass
   - ☐ represent chemical reactions and the conservation of atoms, using molecular models
   - ☐ write and balance (using the lowest whole number coefficients) chemical equations from formulae, word equations, or descriptions of experiments
   - ☐ identify, give evidence for, predict products of, and classify the following types of chemical reactions:
     - synthesis (combination)
     - decomposition
     - single and double replacement
     - neutralization (acid-base)
     - combustion
   - ☐ explain how factors such as temperature, concentration, presence of a catalyst, and surface area can affect the rate of chemical reactions
5. Explain radioactivity using modern atomic theory
   - define *isotope* in terms of atomic number and mass number, recognizing how these are communicated in standard atomic notation (e.g., uranium-238: $^{238}_{92}U$)
   - relate radioactivity decay (e.g., alpha—α, beta—β, gamma—γ) to changes in the nucleus
   - relate the following subatomic particles to radioactive decay:
     - proton ($^{1}_{1}p$)
     - neutron ($^{1}_{0}n$)
     - electron ($^{0}_{-1}e$)
     - alpha particle ($^{4}_{2}\alpha$) ($^{4}_{2}He$)
     - beta particle ($^{0}_{-1}\beta$)
   - ☐ explain half-life with reference to rates of radioactive decay
   - ☐ compare fission and fusion
   - ☐ complete and balance nuclear equations to illustrate radioactive decay, fission, and fusion

By the end of this unit, you should understand the following key ideas:

1. Atomic theory explains the formation of compounds.
2. Compounds are classified in different ways.
3. Chemical reactions occur in predictable ways.
4. The atomic theory explains radioactivity.

To help you study you should have the following:

- *BC Science 10* student book, pages 163 to 337. Note the practice exam questions on pages 336 and 337.
- BC Science 10 Provincial Exam Data Pages, pages 1 to 4.
- BC Science 10 Provincial Exam Vocabulary List, page 2
- Access to www.bcscience10.ca.

7.3 Nuclear Reactions

I. Summary of Key Points

- Fission is a nuclear reaction in which a large nucleus breaks apart, producing two or more smaller nuclei, subatomic particles, and energy.
- Fission is the source of energy for all nuclear power generation used today.
- The daughter products are often radioactive and are a significant waste disposal problem.
- Fusion is a nuclear reaction in which small nuclei combine to produce a larger nucleus.
- Other subatomic particles as well as energy are released in this process.
- Fusion is the source of energy in the Sun.

II. Study Notes

Nuclear Fission

1. **Fission** is the process by which a large nucleus splits into two pieces of roughly equal mass, accompanied by the release of large amounts of energy.
2. Nuclear reactions are different than chemical reactions.
   - In chemical reactions, mass is conserved, energy changes are relatively small.
   - There are no changes to the nuclei in chemical reactions.
3. In nuclear reactions, the nucleus of an atom changes.
   - Protons, neutrons, electrons, and/or gamma rays can be lost or gained.
   - Small changes of mass = huge changes in energy

Nuclear Equations for Induced Nuclear Reactions

1. Scientists can induce (force) nuclear reactions by smashing nuclei with alpha, beta, and gamma radiation (Figure 7.3).
2. The rules for writing equations for induced nuclear reactions are:
   - The sum of the mass numbers on each side of the equation stays the same.
   - The sum of the charges (represented by atomic numbers) on each side of the equation stays the same.

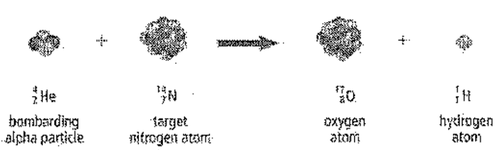


FIGURE 7.3 When a nitrogen-14 nucleus is bombarded by an alpha particle, a fluorine-18 nucleus is produced, which decays into oxygen-17 and a hydrogen atom.

Quick Check

1. What is a fission nuclear reaction? ____________________

____

2. What two quantities do not change during a nuclear reaction?

____________________ ____________________

Getting Help

When you study for a year-end test like the provincial exam, it is not uncommon to get stuck on concepts or have questions on material you have previously covered in class. If you are unsure about a concept or something covered in class, check with a classmate first. If both of you cannot figure out the answer, visit your teacher together.

