PW35-Determining Atomic Mass From Isotopes and Natural Abundance

1) Chlorine has two naturally occurring isotopes: Chlorine-35 and Chlorine-37. The natural abundance of the isotopes, respectively, are 75.78% and 24.22%. Determine the atomic mass for chlorine. (You may check your answers against the periodic table. Remember: your answers will be close, but not exact. I did this on purpose.). \textbf{4 min maximum}

2) Lithium-6 has a natural abundance of 7.59%. Lithium-7 has a natural abundance of 92.41%. Calculate the atomic mass of lithium. \textbf{4 min maximum}

3) Iron has four naturally occurring isotopes: iron-54 (5.845% abundance), iron-56 (91.754% abundance), iron-57 (2.119% abundance), and iron-58 (0.282% abundance). Calculate the atomic mass of iron. \textbf{5 min maximum}

\textbf{Notes about Question 3}

- Question 3 looks tedious, but if you are weak with percentages I would definitely do this one.
- If you got Question 3 wrong, you should look at the solution and then try Question 6.

4) Silicon has three naturally occurring isotopes: silicon-28, silicon-29, and silicon-30. The natural abundance of each isotope, respectively, are 92.23%, 4.68%, and 3.09%. Calculate the atomic mass of silicon. \textbf{5 min maximum}

5) The natural abundances of boron-10 and boron-11 are 19.9% and 80.1%, respectively. Calculate the atomic mass of boron. \textbf{4 min maximum}

6) Nickel has five naturally occurring isotopes: nickel-58, nickel-60, nickel-61, nickel-62, and nickel-64. The percent abundance values, respectively, are as follows: 68.0769%, 26.2231%, 1.1399%, 3.6346%, and 0.9256%. Calculate the atomic mass of nickel. \textbf{6 min maximum}

\textbf{Notes}

- Because I used approximate values for the atomic mass of each isotope, the atomic mass values should be very close to the values on the periodic table, but they should not match.
- If they match, I know that you are bluffing.
- You must show the setup, and you must show units through every step.
- Remember that the final answer should have units.
- Ignore sigfigs rules for atomic mass calculations. No matter what is in front of the decimal point, each answer should be written with two digits total after the decimal point.
- The answer key is on the next page.
- The solutions are begin on the page after the answer key.
Answers
1) 35.48 amu (which is very close to 35.45 amu on the periodic table).
2) 6.92 amu (which is very close to 6.94 amu on the periodic table).
3) 55.91 amu (which is very close to 55.85 amu on the periodic table).
4) 28.11 amu (which is very close to 28.09 amu on the periodic table)
5) 10.80 amu (which is very close to 10.81 amu on the periodic table)
6) 58.76 amu (which is very close to 58.69 amu on the periodic table)

Detailed Solutions are on the next page
Solutions

- First, if you are not getting the right answers – **and you did not show all steps/all work** – go back and redo these, showing each step. That way, you can find where you made your error.
- Remember, you must show at least two steps between your set up and your final answer.
- There are two ways to set this information up. I will show you both ways in this Solutions Set.

1) Chlorine has two naturally occurring isotopes: Chlorine-35 and Chlorine-37. The natural abundance of the isotopes, respectively, are 75.78% and 24.22%. Determine the atomic mass for chlorine. (You may check your answers against the periodic table. Remember: your answers will be close, but not exact. I did this on purpose.). **4 min maximum**

**Method 1**

Set Up: 
\[35 \text{ amu} \times \frac{75.78}{100}\] + \[37 \text{ amu} \times \frac{24.22}{100}\]

Step 1: 
\[35 \text{ amu} \times 0.7578\] + \[37 \text{ amu} \times 0.2422\]

Step 2: 
26.5230 amu + 8.9614 amu

Answer: 
35.4844 amu \rightarrow 35.48 amu

**Method 2**

\[
\begin{align*}
35 \text{ amu} \times \frac{75.78}{100} &= 35 \text{ amu} \times 0.7578 = 26.5230 \text{ amu} \\
37 \text{ amu} \times \frac{24.22}{100} &= 37 \text{ amu} \times 0.2422 = 8.9614 \text{ amu}
\end{align*}
\]

(add)

35.4844 amu

\[
\begin{array}{c}
\downarrow \\
35.48 \text{ amu}
\end{array}
\]
2) Lithium-6 has a natural abundance of 7.59%. Lithium-7 has a natural abundance of 92.41%. Calculate the atomic mass of lithium. **4 min maximum**

**Method 1**

Set Up: \[ [6 \text{ amu} \times (7.59 \div 100)] + [7 \text{ amu} \times (92.41 \div 100)] \]

Step 1: \[ [6 \text{ amu} \times 0.0759] + [7 \text{ amu} \times 0.9241] \]

Step 2: 0.4554 amu + 6.5687 amu

Answer: 6.9241 amu \rightarrow 6.92 \text{ amu}

**Method 2**

\[
\begin{align*}
6 \text{ amu} \times 7.59 \div 100 &= 35 \text{ amu} \times 0.0759 = 0.4554 \text{ amu} \\
7 \text{ amu} \times 92.41 \div 100 &= 37 \text{ amu} \times 0.9241 = 6.5687 \text{ amu}
\end{align*}
\]

\[ 0.4554 \text{ amu} + 6.5687 \text{ amu} = 6.9241 \text{ amu} \]

\[ \downarrow \]

\[ 6.92 \text{ amu} \]
Iron has four naturally occurring isotopes: iron-54 (5.845% abundance), iron-56 (91.754% abundance), iron-57 (2.119% abundance), and iron-58 (0.282% abundance). Calculate the atomic mass of iron. **5 min maximum**

