CHEM1101 Worksheet 1: Atoms and Isotopes

Model 1: Isotopes

Each element found in nature occurs as a mixture of isotopes. Isotopic abundances can vary appreciably on an astronomical scale – e.g. in the Sun versus the Earth. On Earth, however, natural abundance varies little from place to place.

### Critical thinking questions

1. **How many isotopes of magnesium occur naturally on Earth?**

2. **Describe what all isotopes of magnesium have in common and also how they are different.**

3. **If you select one carbon atom at random, what is the mass of that atom is most likely to be (in amu)?**

4. **What is the mass (in amu) of 100 \(^{12}\)C atoms? Of 100 \(^{13}\)C atoms?**

### Table 1. Natural abundance and atomic masses for various isotopes.

<table>
<thead>
<tr>
<th>Isotope</th>
<th>Natural Abundance on Earth (%)</th>
<th>Atomic Mass (amu)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(^1)H</td>
<td>99.985</td>
<td>1.0078</td>
</tr>
<tr>
<td>(^2)H</td>
<td>0.015</td>
<td>2.0140</td>
</tr>
<tr>
<td>(^{12})C</td>
<td>98.89</td>
<td>12.0000</td>
</tr>
<tr>
<td>(^{13})C</td>
<td>1.11</td>
<td>13.0034</td>
</tr>
<tr>
<td>(^{35})Cl</td>
<td>75.77</td>
<td>34.9689</td>
</tr>
<tr>
<td>(^{37})Cl</td>
<td>24.23</td>
<td>36.9659</td>
</tr>
<tr>
<td>(^{24})Mg</td>
<td>78.99</td>
<td>23.9850</td>
</tr>
<tr>
<td>(^{25})Mg</td>
<td>10.00</td>
<td>24.9858</td>
</tr>
<tr>
<td>(^{26})Mg</td>
<td>11.01</td>
<td>25.9826</td>
</tr>
</tbody>
</table>

1 amu = \(1.6606 \times 10^{-24}\) g
5. If you select one hundred carbon atoms at random, what will the total mass likely be?

(a) 1200.00 amu, (b) slightly more than 1200.00 amu,  
(c) slightly less than 1200.00 amu, (d) 1300.34 amu or  
(e) slightly less than 1300.34 amu

Explain your reasoning.

**Model 2: Average Mass**

In a collection of marbles, 25% of the marbles have a mass of 5.00 g and 75% of the marbles have a mass of 7.00 g. The average mass of a marble is 6.50 g.

The average mass of a marble can be determined by dividing the total mass of the marbles by the total number of marbles:

\[
\text{average mass of a marble} = \frac{1 \times 5.00 \text{ g} + 3 \times 7.00 \text{ g}}{4} = 6.50 \text{ g}
\]  

(1)

Or, the average mass of a marble can be determined by (a) multiplying the fraction of marbles of a particular type by the mass of a marble of that type and (b) taking a sum over all types of marbles:

\[
\text{average mass of a marble} = 0.2500 \times 5.00 \text{ g} + 0.7500 \times 7.00 \text{ g} = 6.50 \text{ g}
\]  

(2)

**Critical thinking questions**

1. Show that equations (1) and (2) are equivalent.
2. Do any of the marbles in Model 2 have the average mass?

3. (a) Use the method of equation (2) and the data in Table 1 to calculate the average mass of a chlorine atom in amu.

(b) Does any chlorine atom have this mass?

(c) What is the average atomic mass of chlorine in any large collection of chlorine atoms?

(d) What is the average mass of a chlorine atom (in g)?

(e) Based on this answer, what is the mass of $6.022 \times 10^{23}$ (randomly selected) chlorine atoms (in g)?

4. Suppose that on another planet the following stable isotopes and abundances of sulfur are found:

\[
\begin{array}{ccc}
\text{S}^{32} & 31.972072 \text{ amu} & 48.32 \% \\
\text{S}^{33} & 32.971459 \text{ amu} & 17.78 \% \\
\text{S}^{34} & 33.967868 \text{ amu} & 33.90 \% \\
\end{array}
\]

What would the average atomic mass of sulfur be on that planet?

5. Naturally-occurring silver is composed of two isotopes, $^{107}\text{Ag}$ with mass 106.9051 amu, and $^{109}\text{Ag}$ with mass 108.9048 amu. The average atomic mass of silver is 107.8682. What are the percentages of $^{107}\text{Ag}$ and $^{109}\text{Ag}$ in naturally-occurring silver?
Exercise

That's puntastic!

The idea is to use the element name as a pun to complete the sentences. Answers are made by placing the correct elemental symbol in the blanks. Share ideas with your group and with the other groups in the class.

1. What language is spoken by the people of Mangan? __________
2. "We brought everything but the kitchen __________!"
3. To be a good neighbour, you must learn to mind your own __________
4. To park here you must put a __________ in the meter.
5. Dial 000 to call a __________ when you witness a crime.
6. If you find your cat has been run over all you can do is __________.
7. Are the baby birds still in the nest? No, they __________.
8. Doctors amputated the bottom half of his leg, but they left his __________.
9. His old Ford was worn out so he bought a new __________.
10. A prisoner who acts in a silly manner is called a __________.
11. "We out of foss," he said. "Please go to the store and get some __________."
12. I borrowed a dollar from Sam and fifty cents from Dean. So I owe Sam more than __________.
13. Five times two is __________
14. The Boy Scout took the lady by the arm and __________ her across the street.
15. He demanded payment in gold because he said he was __________.
16. At the end of his first day, as a car salesman, Mr. Umm was asked: "Did you __________?"
17. The gold in pharaoh's crypt weighed exactly 1000 kgs; and so it became known as the __________.
18. As the masked man rode away, he was heard to say: "Hi Ho __________ away."
19. Housewife's complaint: "On Mondays, all I do is wash and __________."
20. His name is Sullivan, but he call him "Sul". He's the reason our rugs and furniture are covered with __________.
21. Cadbury's Chocolate Co. bought out Mee-Yum Fortune Cookies and now they make __________ chocolate fortune cookies.
22. News reporter Nick asked the chief what caused the warehouse fire. The chief replied: "It was __________."
23. The well-driller had bored a hole to a depth of 10 m. He found no water, so he was told to __________
24. "Calvin, did you see the man who stole my horse?" "Yes, __________," replied the Indian.
25. The makers of "Raid" have developed a slogan to advertise their new insect repellent. It reads: "Don't go out without your __________."
26. How did I find out what teenagers think: I __________ of course!
27. Samantha was in love with Darren when they ran away from home. Her mother was very concerned. "Did __________?" she asked anxiously.
28. A boy named Coe lost his dog Bo and as a result __________ his eyes out.
29. After months of intensive investigation, the undercover narcotics agent approached the suspect. "Here's your $25,000. " said the officer. "And here's __________." replied the drug dealer.
30. "The bandits rode through here" said the sheriff. "Do you see those tracks?" "No, I don't __________." said the deputy.