

Relative Formula Mass

Mark Scheme



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1. The relative formula mass (M_r) of a compound is the sum of the relative atomic masses (A_r) of all the atoms shown in its chemical formula, using values from the periodic table.

Circle the letter of the correct answer for each of the following questions.

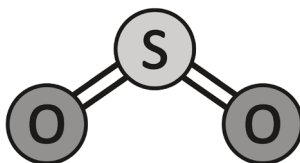
- a) What is the relative formula mass (M_r) of methane, CH_4 ?

B – is the only correct answer.	1 mark
	Total: 1 mark

- b) A molecule of water has the formula H_2O . What is its relative formula mass (M_r)?

C – is the only correct answer.	1 mark
	Total: 1 mark

- c) What is the relative formula mass (M_r) of sulfur dioxide, SO_2 ?



A – is the only correct answer.	1 mark
	Total: 1 mark

- d) What is the relative formula mass (M_r) of ammonia, NH_3 ?

B – is the only correct answer.	1 mark
	Total: 1 mark

- e) Carbon dioxide has the formula CO_2 . What is its relative formula mass (M_r)?

C – is the only correct answer.	1 mark
	Total: 1 mark

(Total for Question 1 is 5 marks)

2. Determine the relative formula mass (Mr) of the following molecules.

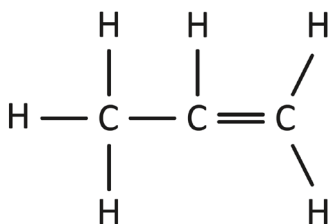
Show your working

a) Water (H ₂ O) $(2 \times 1) + 16 = 18$	b) Nitric acid (HNO ₃) $1 + 14 + (3 \times 16) = 63$
c) Chlorine (Cl ₂) $2 \times 35.5 = 71$	d) NaCl $23 + 35.5 = 58.5$
e) Hydrogen Chloride (HCl) $1 + 35.5 = 36.5$	f) Methane (CH ₄) $12 + (4 \times 1) = 16$
g) Carbon Dioxide (CO ₂) $12 + (2 \times 16) = 44$	h) Ammonia (NH ₃) $14 + (3 \times 1) = 17$
i) Hydrogen Sulfide (H ₂ S) $(2 \times 1) + 32 = 34$	j) Sulfur Dioxide (SO ₂) $(32 + (2 \times 16)) = 64$
k) Ethanol (C ₂ H ₅ OH) $(2 \times 12) + (6 \times 1) + 16 = 46$	l) Ethane (C ₂ H ₆) $(2 \times 12) + (6 \times 1) = 30$
m) Al ₂ O ₃ $(2 \times 27) + (3 \times 16) = 54 + 48 = 102$	n) (NH ₄) ₃ PO ₄ $3 \times (14 + 4) + 31 + (4 \times 16) = 54 + 31 + 64 = 149$
o) Fe(OH) ₃ $56 + 3 \times (16 + 1) = 56 + 51 = 107$	p) K ₂ SO ₄ $(2 \times 39) + 32 + (4 \times 16) = 78 + 32 + 64 = 174$
q) NaHCO ₃ $23 + 1 + 12 + (3 \times 16) = 84$	r) C ₂ H ₅ Br $(2 \times 12) + (5 \times 1) + 80 = 24 + 5 + 80 = 109$
s) C ₆ H ₁₂ O ₆ $(6 \times 12) + (12 \times 1) + (6 \times 16) = 72 + 12 + 96 = 180$	t) Iron(III) Chloride (FeCl ₃) $56 + (3 \times 35.5) = 56 + 106.5 = 162.5$
u) Ti ₂ CO ₃ $(2 \times 48) + 12 + (3 \times 16) = 96 + 12 + 48 = 156$	v) C ₅ H ₁₂ $(5 \times 12) + (12 \times 1) = 60 + 12 = 72$
w) Na ₂ CO ₃ ·7H ₂ O $(2 \times 23) + 12 + (3 \times 16) + 7 \times (18) = 46 + 12 + 48 + 126 = 106 + 126 = 232$	

(Total for Question 2 is 23 marks)

3. Determine the molecular formula and the relative formula mass (Mr) of the following substances. Show all of your working.

a.

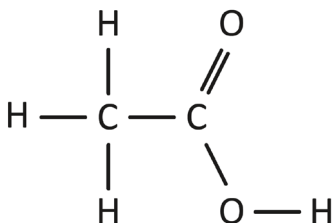


Molecular formula: C_3H_6

$$\text{Mr: } (3 \times 12) + (6 \times 1) = 42$$

(2 marks)

b.

