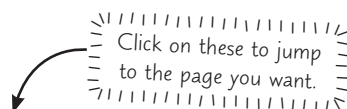


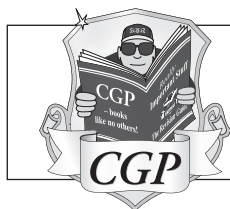


Formula Practice Sheet — Answers

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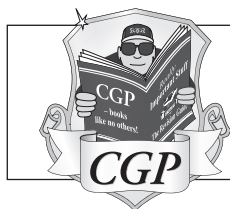
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Formula Practice Sheet — Answers

Relative Atomic Mass

- Q1** To answer the following questions, subtract the percentage abundances provided from 100%:
- $100 - 0.2 - 0.3 - 88.5 = \mathbf{11.0\%}$
 - $100 - 5.8 - 2.1 - 0.3 = \mathbf{91.8\%}$
 - $100 - 68.08 - 1.14 - 3.63 - 0.93 = \mathbf{26.22\%}$
- Q2** To answer the following questions, substitute the data for the two isotopes into the equation for A_r :
- $A_r = ((79 \times 50.7) + (81 \times 49.3)) \div (50.7 + 49.3) = 79.986 = \mathbf{80.0 (1 d.p.)}$
 - $A_r = ((69 \times 60.1) + (71 \times 39.9)) \div (60.1 + 39.9) = 69.798 = \mathbf{69.8 (1 d.p.)}$
 - $A_r = ((191 \times 37.3) + (193 \times 62.7)) \div (37.3 + 62.7) = 192.254 = \mathbf{192.3 (1 d.p.)}$
 - $A_r = ((107 \times 51.8) + (109 \times 48.2)) \div (51.8 + 48.2) = 107.964 = \mathbf{108.0 (1 d.p.)}$
 - $A_r = ((151 \times 47.8) + (153 \times 52.2)) \div (47.8 + 52.2) = 152.044 = \mathbf{152.0 (1 d.p.)}$
- Q3** To answer the following questions, substitute the data for all of the isotopes into the equation for A_r :
- $A_r = ((50 \times 4.3) + (52 \times 83.8) + (53 \times 9.5) + (54 \times 2.4)) \div (4.3 + 83.8 + 9.5 + 2.4) = 52.057 = \mathbf{52.1 (1 d.p.)}$
 - $A_r = ((204 \times 1.4) + (206 \times 24.1) + (207 \times 22.1) + (208 \times 52.4)) \div (1.4 + 24.1 + 22.1 + 52.4) = 207.241 = \mathbf{207.2 (1 d.p.)}$
 - $A_r = ((64 \times 48.6) + (66 \times 27.9) + (67 \times 4.1) + (68 \times 18.8) + (70 \times 0.6)) \div (48.6 + 27.9 + 4.1 + 18.8 + 0.6) = 65.469 = \mathbf{65.5 (1 d.p.)}$
 - $A_r = ((180 \times 0.1) + (182 \times 26.5) + (183 \times 14.3) + (184 \times 30.7) + (186 \times 28.4)) \div (0.1 + 26.5 + 14.3 + 30.7 + 28.4) = 183.891 = \mathbf{183.9 (1 d.p.)}$
- Q4** To answer the following questions, calculate the missing percentage abundance(s) and then use the equation to calculate the relative atomic mass:
- abundance of Sb-123 = $100 - 57.2 = 42.8\%$
 $A_r = ((121 \times 57.2) + (123 \times 42.8)) \div 100 = 121.856 = \mathbf{121.9 (1 d.p.)}$
 - abundance of Si-28 = $100 - 4.7 - 3.1 = 92.2\%$
 $A_r = ((28 \times 92.2) + (29 \times 4.7) + (30 \times 3.1)) \div 100 = 28.109 = \mathbf{28.1 (1 d.p.)}$
 - abundance of Sr-88 = $100 - 7.0 - 9.8 - 0.6 = 82.6\%$
 $A_r = ((84 \times 0.6) + (86 \times 9.8) + (87 \times 7.0) + (88 \times 82.6)) \div 100 = 87.71 = \mathbf{87.7 (1 d.p.)}$
 - abundance of (Ge-73 + Ge-76) = $100 - 20.6 - 27.5 - 36.5 = 15.4\%$
 abundance of Ge-73 = abundance of Ge-76 = $15.4 \div 2 = 7.7\%$
 $A_r = ((70 \times 20.6) + (72 \times 27.5) + (73 \times 7.7) + (74 \times 36.5) + (76 \times 7.7)) \div 100 = 72.703 = \mathbf{72.7 (1 d.p.)}$
- Q5** Find the mass numbers for each neon isotope from their chemical symbols. Substitute these and the isotope abundances into the equation for A_r :
 $A_r = ((20 \times 90.48) + (21 \times 0.27) + (22 \times 9.25)) \div (90.48 + 0.27 + 9.25) = 20.1877 = \mathbf{20.19 (2 d.p.)}$
- Q6** Calculate the percentage abundance for the isotope of unknown mass number:
 $100 - 4.3 = 95.7\%$
 Substitute the known values into the equation for A_r :
 $((113 \times 4.3) + (95.7 \times \text{mass number})) \div 100 = 114.82$
 Rearrange the equation above to make 'mass number' the subject of the equation:
 $\text{mass number} = ((114.82 \times 100) - (113 \times 4.3)) \div 95.7 = 114.901\dots = \mathbf{115}$

