Corrections 1

Exercise 1.1

How many protons, neutrons, and electrons are there in an atom of ^{56}Fe?

According to the periodic table, iron has 26 protons, so 56 - 26 = 30 neutrons and 26 electrons.

Exercise 1.2

If the mass of a nitrogen atom is $15 \cdot 1.67 \cdot 10^{-27}\ kg$ ($\cong 15\ u$), which isotope of nitrogen is it?

If the mass of a nitrogen atom is about 15 u, then we have the isotope ^{15}N, composed of 7 protons and 8 neutrons.

Exercise 1.3

Taking into account the different isotopes of carbon and hydrogen, in how many different forms can a stable C_2H_2 molecule exist? Among them, how many have different masses?

C and H both have 2 stable isotopes: ^{1}H ^{2}H ^{12}C and ^{13}C. The possible combinations are as follows, with their respective masses:

^{12}C ^{12}C ^{1}H ^{1}H, m=26 ;	^{12}C ^{12}C ^{1}H ^{2}H, m=27 ;	^{12}C ^{12}C ^{2}H ^{2}H, m=28
^{12}C ^{13}C ^{1}H ^{1}H, m=27 ;	^{12}C ^{13}C ^{1}H ^{2}H, m=28 ;	^{12}C ^{13}C ^{2}H ^{2}H, m=29
^{13}C ^{13}C ^{1}H ^{1}H, m=28 ;	^{13}C ^{13}C ^{1}H ^{2}H, m=29 ;	^{13}C ^{13}C ^{2}H ^{2}H, m=30

Considering the structure of the molecule, there is yet another combination. Indeed, ^{1}H ^{12}C ^{13}C ^{2}H and ^{2}H ^{12}C ^{13}C ^{1}H are distinct. We therefore have 10 different stable combinations and 5 different masses (26, 27, 28, 29, 30 u).

Exercise 1.4

What is the ratio of the density of water H_2O to that of heavy water D_2O, given that these two molecules have the same volume?

H_2O and D_2O occupy the same volume, but have different masses. The ratio of their densities can therefore be replaced by that of their masses.
In atomic units,

$$m_{H_2O} = 2m_H + m_O \approx 2 + 16 = 18\ \text{u}$$
$$m_{D_2O} = 2m_D + m_O \approx 2 \cdot 2 + 16 = 20\ \text{u}$$

So we have:

$$\frac{\rho_{H_2O}}{\rho_{D_2O}} = \frac{18}{20} = 0.9$$

Exercise 1.5

An atom has 48 protons and 63 neutrons. What nuclide is it?

48 protons, so Cd. 48 + 63 = 111 nucleons. So it is $^{111}_{48}$Cd.

Exercise 1.6

What is the atomic number and molar mass of calcium? What is the atomic number and mass number of the most common isotope of chlorine?

Calcium: Z = 20 and M = 40.08 g/mol.
Chlorine: Z = 17. Chlorine has 2 stable isotopes: ^{35}Cl and ^{37}Cl. The molar mass of chlorine is 35.45 g/mol, and it is calculated by averaging the isotopic masses weighted by their abundances. Since this average is closer to 35 than to 37, ^{35}Cl is the most abundant. So for the most common isotope naturally, A = 35.

Exercise 1.7

You've been presented with three unknown samples, each from a different element. Using a mass spectrometer, you find that:

- *Sample A has three isotopes with masses of 19.99 amu, 20.99 amu, and 21.99 amu.*
- *Sample B has two isotopes with masses of 34.97 amu and 36.97 amu.*
- *Sample C has one isotope with a mass of 4.00 amu.*

Identify each sample by its element. Explain how the presence of these isotopes influences the average atomic mass of the elements.

Sample A:
- These isotope masses are typical of **Neon**. The three isotopes are Ne-20, Ne-21, and Ne-22.
- The average atomic mass is a weighted average based on their abundance in nature. Without knowing the exact abundances, we can't calculate the average atomic mass, but it would fall somewhere between the lightest and heaviest isotope.

Sample B:
- These isotope masses are typical of **Chlorine**. The two isotopes are Cl-35 and Cl-37.
- Chlorine's average atomic mass is around 35.45 amu, reflecting the fact that Cl-35 is more abundant than Cl-37.

Sample C:
- The single isotope mass is typical of **Helium**, specifically He-4.
- As there's only one isotope in this sample, the average atomic mass would be 4.00 amu.

Exercise 1.8

a) *How many neutrons, protons and what atomic number does the nuclide ^{13}C have?*
b) *How many neutrons, protons and what atomic number does the nuclide ^{238}U have?*

c) Fill in the blank spaces using a periodic table:

Atom	*Z*	*N*	*A*
^{40}Ar			
^{127}I			
Si			
Cs			

a) ^{13}C has 6 protons, 7 neutrons and has an atomic number of 13
b) ^{238}U has 92 protons, 146 neutrons and has an atomic number of 238
c)

Atom	Z	N	A
^{40}Ar	18	22	40
^{127}I	53	74	127
Si	14	14	28
Cs	55	78	133

Exercise 1.9

Find isotopes and isobars from the following nuclides: ^{12}C, ^{13}C, ^{14}N, ^{14}C, ^{3}H, ^{3}He, ^{1}H.

Isotopes are atoms having same atomic number but different mass number ^{12}C, ^{13}C and ^{14}C are isotopes and ^{3}H and ^{1}H are isotopes.
Isobars are atoms of different elements which have the same mass number but different atomic numbers ^{14}N and ^{14}C; ^{3}H and ^{3}He are isobars.

Exercise 1.10

Calculate the average atomic mass of bromine from the isotopic masses.

Isotop	*Abundance*	*Isotopic mass*
^{79}Br	*50.5%*	*78.92 u*
^{81}Br	*49.5%*	*80.92 u*

Atomic mass: $\frac{50.5}{100} \cdot 78.92 + \frac{49.5}{100} \cdot 80.92 = 79.91\ u$

Exercise 1.11

Read each statement carefully and decide whether it is True or False.

a) The atomic number of an element is equal to the number of neutrons in its nucleus.
True / **False**

b) Isotopes of an element have different chemical properties because they have different numbers of neutrons
True / **False**

c) The atomic number determines the identity of an element.
True / False

Isobars are atoms of different elements that have the same number of protons.
True / **False**

d) Isotopes have the same atomic number but different mass numbers.
True / False

e) All isotopes of an element are stable.
True / **False**

f) Isobars have different atomic numbers but the same atomic mass.
True / False

g) *The number of protons in the nucleus of an atom can vary in isotopes of the same element.*
True / **False**