Tips from Experts

Study experts have a common list of hints they provide to people of all ages. Research has shown that these tips help you study.

- Have a **positive attitude.**
- **Be motivated** and take responsibility for your learning.
- **Attend class** so you do not miss key points about what you are learning. Your friend's notes are not a replacement for being present in class and learning the concepts while they are being taught.
- **Study regularly** to help you identify areas where you need extra help.
- **Get help** when you need it, and do not be afraid to ask questions. There are no bad questions when it comes to figuring something out.
- **Be a good test taker.** Have a good sleep the night before the test and be sure to eat a nutritious breakfast the day of the test. During the test, read each question carefully before selecting your answer.

Here is a list of common hints that science teachers in British Columbia have shared with their students.

- Know how to use your Data Pages.
- Practise reading graphs.
- Practise interpreting illustrations.
- Do not spend extra time studying what you already know.
- When you are writing the exam, read the question first, then read the possible answers. If you do not know the answer, then look at the picture (if there is a picture).
- Take your time when you write the exam. Answer the questions you know first, and then go back to questions that you are not sure of.

Chapter 7 The atomic theory explains radioactivity.

7.1 Atomic Theory, Isotopes, and Radioactive Decay

I. Summary of Key Points

- Radiation refers to high-energy rays and particles emitted by radioactive sources.
- Isotopes are atoms of the same element that differ in the number of neutrons in the nucleus.
- Radioisotopes are natural or human-made isotopes that decay into other isotopes, releasing radiation.
- The three major types of radiation are alpha particles, beta particles, and gamma rays.
- A nuclear reaction occurs when radiation is released from the nucleus.
- Radioactivity results when the nucleus of an atom decays.
- If the atom emits one or more protons as it decays, the atom changes into an atom of another element.

II. Study Notes

Isotopes and Mass Number

1. **Mass number** is the total number of protons and neutrons found in the nucleus of an atom.
   - **Atomic mass** is the average total mass of the protons, neutrons, and electrons that make up an atom.
2. **Isotopes** are atomic nuclei of the same element having the same number of protons but different numbers of neutrons.
   - Isotopes of an element have the same symbol and the same atomic number (number of protons) as each other.
   - Since they have different numbers of neutrons, isotopes have different mass numbers.

Representing Isotopes

1. Isotopes are represented using **standard atomic notation** or **isotope notation**, which shows the chemical symbol, the atomic number, and the mass number.
   - The mass number is written above the atomic number.
   - The isotope potassium-39 is written $^{39}_{19}K$, which shows that there are a total of 39 protons and neutrons, of which 19 are protons.

Radioactive Decay

1. **Radiation** is the high-energy rays and particles emitted by a substance as a result of changes in the nuclei of its atoms.
   - Radioactive atoms emit radiation because their nuclei are unstable. When these nuclei lose energy and break apart, radioactive decay occurs.
   - Radioactive atoms release energy until they become stable, often as different atoms.
   - An element may have only certain isotopes that are radioactive. These are called radioisotopes.
2. **Radioactive decay** is the process in which the nuclei of radioactive parent isotopes emit alpha, beta, or gamma radiation to form decay products.

7.2 Half-Life

I. Summary of Key Points

- A half-life can be used to compare the rate of radioactive decay for an isotope.
- The shorter the half-life, the faster the decay rate.
- All radioactive decay rates follow a similar pattern called a decay curve.
- The difference between different isotopes is the length of their half-lives.
- The Common Isotope Pairs Chart identifies the parent isotope (which decays) and the daughter isotope (one of the decay products).
- The chart also shows the half-life of the parent and the dating range the isotope can be used for in radioisotope dating.
- A decay curve can be used to estimate the amount of parent isotope remaining or the amount of daughter isotope produced at any time after the radioactive sample first formed or, in the case of carbon dating, after the organism died.

