

Isotopes & Average Atomic Mass

Key ideas

Atomic number (Z) = protons · **mass number (A)** = protons + neutrons · neutrons = $A - Z$ · electrons = protons – charge

Isotopes have the same number of protons but different numbers of neutrons, e.g. carbon-12 and carbon-14.

Average atomic mass = Σ (isotope mass $\times$ fractional abundance), where fractional abundance = $\% \div 100$.

A Protons, neutrons and electrons

3 marks

$\frac{1}{2}$ mark per row. Use the periodic table for atomic numbers.

	Atom or ion	Protons	Neutrons	Electrons
1.	Carbon-14			
2.	$^{23}_{11}\text{Na}^+$			
3.	$^{35}_{17}\text{Cl}^-$			
4.	$^{56}_{26}\text{Fe}^{3+}$			
5.	Uranium-235			
6.	$^{16}_8\text{O}^{2-}$			

B Isotope notation

3 marks

7. An atom has 17 protons and 20 neutrons. Write its nuclear symbol and its hyphen notation.

8. An atom has 29 protons and 36 neutrons. Write its nuclear symbol and its hyphen notation.

9. Which pair are isotopes? (a) $^{12}_6\text{C}$ and $^{14}_6\text{C}$ (b) $^{14}_6\text{C}$ and $^{14}_7\text{N}$ (c) $^{40}_{19}\text{K}$ and $^{40}_{20}\text{Ca}$. Explain.

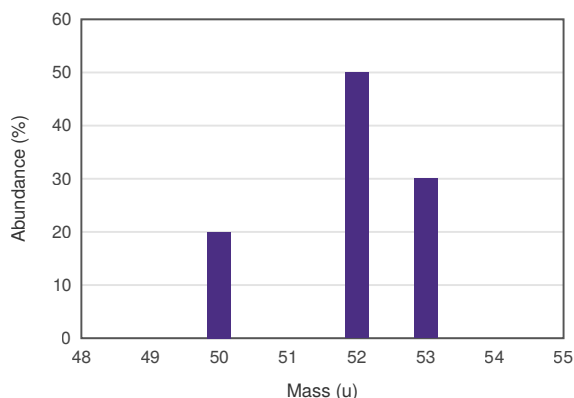
C Calculating average atomic mass

8 marks

10. Chlorine has two isotopes: chlorine-35 (34.969 u, 75.78%) and chlorine-37 (36.966 u, 24.22%). Calculate the average atomic mass of chlorine. (2 marks)

11. Magnesium has three isotopes: Mg-24 (23.985 u, 78.99%), Mg-25 (24.986 u, 10.00%) and Mg-26 (25.983 u, 11.01%). Calculate its average atomic mass. (2 marks)

12. Copper is 69.15% copper-63 (62.930 u) and 30.85% copper-65 (64.928 u). Calculate its average atomic mass.



Mass spectrum of element X

13. Read the mass spectrum. List the mass and percent abundance of each isotope of element X.

14. Calculate the average atomic mass of X and use the periodic table to identify it. (2 marks)

D Finding percent abundance

3 marks

15. Gallium has two isotopes, Ga-69 (68.926 u) and Ga-71 (70.925 u). Its average atomic mass is 69.72 u. Find the percent abundance of each isotope. (2 marks)

16. Boron is made of B-10 (10.013 u) and B-11 (11.009 u). Its average atomic mass is 10.81 u. What percent of boron is B-10?

E Thinking about isotopes

2 marks

17. Why is the average atomic mass of most elements not a whole number?

18. Copper's average atomic mass is 63.55 u. Without calculating, which isotope (Cu-63 or Cu-65) is more abundant? Explain.

F Spot the mistake

2 marks

19. A student writes: "Isotopes of an element have different numbers of protons." Explain the error and correct it.

20. A student calculates chlorine's average atomic mass as $(35 + 37) \div 2 = 36$ u. Explain the error and correct it.

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ANSWER KEY

Date: _____ Score: ____ / 21

Key ideas

Atomic number (Z) = protons · **mass number (A)** = protons + neutrons · neutrons = A – Z · electrons = protons – charge

Isotopes have the same number of protons but different numbers of neutrons, e.g. carbon-12 and carbon-14.

Average atomic mass = Σ (isotope mass $\times$ fractional abundance), where fractional abundance = % $\div$ 100.

A Protons, neutrons and electrons

3 marks

$\frac{1}{2}$ mark per row. Use the periodic table for atomic numbers.

