Reacting ratios: masses

Introduction

These questions are designed to help you to develop mental models (pictures in your head) of the large number of atoms or molecules that react (or are produced) in a ratio described by the balanced chemical equation for a reaction. The questions also aim to help you to connect the number of atoms or molecules reacting or that are produced with the observable mass. Use the icon in the margin to find out which level of understanding the question is developing.

Macroscopic: what we can see. Think about the properties that we can observe, measure and record.

Sub-microscopic: smaller than we can see. Think about the particle or atomic level.
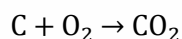
Symbolic: representations. Think about how we represent chemical ideas including symbols and diagrams.

Questions

1. Carbon reacts with oxygen to form carbon dioxide.

A balanced chemical equation of the reaction shows the ratio of the reactants and products formed.

$$C + O_2 \rightarrow CO_2$$

Remember that this chemical equation means: $1C + 1O_2 \rightarrow 1CO_2$

(a) Complete the sentence to describe the ratio in which the carbon atoms and oxygen molecules react. Use the words **atom** or **molecule**.

Each _____ of carbon reacts with one _____ of oxygen to produce

one _____ of carbon dioxide.

(b) Complete the table to show the number of atoms and molecules that react and that are produced.

Number of carbon atoms	Number of oxygen molecules	Number of carbon dioxide molecules
1 million		
	1 billion	
		6.02×10^{23}

The relative atomic mass (RAM) of carbon is 12 and the RAM of oxygen is 16. Relative atomic mass is sometimes shown as A_r.

(c) Explain why the relative formula mass (RFM) of an oxygen molecule is 32. Relative formula mass is sometimes shown as M_r.

_____

_____

(d) Calculate the relative formula mass of carbon dioxide.

_____

_____

(e) Complete the table to show the mass of oxygen and carbon dioxide that have the same number of molecules as there are atoms in 12 g of carbon.

	carbon	oxygen	carbon dioxide
Mass with an equal number of atoms/molecules	12 g		

(f) Complete the table to show the masses of oxygen and carbon dioxide that have the same number of molecules as there are atoms in the given masses of carbon.

mass of carbon	mass of oxygen	mass of carbon dioxide
24 g		
6 g		
3 g		

(g) Use the table in part (d) to answer the following:

   i.   Give the mass of carbon dioxide formed when 24 g of carbon burns completely in oxygen. _____ g

   ii.   Give the mass of carbon needed to produce 11 g of carbon dioxide. _____ g

(h) Explain why 12 g of carbon does not produce 12 g of carbon dioxide.

_____

_____

_____

_____

2.   12 g of carbon contains one mole (6.02×10^{23}) atoms.

(a) Give the mass that contains:

   i.   One mole of oxygen molecules. _____ g

   ii.   One mole of carbon dioxide molecules. _____ g

(b) Calculate the mass of carbon that contains:

   i.   Two moles of carbon atoms.   2 x 12 g = _____ g

   ii.   Three moles of carbon atoms.   __ x 12 g = _____ g

   iii.   10 moles of carbon atoms.   __ x 12 g = _____ g

(c) Calculate the mass of oxygen that contains:

   i.   Two moles of oxygen molecules.   2 x 32 g = _____ g

   ii.   Three moles of oxygen molecules.   _____ x _____ g = _____ g

   iii.   10 moles of oxygen molecules.   _____ x _____ g = _____ g
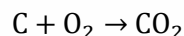
(d) Calculate the mass of carbon dioxide that contains:

   i.   Two moles of carbon dioxide molecules. _____ x _____ g = _____ g

   ii.   Three moles of carbon dioxide molecules. _____ x _____ g = _____ g

   iii.   10 moles of carbon dioxide molecules. _____ x _____ g = _____ g

3. A balanced chemical equation shows the ratio of the number of moles of reactants and products.

(a) Complete the sentence to describe what is represented by the balanced chemical equation.

$$C + O_2 \rightarrow CO_2$$

Each mole of carbon atoms reacts with _____ of oxygen molecules to

form _____ of carbon dioxide molecules.

(b) Complete the sentence to describe the masses that react and are formed when 12 g of carbon burns. Remember, one mole of a substance is equal to its relative atomic mass or relative formula mass in grams.

12 g (one mole) of carbon reacts with _____g of oxygen to form _____g of carbon

dioxide.

(c) Complete the table to work out the mass of carbon dioxide produced when the given mass of carbon is burned.

carbon mass	carbon moles	carbon dioxide moles	carbon dioxide mass
12 g	1	1	44 g
24 g	2		
6 g			
20.4 g			

(d) Show the two calculations that were needed to complete the last row of the table.
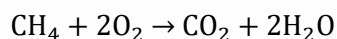
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_____

(e) Use the same process to work out the mass of carbon dioxide formed from 28.8 g of carbon.

_____

_____

(f) Complete the table to show the mass of carbon needed to produce the given masses of carbon dioxide.

carbon dioxide mass	carbon dioxide moles	carbon moles	carbon mass
44 g	1	1	12 g
88 g	2		
11 g			
57.2 g			

(g) Show the two calculations that were needed to complete the last row of the table.

_____

_____

4. Methane burns in oxygen to form carbon dioxide and water. The balanced chemical equation for the reaction is:

$$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$$

(a) Complete the sentences to describe the ratio of the reactants and products in moles.

Each mole of methane _____ reacts with two moles of oxygen

_____. This produces _____ mole of carbon dioxide

molecules and _____ moles of water molecules.

(b) The relative atomic masses of carbon, oxygen and hydrogen are 12, 16 and 1.

Calculate the relative formula masses (M_r) of:

    i. CH_4 _____

    ii. O_2 _____

    iii. CO_2 _____

    iv. H_2O _____

(c) Complete the table to show the mass of each substance that react and are produced when one mole of methane burns.

Substance	methane CH_4	oxygen O_2	carbon dioxide CO_2	water H_2O
Number of moles	1	2		
Mass	16 g			

(d) Complete the table to show the mass of water produced when the given masses of methane burn in oxygen.

×2

methane mass	methane moles	water moles	water mass
8 g	0.5	1	
32 g	2		
22.4 g			