

2.1 RELATIVE MASSES OF ATOMS AND MOLECULES

Learning outcomes

Candidates should be able to:

1. define the unified atomic mass unit as one twelfth of the mass of a carbon-12 atom
2. define relative atomic mass, A_r , relative isotopic mass, relative molecular mass, M_r , and relative formula mass in terms of the unified atomic mass unit

Masses of atoms and molecules

unified atomic mass unit: one twelfth of the mass of a carbon-12 atom

$$1 \text{ unified atomic mass unit} = 1.66 \times 10^{-27} \text{ kg}$$

Relative atomic mass:

$$A_r = \frac{\text{weighted average mass of atoms in a given sample of an element}}{\text{unified atomic mass unit}}$$

$$\text{relative atomic mass of element E} = \frac{\text{average mass of one atom of E}}{\frac{1}{12} \text{ the mass of one atom of } ^{12}\text{C}}$$

Relative isotopic mass

Relative molecular mass

Relative formula mass

Formula unit: the simplest formula for a covalent giant structure or an ionic giant structure, e.g. SiO_2 , MgCl_2

(study their definitions and examples from your textbook)

1. Define relative atomic mass. [2]
2. (i) Define the unified atomic mass unit. [1]

(ii) Define relative atomic mass, A_r , in terms of the unified atomic mass unit. [1]
3. Ethanedioic acid, $\text{HO}_2\text{CCO}_2\text{H}$, has a relative molecular mass of 90.0.
Explain what is meant by the term relative molecular mass. [1]
4. Combustion data can be used to calculate the empirical formula, molecular formula and relative molecular mass of many organic compounds.
Define the term relative molecular mass. [2]
5. Ammonium iron(II) sulfate, $(\text{NH}_4)_2\text{Fe}(\text{SO}_4)_2$, has a relative formula mass, M_r , of 284.
(a) Define the term relative formula mass. [1]

6. Define the term relative isotopic mass. [2]
7. The accurate relative atomic mass of iron, Fe, is 55.8. Explain why the accurate relative atomic mass is not a whole number. [1]
8. Gallium is a metal in Group 13 of the Periodic Table.
There are two stable isotopes of gallium, ^{69}Ga and ^{71}Ga .
State what further information is needed to calculate the relative atomic mass of gallium. [1]
9. Table 1.2 shows the relative abundances of isotopes in a sample of an alloy containing rhodium and iridium only.

isotope	relative isotopic mass	relative abundance in alloy
$^{103}_{45}\text{Rh}$	102.91	50.00
$^{191}_{77}\text{Ir}$	190.96	15.18
$^{193}_{77}\text{Ir}$	192.96	34.82

Use Table 1.2 to calculate the relative atomic mass, A_r , of iridium in the alloy.
Give your answer to two decimal places.

relative atomic mass of iridium = [2]

10. Boron occurs naturally as a mixture of two stable isotopes, ^{10}B and ^{11}B . The relative isotopic masses and percentage abundances are shown.

isotope	relative isotopic mass	abundance / %
^{10}B	10.0129	19.78
^{11}B	to be calculated	80.22

Calculate the relative isotopic mass of ^{11}B .

Give your answer to six significant figures. Show your working

[2]

11. Pelopium was the suggested name for a new element discovered in a mineral.

Pelopium was later found to be a mixture of niobium, Nb, and tantalum, Ta.

(a) Only one naturally occurring isotope exists for each of Nb and Ta.

Complete Table 1.1.

[2]

isotope	relative isotopic mass	number of protons	number of neutrons
$^{93}_{41}\text{Nb}$	92.91		
$^{181}_{73}\text{Ta}$	180.95		

- (b) A sample of pelopium contains 90.9% by mass $^{93}_{41}\text{Nb}$ and 9.1% by mass $^{181}_{73}\text{Ta}$

Calculate the theoretical relative atomic mass of pelopium based on these data and Table 1.1.

Give your answer to two decimal places.

Show your working.

theoretical relative atomic mass of pelopium =

[2]

1. Which statement is correct?

- A The relative atomic mass of a ^{35}Cl atom is 35.5.
- B The relative formula mass of CaCO_3 is 100.1.
- C The relative isotopic mass of a ^{24}Mg atom is 24.3.
- D The relative molecular mass of O_2 is 16.0.

2. Which statement is correct?

- A Cl has a relative isotopic mass of 35.5.
- B Cl_2 has a relative molecular mass of 70.
- C ICl has a relative molecular mass of 162.4.
- D NaCl has a relative molecular mass of 58.5.

This is not a complete note. It is to guide you. It is recommended to study the prescribed textbooks along with this material.