# Answers to Unit 2, Chapter 3, Lesson 3 Questions: U2Ch3L3

## Essential Question

1. How do isotopes affect the atomic mass of an element?  
 - Isotopes are atoms of the same element with differing numbers of neutrons. This difference causes variations in the mass number. The atomic mass of an element is calculated as a weighted average based on the relative abundance of each isotope in nature. For example, the atomic mass of chlorine (approximately 35.45 amu) reflects the relative abundances of its isotopes, chlorine-35 and chlorine-37.

## Progress Check 1

2. Compare the number of subatomic particles in hydrogen (H), deuterium (D), and tritium (T):  
 - Hydrogen (H): 1 proton, 0 neutrons, 1 electron.  
 - Deuterium (D): 1 proton, 1 neutron, 1 electron.  
 - Tritium (T): 1 proton, 2 neutrons, 1 electron.

3. Calculate their atomic number and mass numbers:  
 - Hydrogen (H): Atomic number = 1, Mass number = 1.  
 - Deuterium (D): Atomic number = 1, Mass number = 2.  
 - Tritium (T): Atomic number = 1, Mass number = 3.

## Progress Check 2

4. What are the differences between atoms of the same element with different masses?  
 - Atoms of the same element with different masses are isotopes. They have the same number of protons and electrons but differ in the number of neutrons. This difference affects their physical properties, such as mass, while their chemical properties remain similar.

## Progress Check 3

5. A molecule of water is made of two protium and one oxygen atom. Another molecule of water is made of two \( ^2H \) (D) and one oxygen atom. How are these molecules different or the same?  
 - The molecules are chemically the same, as both have the molecular formula \( H\_2O \). However, the second molecule, containing deuterium, has a greater mass due to the extra neutrons in deuterium. This difference can affect physical properties like boiling and freezing points.

## Progress Check 4

6. Carbon has two stable isotopes: Carbon-12 and Carbon-13. The relative abundances of these isotopes are as follows: Carbon-12 makes up 98.9% of natural carbon, while Carbon-13 accounts for 1.1%. Using this information, calculate the average atomic mass of carbon:  
 - Formula:   
 Atomic Mass = (Relative abundance of \( ^{12}C \) × Mass of \( ^{12}C \)) + (Relative abundance of \( ^{13}C \) × Mass of \( ^{13}C \))  
 Atomic Mass = (0.989 × 12) + (0.011 × 13)  
 Atomic Mass = 11.868 + 0.143 = 12.011 amu.

## Progress Check 5

7. Can you find one real-world example where either Carbon-12 or Carbon-14 is used? Share your findings with the class:  
 - Carbon-12 is used in calculating atomic masses as a standard reference.  
 - Carbon-14 is used in radiocarbon dating to estimate the age of organic materials, such as fossils and archaeological artifacts.

## Lesson Check

8. Describe how the concept of isotopes can explain the difference in the atomic masses of elements such as oxygen, which has isotopes oxygen-16 and oxygen-18:  
 - The atomic mass of oxygen is a weighted average of its isotopes. While oxygen-16 is more abundant, oxygen-18 has a higher mass due to two additional neutrons. This isotopic variation leads to an average atomic mass of approximately 16.00 amu.

9. Analyze the role of Carbon-14 isotopes in radiocarbon dating. How does the atomic structure of this isotope allow scientists to estimate the age of organic materials?  
 - Carbon-14 is radioactive and decays over time at a known rate (half-life of about 5730 years). Scientists measure the remaining Carbon-14 in a sample to estimate its age, as the isotope's decay correlates with the time elapsed since the organism's death.

10. A sample of boron contains 80% \( ^{10}B \) and 20% \( ^{11}B \). Calculate the average atomic mass of the sample:  
 - Formula:   
 Atomic Mass = (Relative abundance of \( ^{10}B \) × Mass of \( ^{10}B \)) + (Relative abundance of \( ^{11}B \) × Mass of \( ^{11}B \))  
 Atomic Mass = (0.80 × 10) + (0.20 × 11)  
 Atomic Mass = 8.0 + 2.2 = 10.2 amu.

11. Explain why isotopes of an element exhibit the same chemical properties but different physical properties:  
 - Isotopes have the same number of protons and electrons, which determines their chemical behavior. Differences in neutrons result in variations in mass, affecting physical properties like density and boiling points.

12. Magnesium has three common isotopes: magnesium-24, magnesium-25, and magnesium-26. Which of the three is the most abundant? Explain your answer:  
 - Magnesium-24 is the most abundant because the atomic mass of magnesium (24.305 amu) is closest to its mass.

13. Iron exists with four stable isotopes:  
 - Correct atomic mass: C) 55.84 amu.  
 - How to calculate atomic mass: C) Calculation of the weighted average of isotope masses as per their relative abundances.  
 - Correct statement regarding isotopes of Fe: A) Due to the highest abundance of \( ^{56}Fe \), it contributes most to the atomic mass.

## Beyond the Lesson

14. Explore the concept of isotopes, their properties, applications in everyday life, safety, and environmental impacts of products that contain isotopes:  
 - Isotopes are used in diverse industries such as:  
 - Medicine: Radioactive isotopes like iodine-131 for thyroid treatment.  
 - Energy: Uranium-235 as nuclear reactor fuel.  
 - Agriculture: Tracers to study plant nutrient uptake.  
 - Environmental Science: Tracking pollution sources using nitrogen isotopes.  
 - Safety: Rules and regulations ensure isotopes are safely handled and disposed of, reducing health and environmental risks.