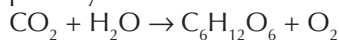


Formula Practice Sheet — Answers

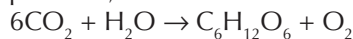
Balancing Chemical Equations

- Q1**
- a) reactants: H = 2, O = 2
products: H = 2, O = 1
The equation is not balanced.
- b) reactants: N = 2, F = 6
products: N = 2, F = 6
The equation is balanced.
- c) reactants: C = 4, S = 8
products: C = 4, S = 8
The equation is balanced.
- d) reactants: Ti = 1, Cl = 4, H = 4, O = 2
products: Ti = 1, Cl = 2, H = 2, O = 2
The equation is not balanced.
- e) reactants: Cu = 1, O = 5, H = 2, S = 1
products: Cu = 1, O = 5, H = 2, S = 1
The equation is balanced.
- f) reactants: Fe = 2, O = 3, C = 3
products: Fe = 2, O = 6, C = 3
The equation is not balanced.
- Q2**
- a) $2\text{Li} + \text{S} \rightarrow \text{Li}_2\text{S}$
- b) $\text{F}_2 + 2\text{NaCl} \rightarrow 2\text{NaF} + \text{Cl}_2$
- c) $2\text{K} + \text{Br}_2 \rightarrow 2\text{KBr}$
- d) $\text{Mg} + 2\text{HCl} \rightarrow \text{MgCl}_2 + \text{H}_2$
- e) $2\text{Al} + 3\text{Cl}_2 \rightarrow 2\text{AlCl}_3$
- f) $\text{N}_2 + 3\text{H}_2 \rightarrow 2\text{NH}_3$
- g) $4\text{Fe} + 3\text{O}_2 \rightarrow 2\text{Fe}_2\text{O}_3$
- h) $2\text{KClO}_3 \rightarrow 2\text{KCl} + 3\text{O}_2$
- i) $8\text{Ag}_2\text{S} \rightarrow 16\text{Ag} + \text{S}_8$
- There's more than one way to balance an equation — for example for Q2a) you could write $4\text{Li} + 2\text{S} \rightarrow 2\text{Li}_2\text{S}$. The reactants and products have equal numbers of each type of atom, so it is balanced. In these answers, we've given the form of the balanced equation where the big numbers before the reactants or products are the smallest possible whole numbers.
- Q3**
- a) $2\text{ZnS} + 3\text{O}_2 \rightarrow 2\text{ZnO} + 2\text{SO}_2$
- b) $\text{CH}_4 + 2\text{O}_2 \rightarrow \text{CO}_2 + 2\text{H}_2\text{O}$
- c) $3\text{HClO}_2 \rightarrow 2\text{HClO}_3 + \text{HCl}$
- d) $\text{P}_4\text{O}_{10} + 6\text{H}_2\text{O} \rightarrow 4\text{H}_3\text{PO}_4$
- e) $\text{C}_5\text{H}_{12} + 8\text{O}_2 \rightarrow 5\text{CO}_2 + 6\text{H}_2\text{O}$
- f) $2\text{Na} + 2\text{NH}_3 \rightarrow 2\text{NaNH}_2 + \text{H}_2$
- Q4**
- a) $(\text{NH}_4)_2\text{Cr}_2\text{O}_7 \rightarrow \text{Cr}_2\text{O}_3 + \text{N}_2 + 4\text{H}_2\text{O}$
- b) $3\text{KBr} + \text{Al}(\text{ClO}_4)_3 \rightarrow \text{AlBr}_3 + 3\text{KClO}_4$
- c) $\text{Al}_2(\text{SO}_4)_3 + 3\text{Ca}(\text{OH})_2 \rightarrow 2\text{Al}(\text{OH})_3 + 3\text{CaSO}_4$
- d) $\text{CuSO}_4 + 4\text{NH}_3 + 4\text{H}_2\text{O} \rightarrow \text{Cu}(\text{NH}_3)_4(\text{H}_2\text{O})_2(\text{OH})_2 + \text{H}_2\text{SO}_4$
- e) $2\text{Na}_3\text{PO}_4 + 3\text{MgCl}_2 \rightarrow 6\text{NaCl} + \text{Mg}_3(\text{PO}_4)_2$
- f) $\text{Mg}_3\text{Si}_2\text{O}_5(\text{OH})_4 + 3\text{CO}_2 \rightarrow 3\text{MgCO}_3 + 2\text{SiO}_2 + 2\text{H}_2\text{O}$