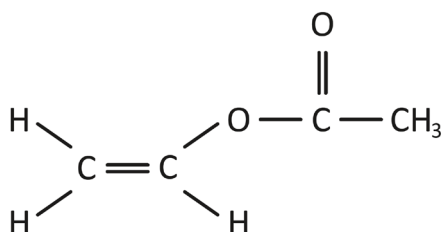


Molecular formula: CH_3COOH or $\text{C}_2\text{H}_4\text{O}_2$

$$\begin{aligned} \text{Mr: } (2 \times 12) + (4 \times 1) + (2 \times 16) \\ = 24 + 4 + 32 = 60 \end{aligned}$$

(2 marks)

c.

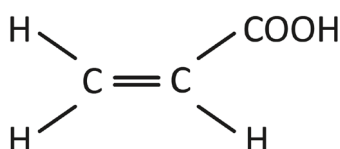


Molecular formula: $\text{C}_4\text{H}_6\text{O}_2$

$$\begin{aligned} \text{Mr: } (4 \times 12) + (6 \times 1) + (2 \times 16) \\ = 48 + 6 + 32 = 86 \end{aligned}$$

(2 marks)

d.

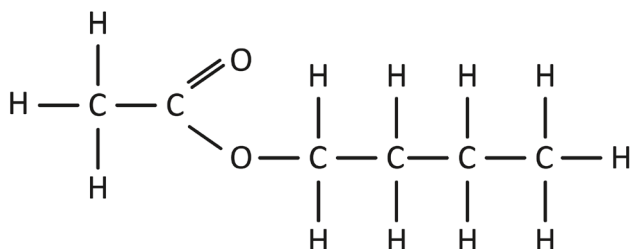


Molecular formula: $\text{C}_3\text{H}_4\text{O}_2$

$$\begin{aligned} \text{Mr: } (3 \times 12) + (4 \times 1) + (2 \times 16) \\ = 36 + 4 + 32 = 72 \end{aligned}$$

(2 marks)

e.



Molecular formula: $\text{C}_6\text{H}_{12}\text{O}_2$

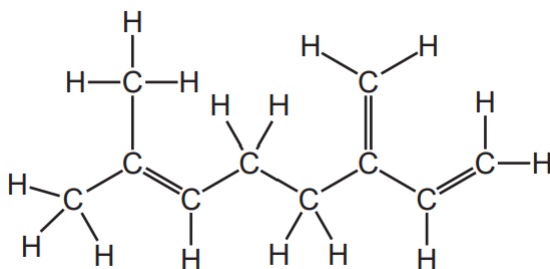
$$\begin{aligned} \text{Mr: } (6 \times 12) + (12 \times 1) + (2 \times 16) \\ = 72 + 12 + 32 = 116 \end{aligned}$$

(2 marks)

(Total for Question 3 is 10 marks)

4. Determine the molecular formula and the relative formula mass (Mr) of the following substances. Show all of your working.

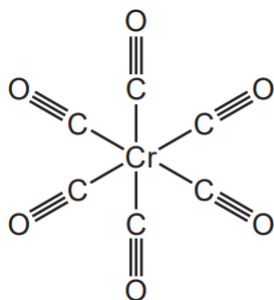
a)



Molecular formula: $\text{C}_{10}\text{H}_{16}$

$$\begin{aligned}\text{Mr: } (10 \times 12) + (16 \times 1) &= 120 + 16 \\ &= 136\end{aligned}$$

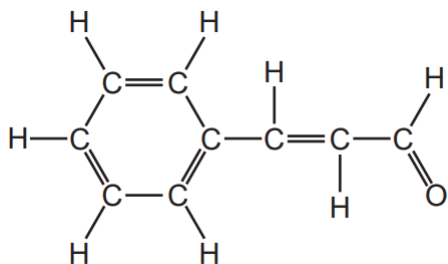
b)



Molecular formula: $\text{Cr}(\text{CO})_6$ or $\text{C}_6\text{O}_6\text{Cr}$

$$\begin{aligned}\text{Mr: } 52 + 6 \times (12 + 16) \\ &= 52 + 6 \times 28 \\ &= 220\end{aligned}$$