	Atom or ion	Protons	Neutrons	Electrons
1.	Carbon-14	6	8	6
2.	$^{23}_{11}\text{Na}^+$	11	12	10
3.	$^{35}_{17}\text{Cl}^-$	17	18	18
4.	$^{56}_{26}\text{Fe}^{3+}$	26	30	23
5.	Uranium-235	92	143	92
6.	$^{16}_8\text{O}^{2-}$	8	8	10

B Isotope notation

3 marks

7. An atom has 17 protons and 20 neutrons. Write its nuclear symbol and its hyphen notation.

$^{37}_{17}\text{Cl}$, chlorine-37

8. An atom has 29 protons and 36 neutrons. Write its nuclear symbol and its hyphen notation.

$^{65}_{29}\text{Cu}$, copper-65

9. Which pair are isotopes? (a) $^{12}_6\text{C}$ and $^{14}_6\text{C}$ (b) $^{14}_6\text{C}$ and $^{14}_7\text{N}$ (c) $^{40}_{19}\text{K}$ and $^{40}_{20}\text{Ca}$. Explain.

(a): same number of protons (6), different numbers of neutrons (6 and 8).

C Calculating average atomic mass

8 marks

10. Chlorine has two isotopes: chlorine-35 (34.969 u, 75.78%) and chlorine-37 (36.966 u, 24.22%). Calculate the average atomic mass of chlorine. (2 marks)

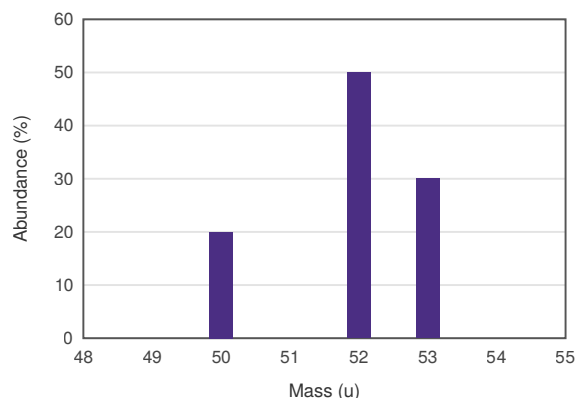
$(34.969 \times 0.7578) + (36.966 \times 0.2422) = 35.45 \text{ u}$

11. Magnesium has three isotopes: Mg-24 (23.985 u, 78.99%), Mg-25 (24.986 u, 10.00%) and Mg-26 (25.983 u, 11.01%). Calculate its average atomic mass. (2 marks)

$(23.985 \times 0.7899) + (24.986 \times 0.1000) + (25.983 \times 0.1101) = 24.31 \text{ u}$

12. Copper is 69.15% copper-63 (62.930 u) and 30.85% copper-65 (64.928 u). Calculate its average atomic mass.

$(62.93 \times 0.6915) + (64.928 \times 0.3085) = 63.55 \text{ u}$



Mass spectrum of element X

13. Read the mass spectrum. List the mass and percent abundance of each isotope of element X.

50 u: 20%; 52 u: 50%; 53 u: 30%

14. Calculate the average atomic mass of X and use the periodic table to identify it. (2 marks)

**$(50.0 \times 0.20) + (52.0 \times 0.50) + (53.0 \times 0.30) = 51.9 \text{ u}$,
closest to chromium (52.00 u)**

D Finding percent abundance

3 marks

15. Gallium has two isotopes, Ga-69 (68.926 u) and Ga-71 (70.925 u). Its average atomic mass is 69.72 u. Find the percent abundance of each isotope. (2 marks)

Let x = fraction of Ga-69: $68.926x + 70.925(1 - x) = 69.72 \rightarrow x = 0.6028$. Ga-69 = 60.3%, Ga-71 = 39.7%

16. Boron is made of B-10 (10.013 u) and B-11 (11.009 u). Its average atomic mass is 10.81 u. What percent of boron is B-10?

$10.013x + 11.009(1 - x) = 10.81 \rightarrow x = 0.200$, so 20.0% B-10

E Thinking about isotopes

2 marks

17. Why is the average atomic mass of most elements not a whole number?

It is a weighted average of several isotopes with different masses and abundances.

18. Copper's average atomic mass is 63.55 u. Without calculating, which isotope (Cu-63 or Cu-65) is more abundant? Explain.

Cu-63: the average is much closer to 63 than to 65.

F Spot the mistake

2 marks

19. A student writes: "Isotopes of an element have different numbers of protons." Explain the error and correct it.

Isotopes have the same number of protons but different numbers of neutrons. Changing the protons changes the element.

20. A student calculates chlorine's average atomic mass as $(35 + 37) \div 2 = 36 \text{ u}$. Explain the error and correct it.

The average must be weighted by abundance. Chlorine-35 is about three times as common, so the average is 35.45 u.