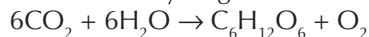
- Q5** Write down the unbalanced symbol equation for photosynthesis:



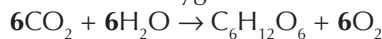
Carbon only appears once in the reactants and products, so it's easiest to balance this first:



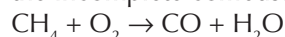
Balance the hydrogen next:



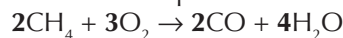
Balance the oxygen:



- Q6** a) Write down the unbalanced symbol equation for the incomplete combustion of methane:



Balance the equation:



It might be easiest to balance the hydrogen first, since this only appears once in the reactants and products. We've given the form of the balanced equation where the big numbers before the reactants or products are the smallest possible whole numbers. But e.g.

$\text{CH}_4 + 1.5\text{O}_2 \rightarrow \text{CO} + 2\text{H}_2\text{O}$ is also balanced so would be correct.

- b) Write down the unbalanced symbol equation for the incomplete combustion of methane:



Balance the equation:



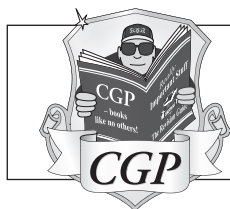
It might be easiest to balance the carbon first, and leave the O_2 until the end. We've given the form of the balanced equation where the big numbers before the reactants or products are the smallest possible whole numbers. But e.g. $2\text{CH}_4 + 2.5\text{O}_2 \rightarrow \text{CO} + \text{C} + 4\text{H}_2\text{O}$ is also balanced so would be correct.