II. Study Notes

Carbon Dating and The Rate of Radioactive Decay

1. **Half-life** is the amount of time required for half the nuclei in a sample of a radioactive isotope to decay.
   - Strontium-90 has a half-life of 29 years. If you have 10 g of strontium-90 today, there will be 5.0 g remaining in 29 years.
2. The half-life for a radioactive element is a constant rate of decay.
3. Radioactivity provides a method to determine age of objects by measuring relative amounts of remaining radioactive material to stable products formed, such as the ratio of carbon-14 atoms to carbon-12 atoms.

Quick Check

Use this information to answer questions 3 and 4:

Suppose a 64 gram sample of a certain isotope has a half-life of 1000 years.

1. What is a half-life? ____________________

____

2. How does radioactivity provide a method for determining the age of objects? ____________________

____

____

3. State what length of time has gone by after:
   (a) two half-lives ____________
   (b) four half-lives ____________
4. How many grams of the isotope are left after:
   (a) 1000 years ____________
   (b) 2000 years ____________
   (c) three half-lives ____________

Chapter 6 Chemical reactions occur in predictable ways.

6.1 Types of Chemical Reactions

I. Summary of Key Points

- Chemical reactions can be classified as one of six main types: synthesis, decomposition, single replacement, double replacement, neutralization (acid-base), and combustion.
- You can identify each type of reaction by examining the reactants.
- This makes it possible to classify a reaction and then predict the identity of the products.

II. Study Notes

Synthesis Reactions

1. **Synthesis** (combination) is a type of chemical reaction in which two or more elements or compounds combine to form a single compound.
   - $A + B \rightarrow AB$ where A and B represent elements
   - The elements may form ionic compounds.
     Example: Sodium metal and chlorine gas combine to form sodium chloride.
     $2Na + Cl_2 \rightarrow 2NaCl$
     Example: Magnesium metal reacts with oxygen gas to form magnesium oxide.
     $2Mg + O_2 \rightarrow 2MgO$
   - The elements may form covalent compounds.
     Example: Nitrogen gas and oxygen gas join to form dinitrogen monoxide.
     $2N_2 + O_2 \rightarrow 2N_2O$

Quick Check

1. Complete and balance the following synthesis reactions. Remember to consider the chemical formulas of the products carefully before you begin to balance.
   (a) ____ Al + ____ $F_2 \rightarrow$ ____________
   (b) ____ K + ____ $O_2 \rightarrow$ ____________
   (c) ____ Cd + ____ $I_2 \rightarrow$ ____________
2. Identify whether each of the following chemical equations is a synthesis reaction.
   (a) $2Fe + 3CuCl_2 \rightarrow 2FeCl_3 + 3Cu$ ____________
   (b) $2KClO_3 \rightarrow 2KCl + 3O_2$ ____________
   (c) $2Ni + 3Cl_2 \rightarrow 2NiCl_3$ ____________

6.2 Factors Affecting the Rate of Chemical Reactions

I. Summary of Key Points

- Understanding the factors that affect reaction rates helps chemists speed up or slow down chemical reactions.
- Four main factors affect the rate of chemical reactions: temperature (hotter is faster), surface area (the more surface contact between reactants, the faster the reaction), concentration (the greater the concentration, the faster the reaction rate), and the presence of a catalyst (the catalyst helps the reaction go more quickly but is still present in the same amount at the end of the reaction).

II. Study Notes

Temperature

1. In a chemical reaction, how quickly or how slowly reactants turn into products is called rate of reaction.
2. The rate of reaction changes with the temperature.
   - Temperature is a measure of the average energy of molecules.
3. The more energy molecules have, the higher the temperature.
   - When molecules have more energy, they react faster.
   - Higher temperature = faster reaction rate
     Example: We cook food to speed up the chemical reactions.
   - Lower temperature = slower reaction rate
     Example: We refrigerate food to slow down the chemical reactions.

Concentration

1. **Concentration** is the amount of solute present in a specific volume of a solution.
   - Concentration is measured in mass per unit volume (g/L).
2. Usually, the higher the concentration of reactants, the faster the reaction occurs.
   - Since there are more molecules per unit volume in high concentrations, there are more opportunities for molecules to collide and react.
   - A splint of wood glows brighter in highly concentrated oxygen than in normal air with a lower concentration of oxygen.