**Method 1**

Set Up:  
\[ \text{atomic mass} = (54 \text{ amu} \times \frac{5.845}{100}) + (56 \text{ amu} \times \frac{91.754}{100}) + (57 \text{ amu} \times \frac{2.119}{100}) + (58 \text{ amu} \times \frac{0.282}{100}) \]

Step 1:  
\[ (54 \text{ amu} \times 0.05845) + (56 \text{ amu} \times 0.91754) + (57 \text{ amu} \times 0.02119) + (58 \text{ amu} \times 0.00282) \]

Step 2:  
\[ 3.1563 \text{ amu} + 51.38224 \text{ amu} + 1.20783 \text{ amu} + 0.16356 \text{ amu} \]

Answer:  
\[ 55.90993 \text{ amu} \rightarrow 55.91 \text{ amu} \]

**Method 2**

\[
\begin{align*}
54 \text{ amu} \times \frac{5.845}{100} &= 54 \text{ amu} \times 0.05845 \approx 3.1563 \text{ amu} \\
56 \text{ amu} \times \frac{91.754}{100} &= 56 \text{ amu} \times 0.91754 = 51.38224 \text{ amu} \\
57 \text{ amu} \times \frac{2.119}{100} &= 57 \text{ amu} \times 0.02119 = 1.20783 \text{ amu} \\
58 \text{ amu} \times \frac{0.282}{100} &= 58 \text{ amu} \times 0.00282 = 0.16356 \text{ amu}
\end{align*}
\]

\[ 55.90993 \text{ amu} \rightarrow 55.91 \text{ amu} \]
4) Silicon has three naturally occurring isotopes: silicon-28, silicon-29, and silicon-30. The natural abundance of each isotope, respectively, are 92.23%, 4.68%, and 3.09%. Calculate the atomic mass of silicon. 5 min maximum

**Method 1**

Set Up: \[28 \text{ amu} \times (92.23 \div 100)] + [29 \text{ amu} \times (4.68 \div 100)] + [30 \text{ amu} \times (3.09 \div 100)]

Step 1: \[28 \text{ amu} \times 0.9223] + [56 \text{ amu} \times 0.91754] + [57 \text{ amu} \times 0.02119]

Step 2: 25.8244 amu + 1.3572 amu + 0.9270 amu

Answer: 28.1086 amu → 28.11 amu

**Method 2**

\[28 \text{ amu} \times 92.23 \div 100 = 28 \text{ amu} \times 0.9223 = 25.8244 \text{ amu}

\[29 \text{ amu} \times 4.68 \div 100 = 29 \text{ amu} \times 0.0468 = 1.3572 \text{ amu}\]

\[30 \text{ amu} \times 3.09 \div 100 = 30 \text{ amu} \times 0.0309 = 0.9270 \text{ amu}\]

28.1086 amu

↓

28.11 amu
5) The natural abundances of boron-10 and boron-11 are 19.9% and 80.1%, respectively. Calculate the atomic mass of boron. 4 min maximum

**Method 1**

Set Up: \[10 \text{ amu} \times \left(\frac{19.9}{100}\right) + 11 \text{ amu} \times \left(\frac{80.1}{100}\right)\]

Step 1: \[10 \text{ amu} \times 0.199 + 11 \text{ amu} \times 8.811\]

Step 2: \[1.99 \text{ amu} + 1.3572 \text{ amu}\]

Answer: 10.801 amu \(\rightarrow\) 10.80 amu

**Method 2**

\[
\begin{align*}
10 \text{ amu} \times 19.9 \div 100 &= 10 \text{ amu} \times 0.199 = 1.99 \text{ amu} \\
11 \text{ amu} \times 80.1 \div 100 &= 11 \text{ amu} \times 0.801 = 8.811 \text{ amu}
\end{align*}
\]

10.801 amu \(\downarrow\) 10.80 amu
6) Nickel has five naturally occurring isotopes: nickel-58, nickel-60, nickel-61, nickel-62, and nickel-64. The percent abundance values, respectively, are as follows: 68.0769%, 26.2231%, 1.1399%, 3.6346%, and 0.9256%. Calculate the atomic mass of nickel. 6 min maximum

Method 1

Set Up:  
\[
[54 \text{ amu} \times (5.845 \div 100)] + [56 \text{ amu} \times (91.754 \div 100)] + [57 \text{ amu} \times (2.119 \div 100)] + [58 \text{ amu} \times 0.282 \div 100]) + [57 \text{ amu} \times (2.119 \div 100)]
\]

Step 1:  
\[
[54 \text{ amu} \times 0.05845] + [56 \text{ amu} \times 0.91754] + [57 \text{ amu} \times 0.02119] + [58 \text{ amu} \times 0.00282] + [57 \text{ amu} \times (2.119 \div 100)]
\]

Step 2:  
\[
3.1563 \text{ amu} + 51.3824 \text{ amu} + 1.20783 \text{ amu} + 0.16356 \text{ amu} + [57 \text{ amu} \times (2.119 \div 100)]
\]

Answer: 55.90993 amu → 55.91 amu

Method 2

58 amu \times 68.0769 \div 100 = 58 \text{ amu} \times 0.680769 = 39.484602 \text{ amu}

60 \text{ amu} \times 26.2231 \div 100 = 60 \text{ amu} \times 0.262231 = 15.733860 \text{ amu}

61 \text{ amu} \times 1.1399 \div 100 = 61 \text{ amu} \times 0.011399 = 0.695399 \text{ amu} \text{ (add)}

62 \text{ amu} \times 3.6346 \div 100 = 62 \text{ amu} \times 0.036346 = 2.253452 \text{ amu}

64 \text{ amu} \times 0.9256 \div 100 = 64 \text{ amu} \times 0.009256 = 0.592384 \text{ amu}

\[
58.759637 \text{ amu} \downarrow
\]

\boxed{58.76 \text{ amu}}