Formula Practice Sheet — Answers

Relative Formula Mass

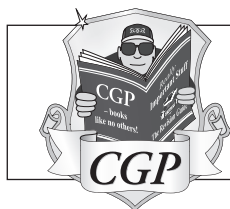
- Q1**
- 12
 - 16
 - 31
 - 39
 - 24
 - 197
 - 119
 - 63.5
 - 184
- Q2** To answer the following questions, add up the relative atomic masses of all the elements in the chemical formula:
- A_r of Li = 7
 A_r of F = 19
 M_r of LiF = 7 + 19 = **26**
 - A_r of Na = 23
 A_r of Cl = 35.5
 M_r of NaCl = 23 + 35.5 = **58.5**
 - A_r of Ca = 40
 A_r of Br = 80
 M_r of CaBr₂ = 40 + (80 × 2) = **200**
 - A_r of C = 12
 A_r of H = 1
 M_r of C₂H₄ = (12 × 2) + (1 × 4) = **28**
 - A_r of Rb = 85
 A_r of I = 127
 M_r of RbI = 85 + 127 = **212**
 - A_r of K = 39
 A_r of N = 14
 A_r of O = 16
 M_r of KNO₃ = 39 + 14 + (16 × 3) = **101**
 - A_r of Al = 27
 A_r of O = 16
 M_r of Al₂O₃ = (27 × 2) + (16 × 3) = **102**
 - A_r of H = 1
 A_r of S = 32
 A_r of O = 16
 M_r of H₂SO₄ = (1 × 2) + 32 + (16 × 4) = **98**
 - A_r of N = 14
 A_r of H = 1
 A_r of O = 16
 M_r of NH₄NO₃ = 14 + (1 × 4) + 14 + (16 × 3) = **80**
- Q3** To answer the following questions, add up the relative atomic masses of all the elements in the chemical formula:
- A_r of Pb = 207
 A_r of O = 16
 A_r of H = 1
 M_r of Pb(OH)₂ = 207 + (16 × 2) + (1 × 2) = **241**
 - A_r of Cu = 63.5
 A_r of N = 16
 A_r of O = 16
 M_r of Cu(NO₃)₂ = 63.5 + (14 × 2) + (16 × 6) = **187.5**
- Q4**
- A_r of Al = 27
 A_r of S = 32
 A_r of O = 16
 M_r of Al₂(SO₄)₃ = (27 × 2) + (32 × 3) + (16 × 12) = **342**
 - A_r of N = 14
 A_r of H = 1
 A_r of C = 12
 A_r of O = 16
 M_r of = (14 × 2) + (1 × 8) + 12 + (16 × 3) = **96**
 - A_r of Fe = 56
 A_r of C = 12
 A_r of H = 1
 A_r of O = 16
 M_r of = 56 + (12 × 21) + (1 × 15) + (16 × 6) = **419**
 - A_r of C = 12
 A_r of H = 1
 A_r of O = 16
 M_r of (CH₃(CH₂)₁₆COO)₃C₃H₅ = (12 × 57) + (1 × 110) + (16 × 6) = **890**
 - A_r of Pt = 195
 A_r of N = 14
 A_r of O = 16
 A_r of H = 1
 A_r of Cl = 35.5
 M_r of Pt(NO₂)(NH₃)₂Cl = 195 + (14 × 3) + (16 × 2) + (1 × 6) + 35.5 = **310.5**
 - A_r of Zn = 65
 A_r of N = 14
 A_r of H = 1
 A_r of S = 32
 A_r of O = 16
 M_r of [Zn(NH₃)₄]SO₄ = 65 + (14 × 4) + (1 × 12) + 32 + (16 × 4) = **229**
 - A_r of Co = 59
 A_r of N = 14
 A_r of H = 1
 A_r of O = 16
 A_r of Cl = 35.5
 M_r of [Co(NH₃)₅(H₂O)]Cl₃ = 59 + (14 × 5) + (1 × 17) + 16 + (35.5 × 3) = **268.5**
- Q4** To answer the following questions, calculate the relative formula masses of the reactants and products in each reaction:
- M_r of H₂ = (1 × 2) = 2
 M_r of N₂ = (14 × 2) = 28
 M_r of NH₃ = 14 + (1 × 3) = 17
 Largest M_r = **N₂**
 - M_r of CuSO₄ = 63.5 + 32 + (16 × 4) = 159.5
 A_r of Zn = 65
 M_r of ZnSO₄ = 65 + 32 + (16 × 4) = 161
 A_r of Cu = 63.5
 Largest M_r = **ZnSO₄**