Quick Check

1. What happens to the rate of a chemical reaction when the temperature is raised?
   ____
2. What does cooling do to the frequency at which particles of reactants can collide?
   ____
3. How does increasing the concentration of an acid result in an increase in reaction rate between the acid and a piece of aluminum metal placed in it? ____________
   ____
   ____
4. Why does blowing on a campfire speed the burning process? ____________
   ____
   ____

5.2 Salts

I. Summary of Key Points

- Salts are a class of compounds including ionic compounds that can be produced when an acid and a base react.
- Oxides and carbonates can chemically react with acids and produce salts.
- Salts can also be produced by the chemical reaction of a metal and an acid.
- Metal oxides combine with water to form bases.
- Non-metal oxides combine with water to form acids.

II. Study Notes

Salts

1. **Salts** are ionic compounds formed when acids and bases react.
2. Salts are also produced when oxides or carbonates react with acids, or when metals react with acids.
3. A salt is made up of a positive ion from a base and negative ion from an acid.

Acid-Base Neutralization and Metal Oxides and Non-Metal Oxides

1. Neutralization reactions occur when an acid and a base react to produce a salt and water.
   Example: $HCl(aq) + NaOH(aq) \rightarrow NaCl(s) + H_2O(\ell)$
   acid *base* *salt* *water*
2. A **metal oxide** is a chemical compound that contains a metal chemically combined with oxygen.
   - Metal oxides react with water to form bases.
     Example: $Na_2O(s) + H_2O(\ell) \rightarrow 2NaOH(aq)$
3. A **non-metal oxide** is a chemical compound that contains a non-metal chemically combined with oxygen.
   - Non-metal oxides react with water to form acids.
     Example: $SO_2(g) + H_2O(\ell) \rightarrow H_2SO_3(aq)$
   - Non-metal oxides are formed from the burning of fossil fuels.
   - Non-metal oxides dissolve in rainwater to produce acid precipitation.

Quick Check

1. Identify each of the following as an acid, a base, a salt, a metal oxide, or a non-metal oxide.
   (a) $Ba(OH)_2$ ____________
   (b) H_2SO_4 ____________
   (c) NaCl ____________
   (d) K_2O ____________
   (e) SO_2 ____________
2. Which kinds of oxides react with water to form acid precipitation? ____________
3. Complete and balance the following neutralization reactions.
   (a) ___ HF + ___ KOH → ____________
   (b) ___ H_2SO_4 + ___ NaOH → ____________
   (c) ___ HNO_3 + ___ $Mg(OH)_2$ → ____________

5.3 Organic Compounds

I. Summary of Key Points

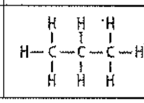
- Organic compounds always contain carbon and almost always contain hydrogen as well.
- Other elements, including metals and non-metals, may also be present.
- Inorganic compounds are all other compounds.
- To recognize a compound as organic, look for an indication of the presence of carbon in its name, chemical formula, or diagram.
- Organic chemistry is the study of compounds that contain carbon.

II. Study Notes

Organic Compounds

1. **Organic** compounds contain carbon and usually contain hydrogen.
   - Organic molecules always have C before H in their formulas.
     - This differentiates organic compounds from acids, which almost always start with H.
   - Carbon has four electrons in its valence shell, which allows for more chemical bonding possibilities than any other element.
2. **Inorganic** compounds are compounds that do not have carbon.
   - Some exceptions to this rule include carbon dioxide and carbon monoxide, which are inorganic compounds even though they contain carbon.
   - Other exceptions to the rule are that carbonates (e.g., $CaCO_3$) and carbides (e.g., SiC) are inorganic.
3. Organic compounds can be represented in several different ways as shown in Table 5.2.