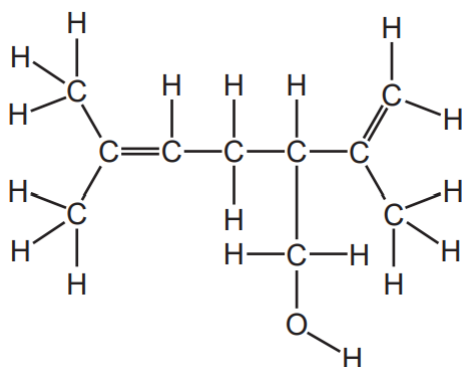
c)



Molecular formula: $\text{C}_9\text{H}_8\text{O}$

$$\begin{aligned}\text{Mr: } (9 \times 12) + (8 \times 1) + 16 \\ &= 108 + 8 + 16 \\ &= 132\end{aligned}$$

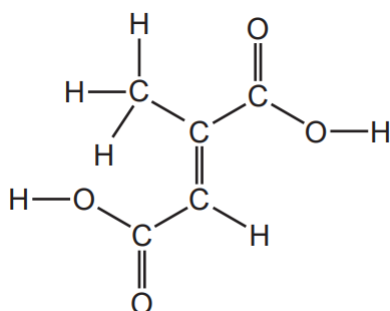
d)



Molecular formula: $\text{C}_{10}\text{H}_{18}\text{O}$

$$\begin{aligned}\text{Mr: } (10 \times 12) + (18 \times 1) + 16 \\ &= 120 + 18 + 16 \\ &= 154\end{aligned}$$

e)



Molecular formula: $\text{C}_4\text{H}_4\text{O}_4$

$$\begin{aligned}\text{Mr: } (4 \times 12) + (4 \times 1) + (4 \times 16) \\ &= 48 + 4 + 64 \\ &= 116\end{aligned}$$

(Total for Question 4 is 10 marks)

5. The relative formula mass (M_r) can be used to find the percentage by mass of an element in a compound. This is useful for comparing substances, for example, to see which fertiliser contains the most nitrogen.

- a) Calculate the percentage by mass of hydrogen (H) in methane (CH_4).

(Relative atomic masses: H = 1, C = 12)

$M_r(\text{CH}_4) = 12 + (4 \times 1) = 16$	1 mark
Percentage H = $(4 \div 16) \times 100$	1 mark
Percentage by mass = 25 %	1 mark
	Total: 3 marks

- b) Calculate the percentage by mass of magnesium (Mg) in magnesium nitrate, $\text{Mg}(\text{NO}_3)_2$.

(Relative atomic masses: N = 14, O = 16, Mg = 24)

$M_r(\text{Mg}(\text{NO}_3)_2) = 24 + 2 \times (14 + 3 \times 16) = 24 + 2 \times (62) = 148$	1 mark
Percentage Mg = $(24 \div 148) \times 100$	1 mark
Percentage by mass = 16.2 % (or 16.22 %)	1 mark
	Total: 3 marks

- c) A farmer needs to buy a fertiliser with the highest possible percentage by mass of nitrogen.

Marking guidance		
Level	Marks	Descriptor
Level 1	1 - 2	A basic attempt is made. Correctly calculates M_r for at least one compound. An attempt to calculate percentage mass is made but contains significant errors. Conclusion is missing or incorrect.
Level 2	3 - 4	The method is generally correct but contains errors. Correctly calculates M_r for both compounds. Makes an error in one or both of the final percentage mass calculations. Provides a conclusion that may be flawed due to the calculation error.
Level 3	5 - 6	A detailed and logical calculation leads to a justified conclusion. Correctly calculates the percentage by mass of nitrogen for both compounds. States the correct conclusion (Urea) with a clear justification.

Ammonium Nitrate (NH_4NO_3):	
$M_r = (2 \times 14) + (4 \times 1) + (3 \times 16) = 28 + 4 + 48 = 80$	1 mark
Percentage of nitrogen = $(28 \div 80) \times 100 = 35 \%$	1 mark
Urea ($\text{CO}(\text{NH}_2)_2$):	
$M_r = 12 + 16 + 2 \times (14 + 2) = 28 + 32 = 60$	1 mark
Percentage of nitrogen = $(28 \div 60) \times 100 = 46.7 \%$ or 46.67 %	1 mark
Conclusion: The farmer should buy <u>Urea</u> because it has a <u>higher percentage by mass of nitrogen</u> .	2 marks
	Total: 6 marks

(Total for Question 5 is 12 marks)