Formula Practice Sheet — Answers

Relative Formula Mass

- c) M_r of $\text{CH}_4 = 12 + (1 \times 4) = 16$
 M_r of $\text{O}_2 = (16 \times 2) = 32$
 M_r of $\text{CO}_2 = 12 + (16 \times 2) = 44$
 M_r of $\text{H}_2\text{O} = (1 \times 2) + 16 = 18$
 Largest $M_r = \text{CO}_2$
- d) M_r of $\text{FeSO}_4 = 56 + 32 + (16 \times 4) = 152$
 M_r of $\text{Fe}_2\text{O}_3 = (56 \times 2) + (16 \times 3) = 160$
 M_r of $\text{SO}_2 = 32 + (16 \times 2) = 64$
 M_r of $\text{SO}_3 = 32 + (16 \times 3) = 80$
 Largest $M_r = \text{Fe}_2\text{O}_3$
- e) M_r of $\text{KCN} = 39 + 12 + 14 = 65$
 M_r of $\text{HBr} = 1 + 80 = 81$
 M_r of $\text{KBr} = 39 + 80 = 119$
 M_r of $\text{HCN} = 1 + 12 + 14 = 27$
 Largest $M_r = \text{KBr}$
- f) M_r of $\text{HNO}_3 = 1 + 14 + (16 \times 3) = 63$
 M_r of $\text{Na}_2\text{CO}_3 = (23 \times 2) + 12 + (16 \times 3) = 106$
 M_r of $\text{NaNO}_3 = 23 + 14 + (16 \times 3) = 85$
 M_r of $\text{H}_2\text{O} = (1 \times 2) + 16 = 18$
 M_r of $\text{CO}_2 = 12 + (16 \times 2) = 44$
 Largest $M_r = \text{Na}_2\text{CO}_3$
- g) A_r of $\text{Cu} = 63.5$
 M_r of $\text{AgNO}_3 = 108 + 14 + (16 \times 3) = 170$
 A_r of $\text{Ag} = 108$
 M_r of $\text{Cu}(\text{NO}_3)_2 = 63.5 + (14 \times 2) + (16 \times 6) = 187.5$
 Largest $M_r = \text{Cu}(\text{NO}_3)_2$
- h) M_r of $\text{Pb}(\text{NO}_3)_2 = 207 + (14 \times 2) + (16 \times 6) = 331$
 M_r of $\text{KI} = 39 + 127 = 166$
 M_r of $\text{PbI}_2 = 207 + (127 \times 2) = 461$
 M_r of $\text{KNO}_3 = 39 + 14 + (16 \times 3) = 101$
 Largest $M_r = \text{PbI}_2$
- Q5** a) M_r of $\text{XCO}_3 = A_r$ of $\text{X} + A_r$ of $\text{C} + (3 \times A_r$ of $\text{O})$
 A_r of $\text{X} = M_r$ of $\text{XCO}_3 - A_r$ of $\text{C} - (3 \times A_r$ of $\text{O})$
 A_r of $\text{X} = 197 - 12 - (3 \times 16) = \mathbf{137}$
- b) Element X is **barium (Ba)**.
- c) $\text{X}(\text{NO}_3)_2 = \text{Ba}(\text{NO}_3)_2$
 M_r of $\text{Ba}(\text{NO}_3)_2 = 137 + (14 \times 2) + (16 \times 6) = \mathbf{261}$
- Q6** a) Relative mass of I and H in iodic acid =
 A_r of I + A_r of H = $127 + 1 = 128$
 Relative mass of O in iodic acid = $176 - 128 = 48$
 A_r of O = 16, so there are $48 \div 16 = 3$ O atoms.
 Chemical formula of iodic acid = **HIO_3**
- b) A_r of I = 127, A_r of O = 16
 There could be 1 or 2 I atoms in the iodine oxide
 ($3 \times 127 > 334$, so there can't be 3 or more I atoms).
 If there is 1 I atom, the relative mass of O in the iodine oxide = $334 - 127 = 207$. However this does not divide by 16, so there must be 2 I atoms.
 Relative mass of O in iodine oxide = $334 - (127 \times 2) = 80$
 So there are $80 \div 16 = 5$ O atoms.
 The chemical formula of the iodine oxide is **I_2O_5** .