TABLE 5.2 Different Ways of Representing Propane

Name	Molecular Formula	Structural Formula	Shortened Structural Formula	Space-Filling Model
propane	C_3H_8		$CH_3CH_2CH_3$	

Quick Check

1. What element must be present for a compound to be considered organic? ____________
2. What are three examples of compounds containing carbon that are inorganic?
   ____
   ____
   ____

4.3 Chemical Equations

I. Summary of Key Points

- A chemical change is a change in the arrangements and connections between ions and atoms.
- One or more chemical changes that occur at the same time are called a chemical reaction.
- Chemical reactions can be represented using a chemical equation.
- A chemical equation may be written in words or in chemical symbols.
- In a chemical reaction, the reactants are written to the left of an arrow and the products are written to the right.
- The symbols for states of matter may be used to show whether each reactant or product is solid, liquid, gas, or aqueous.
- Chemical reactions obey the law of conservation of mass, and atoms are neither created nor produced in a chemical reaction.
- Chemical equations are balanced using the lowest whole number coefficients, which are numbers written in front of the pure substances in the reaction.

II. Study Notes

Chemical Reactions

1. A chemical change occurs when the arrangement of atoms in compounds changes to form new compounds.
2. One or more chemical changes that happen at the same time are called a chemical reaction.
3. The original substances, called reactants, change into new substances called products.
4. Chemical reactions can be written in different ways.
   - A word equation:
     Example: Nitrogen monoxide + oxygen → nitrogen dioxide
   - A **symbolic equation** is a set of chemical symbols and formulas that identify the reactants and products in a chemical reaction.
     Example: $2NO + O_2 \rightarrow 2NO_2$

Conservation of Mass in Chemical Change

1. Chemical change means new compounds are created, but no new matter is created or destroyed; atoms are just rearranged.
   - All of the matter in the reactants = all of the matter in the products
   - Number of each atom in reactants = number of each atom in products
2. The **law of conservation of mass** states that mass is conserved in a chemical reaction; the total mass of the products is always equal to the total mass of the reactants in a chemical reaction.
   - In chemical reactions, atoms are neither created nor destroyed.
   - The law of conservation of mass was formulated by Antoine and Marie-Anne Lavoisier in the 1700s.

Quick Check

1. When does a chemical change occur? ______________________________

____

2. What are two ways that a chemical reaction can be written? ______________________________

____

3. State the law of conservation of mass. ______________________________

____

Chapter 5 Compounds are classified in different ways.

5.1 Acids and Bases

I. Summary of Key Points

- Many common pure substances can be classified according to whether they are acids or bases.
- Some acids and bases are corrosive and poisonous, whereas others add flavour to food or are vitamins.
- Acid-base indicators are chemicals that change colour in response to acidic or basic conditions.
- The pH scale is a number scale for measuring how acidic or basic a solution is.
- A pH value below pH 7 is acidic, ph7 is neutral, and a pH value above pH 7 is basic.
- Generally, the chemical formula for an acid starts with H (hydrogen) on the left of the formula.
- Bases generally have an OH on the right of the chemical formula.

II. Study Notes

The pH Scale

1. Many familiar compounds are acids or bases.
2. Classification as acids or bases is based on chemical composition.
   - Both acids and bases can be very corrosive so you should NEVER try to identify an acid or base by taste or touch!
3. The acidity level of solutions of acids and bases is measured on the pH scale.
   - The **pH scale** is a number scale for measuring how acidic or basic a solution is.
   - pH below 7 = **acidic**, pH above 7 = **basic**, pH 7 = neutral
4. Each decrease of 1 on the pH scale indicates 10× more acidic.
   Examples: pH 4 is 10 times more acidic than pH 5.
   pH 3 is 1000× more acidic than pH6.
5. **Acids** are compounds that produce a solution of less than pH 7 when they dissolve in water.
6. **Bases** are compounds that produce a solution of more than pH 7 when they dissolve in water.
7. If a solution has a pH of 7, it is said to be **neutral**, neither acidic nor basic.

Quick Check

1. What is the pH range for each of these solutions?
   (a) acidic ______________________________
   (b) basic ______________________________
2. How many times has the acidity level increased if the pH drops from pH 4 to pH 3? __________
3. How many times has the acidity level increased if the pH drops from pH 6 to pH 2? __________
4. What is the pH of a solution that is neutral? __________

Chapter 4 Atomic theory explains the formation of compounds.

