7.3 which has the same electron configuration as an atom of neon; (2)
7.4 with the smallest mass. (2)

## Structure of the Atom: Isotopes

- **Isotopes** are atoms of the same element (same atomic number Z) but having different numbers of neutrons (different mass number A).
  The majority of elements are found in nature as a mixture of isotopes.
- The **relative atomic mass $A_r(X)$** of an **element** is calculated by using the percentage of each isotope in a sample of the naturally occurring element and the relative atomic mass of each of the isotopes.

  This is the number that is given on the Periodic Table.

  Example: A sample of chlorine contains 75% of the isotope $^{35}_{17}C\ell$ and 25% of the $^{37}_{17}C\ell$ isotope.

  This means that 75 out of every 100 chlorine atoms will have a relative mass of 35 and 25 atoms will have a relative mass of 37.
  The average mass of chlorine atoms will thus be (75/100)(35) + (25/100)(37) = 35,5
- The relative mass provided on the Periodic Table gives the average relative mass of its isotopes.
  The fact that it is not a whole number does not mean that it contains a fraction of a proton or neutron, but merely that it is the **average of the isotopes**.
- The **relative formula mass**, **$M_r(X)$**, of a **compound** is obtained by adding the relative mass numbers of the atoms composing the molecule and it has **no units**.

### Exercise 11:

1 Give ONE word/term for

1.1 atoms of the same element with different numbers of neutrons. (1)

2 Two particles, X and Y, have the following composition:
X: 16 protons, 16 neutrons, 18 electrons
Y: 17 protons, 20 neutrons, 18 electrons
X and Y are

A isotopes. B atoms of alkali metals.
C negative ions. D atoms of metals. (2)

3 Which ONE of the following pairs of elements contains the same number of neutrons?

A $^{4}_{2}He$ and $^{2}_{1}H$ B $^{14}_{6}C$ and $^{14}_{7}N$
C $^{1}_{1}H$ and $^{3}_{1}H$ D $^{4}_{2}He$ and $^{3}_{1}H$ (2)

4 Which ONE of the following pairs represents two atoms with the same number of neutrons?

A $^{12}_{6}C$ and $^{24}_{10}Mg$ B $^{19}_{9}F$ and $^{20}_{10}Ne$
C $^{23}_{11}Na$ and $^{39}_{19}K$ D $^{59}_{27}Co$ and $^{59}_{28}Ni$ (2)

5 Define the term *isotopes*. (3)

6 An element X consists of the following five types of atoms:

$^{40}_{20}X$ $^{42}_{20}X$ $^{43}_{20}X$ $^{44}_{20}X$ $^{48}_{20}X$

6.1 What are the five types of atoms of X called? (2)
6.2 Concerning the composition of atoms of X, in what
6.2.1 **two** ways do they correspond? (4)
6.2.2 **one** way do they differ? (2)

7 One of the isotopes of sodium is $^{23}_{11}Na$. Complete the following table with reference to the isotope.



Write down the number of the question on your answer sheet with the answer next to it. (9)

| Name of particle | Charge on particle | Mass of particle | Number of particles |
|---|---|---|---|
| Proton | 7.1 | 7.2 | 7.3 |
| Neutron | 7.4 | 7.5 | 7.6 |
| Electron | 7.7 | | 7.8 |

8 Calculate the relative molecular masses of the following substances: (10)

8.1 $H_2O$ 8.1 $H_2SO_4$ 8.3 $Mg(NO_3)_2$ 8.4 $AgNO_3$ 8.5 $FeC\ell_3$

9 The three isotopes of hydrogen have relative masses of 1,0078, 2,0141 and 3,0161.
Their respective % abundances are 99,985%, 0,015% and 0%.
Calculate the relative atomic mass of hydrogen, correct to the third decimal place. (3)

10 The three isotopes of magnesium have relative masses of 24, 25 and 26.
Their respective % abundances are 79%, 10% and 11%.
Calculate the relative atomic mass of magnesium correct to the second decimal place. (3)

11 Two carbon atoms X and Y are shown here: $^{14}_{6}C$ $^{12}_{6}C$

11.1 They are called …….. of the same element. (1)
11.2 Which has the largest atomic number? (1)
11.3 How many neutrons does X have? (2)

12 Complete the table: (30)

| Name | Symbol | Mass number | Atomic number | Number of protons | Number of neutrons | Number of electrons |
|---|---|---|---|---|---|---|
| Nitrogen | | | | | | |
| | Ar | | | | | |
| | | | 13 | | | |
| | | | | 9 | | |
| | $Ca^{2+}$ | | | | | |

13 Uranium exists as two *isotopic* forms: uranium-235 ($^{235}_{92}U$) and uranium-238 ($^{238}_{92}U$).
Enriched uranium-235, which is highly reactive, is used in the generation of electricity and in nuclear weapons. When a country acquires enriched uranium-235, their neighbouring countries become nervous and suspicious.
Uranium-235 forms about 0,7% of the total uranium content of the earth.
Stable uranium-238, which is not suitable for use in nuclear reactors, makes up 99,3%.

13.1 Define the term 'isotope'. (2)
13.2 Calculate the relative atomic mass of uranium correct to the second decimal place. (4)
13.3 Explain why uranium-238, although more abundant, is not suitable for use as fuel in nuclear reactors. (2)
13.4 Name ONE benefit and ONE disadvantage of uranium-235 to humanity. (4)

14 Study the following notation that represents an unknown ion $^{18}_{8}X^{2-}$ and then answer the questions that follow.

14.1 Write down the number of protons X has. (1)
14.2 Calculate:
14.2.1 The number of neutrons X has. (1)
14.2.2 The number of electrons X has. (1)
14.3 Write down the:
14.3.1 Atomic number of X. 14.3.2 Mass number of X. (2)
14.4 Identify X. (3)
14.5 Provide an explanation for your answer in question 14.4. (3)