4.1 Atomic Theory and Bonding

I. Summary of Key Points

- Atoms are composed of protons and neutrons, which make up the nucleus, and electrons, which surround the nucleus in patterns.
- Bohr diagrams show the arrangement of protons, neutrons, and electrons in atoms and also in ions.
- Ions are formed from atoms that have lost or gained electrons.
- Compounds can be ionic or covalent.
- Lewis diagrams show the arrangement of bonds within compounds.

II. Study Notes

Atomic Theory

1. An **atom** is the smallest particle of an element that has the properties of that element.
2. An element is a pure substance that cannot be chemically broken down into simpler substances.
   Example: Oxygen (O) is an element.
3. A **compound** is a pure substance that is made up of two or more different elements that have been combined in a specific way.
   Example: H_2O is a compound made of the elements hydrogen and oxygen.
4. An atom includes smaller particles called protons, neutrons, and electrons
   - **Protons** are subatomic particles that have a 1+ (positive) charge.
   - **Neutrons** are subatomic particles that do not have an electric charge.
   - **Electrons** are subatomic particles that have a 1– (negative) electric charge.

The Nucleus

1. The nucleus is at the centre of an atom (Figure 4.1).
   - The nucleus is composed of protons and neutrons.
   - Electrons exist in the area surrounding the nucleus.
2. The number of protons = the number of electrons in every atom
3. The nuclear charge = the electric charge on the nucleus = the number of protons
4. The **atomic number** = the number of protons = the number of electrons

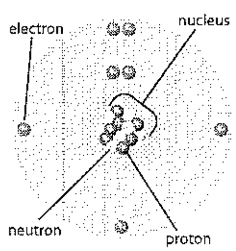


FIGURE 4.1 A model of an atom

4.2 Names and Formulas of Compounds

I. Summary of Key Points

- Compounds can be represented with both a name and a chemical formula.
- In an ionic compound, the first part of the name indicates the positive ion and the second part indicates the negative ion.
- In the formula of an ionic compound, the subscripts indicate the ratio in which the positive ions and negative ions are present together in the compound.
- In a binary compound, both the name and the formula indicate the number of each type of atom present in the compound.

II. Study Notes

The Chemical Name of an Ionic Compound

1. The name of an ionic compound always has two parts, one for each type of ion in it.
   - The name of an ionic compound = positive ion + negative ion + *-ide*
     Example: *magnesium* (positive ion) + *oxygen* (negative ion) + *-ide*
     magnesium oxide
2. Ionic formulas are based on the ions of the atoms involved.
   Example: What is the name of Ca_3N_2?
   Ca, the positive ion, is calcium
   N, the negative ion, is nitrogen
   Drop the end of the negative ion and add *-ide*
   calcium nitride

The Chemical Formula of an Ionic Compound

1. In an ionic compound, the positive charges balance out the negatives.
2. The subscript gives the ratio of each type of ion in the compound.
3. The ratio of positive to negative charges gives the proper formula.
4. The ratio is always written in reduced form.
   Example: What is the formula for magnesium phosphide?
   Magnesium is Mg^{2+}
   Phosphorous is P^{3-}
   Lowest common multiple of 2 and 3 is 6
   3 Mg^{2+} ions and 2 P^{3-} ions
   Mg_3P_2

Quick Check

1. Name the following ionic compounds.
   (a) Li_3P ______________________
   (b) $CaCl_2$ ______________________
   (c) ZnO ______________________
2. Write the formulas of the following ionic compounds.
   (a) sodium sulfide ______________________
   (b) magnesium iodide ______________________
   (c) aluminum oxide ______________________

Part B: Unit Study Notes and Exam Questions

Unit 2 Chemical Reactions and Radioactivity

By the end of this unit, you should be able to:

1. Differentiate between atoms, ions, and molecules using knowledge of their structure and components
   This includes being able to:
   - ☐ demonstrate knowledge of the three subatomic particles, their properties, and their location within the atom (e.g., by creating models)
   - ☐ define and give examples of *ionic bonding* (e.g., metal and non-metal) and *covalent bonding* (e.g., two non-metals, diatomic elements)
   - ☐ with reference to elements 1 to 20 on the periodic table, draw and interpret Bohr models, including protons, neutrons, and electrons, of
     - atoms (neutral)
     - ions (charged)
     - molecules—covalent bonding (e.g., O_2, CH_4)
     - ionic compounds (e.g., $CaCl_2$)
   - ☐ identify valence electrons using the periodic table (excluding lanthanides and actinides)
   - ☐ distinguish between paired and unpaired electrons for a single atom
   - ☐ draw and interpret Lewis diagrams showing single bonds for simple ionic compounds (e.g., NaCl, MgO, $BaBr_2$) and covalent molecules (e.g., H_2O, CH_4, NH_3)
   - ☐ distinguish between lone pairs and bonding pairs of electrons and molecules
2. Classify substances as acids, bases, or salts, based on their characteristics, name, and formula
   This includes being able to:
   - ☐ identify acids and bases using indicators (e.g., methyl orange, bromothymol blue, litmus, phenolphthalein, indigo carmine)
   - ☐ explain the significance of the pH scale, with reference to common substances
   - ☐ differentiate between acids, bases, and salts with respect to chemical formulas and properties
   - ☐ recognize the names and formulas of common acids (e.g., hydrochloric, sulfuric, nitric, acetic)
   - ☐ use the periodic table to
     - explain the classification of elements as metals and non-metals
     - identify the relative reactivity of elements in the alkali metal, alkaline metal, halogen, and noble gas groups
     - distinguish between metal oxide solutions (basic) and non-metal oxide solutions (acidic)
   - ☐ use the periodic table and a list of ions (including polyatomic ions) to name and write chemical formulas for common ionic compounds, using appropriate terminology (e.g., Roman numerals)
   - ☐ convert names to formulas and formulas to names for covalent compounds, using prefixes up to "deca"
3. Distinguish between organic and inorganic compounds
   This includes being able to:
   - ☐ define *organic compounds* and *inorganic compounds*

   - ☐ distinguish between organic and inorganic compounds, based on their chemical structures
   - ☐ recognize a compound as organic or inorganic from its name, from its chemical formula, or from a diagram or model
4. Analyze chemical reactions, including reference to conservation of mass and rate of reaction
   This includes being able to:
   - ☐ define and explain the law of conservation of mass
   - ☐ represent chemical reactions and the conservation of atoms, using molecular models
   - ☐ write and balance (using the lowest whole number coefficients) chemical equations from formulae, word equations, or descriptions of experiments
   - ☐ identify, give evidence for, predict products of, and classify the following types of chemical reactions:
     - synthesis (combination)
     - decomposition
     - single and double replacement
     - neutralization (acid-base)
     - combustion
   - ☐ explain how factors such as temperature, concentration, presence of a catalyst, and surface area can affect the rate of chemical reactions
5. Explain radioactivity using modern atomic theory
   - define *isotope* in terms of atomic number and mass number, recognizing how these are communicated in standard atomic notation (e.g., uranium-238: $^{238}_{92}U$)
   - relate radioactivity decay (e.g., alpha—α, beta—β, gamma—γ) to changes in the nucleus
   - relate the following subatomic particles to radioactive decay:
     - proton ($^{1}_{1}p$)
     - neutron ($^{1}_{0}n$)
     - electron ($^{0}_{-1}e$)
     - alpha particle ($^{4}_{2}\alpha$) ($^{4}_{2}He$)
     - beta particle ($^{0}_{-1}\beta$)
   - ☐ explain half-life with reference to rates of radioactive decay
   - ☐ compare fission and fusion
   - ☐ complete and balance nuclear equations to illustrate radioactive decay, fission, and fusion

By the end of this unit, you should understand the following key ideas:

1. Atomic theory explains the formation of compounds.
2. Compounds are classified in different ways.
3. Chemical reactions occur in predictable ways.
4. The atomic theory explains radioactivity.

To help you study you should have the following:

- *BC Science 10* student book, pages 163 to 337. Note the practice exam questions on pages 336 and 337.
- BC Science 10 Provincial Exam Data Pages, pages 1 to 4.
- BC Science 10 Provincial Exam Vocabulary List, page 2
- Access to www.bcscience10.ca.