Formula Practice Sheet — Answers

Percentage Mass

Q1 To answer the following questions, calculate the M_r of the compound and then substitute the values into the formula in the grey box:

- a) M_r of $H_2O = (1 \times 2) + 16 = 18$
percentage mass of O in $H_2O = ((16 \div 18) \times 100 = 88.88... = 89\%$
- b) M_r of $SO_2 = 32 + (16 \times 2) = 64$
percentage mass of O in $SO_2 = ((16 \times 2) \div 64) \times 100 = 50\%$
- c) M_r of $Fe_2O_3 = (56 \times 2) + (16 \times 3) = 160$
percentage mass of O in $Fe_2O_3 = ((16 \times 3) \div 160) \times 100 = 30\%$
- d) M_r of $CH_3CH_2OH = (12 \times 2) + (1 \times 6) + 16 = 46$
percentage mass of O in $CH_3CH_2OH = (16 \div 46) \times 100 = 34.78... = 35\%$
- e) M_r of $CH_3COOH = (12 \times 2) + (1 \times 4) + (16 \times 2) = 60$
percentage mass of O in $CH_3COOH = ((16 \times 2) \div 60) \times 100 = 53.33... = 53\%$
- f) M_r of $Ca(OH)_2 = 40 + ((16 + 1) \times 2) = 74$
percentage mass of O in $Ca(OH)_2 = ((16 \times 2) \div 74) \times 100 = 43.24... = 43\%$
- g) M_r of $Al(OH)_3 = 27 + ((16 + 1) \times 3) = 78$
percentage mass of O in $Al(OH)_3 = ((16 \times 3) \div 78) \times 100 = 61.53... = 62\%$
- h) M_r of $Mg(HCO_3)_2 = 24 + ((1 + 12 + (16 \times 3)) \times 2) = 146$
percentage mass of O in $Mg(HCO_3)_2 = ((16 \times 6) \div 146) \times 100 = 65.75... = 66\%$
- i) M_r of $Ca_5(PO_4)_3OH = (40 \times 5) + ((31 + (16 \times 4)) \times 3) + 16 + 1 = 502$
percentage mass of O in $Ca_5(PO_4)_3OH = ((16 \times 13) \div 502) \times 100 = 41.43... = 41\%$

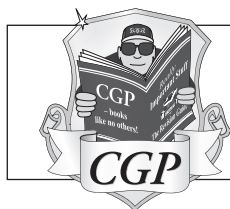
Q2 To answer the following questions, calculate the M_r of the compound and then substitute the values into the formula in the grey box:

- a) M_r of $CS_2 = 12 + (32 \times 2) = 76$
percentage mass of C in $CS_2 = (12 \div 76) \times 100 = 15.78... = 16\%$
- b) M_r of $C_2H_6 = (12 \times 2) + (1 \times 6) = 30$
percentage mass of C in $C_2H_6 = ((12 \times 2) \div 30) \times 100 = 80\%$
- c) M_r of $MgCO_3 = 24 + 12 + (16 \times 3) = 84$
percentage mass of C in $MgCO_3 = (12 \div 84) \times 100 = 14.28... = 14\%$
- d) M_r of $CHCl_3 = 12 + 1 + (35.5 \times 3) = 119.5$
percentage mass of C in $CHCl_3 = (12 \div 119.5) \times 100 = 10.04... = 10\%$
- e) M_r of $Ca(HCO_3)_2 = 40 + ((1 + 12 + (16 \times 3)) \times 2) = 162$
percentage mass of C in $Ca(HCO_3)_2 = ((12 \times 2) \div 162) \times 100 = 14.81... = 15\%$

- f) M_r of $C_5H_6N_2O_2 = (12 \times 5) + (1 \times 6) + (14 \times 2) + (16 \times 2) = 126$
percentage mass of C in $C_5H_6N_2O_2 = ((12 \times 5) \div 126) \times 100 = 47.61... = 48\%$
- g) M_r of $(CH_3)_2CNH = ((12 + (1 \times 3)) \times 2) + 12 + 14 + 1 = 57$
percentage mass of C in $(CH_3)_2CNH = ((12 \times 3) \div 57) \times 100 = 63.15... = 63\%$
- h) M_r of $(CH_3)(CH_2)_3OH = 12 + (1 \times 3) + ((12 + (1 \times 2)) \times 3) + 16 + 1 = 74$
percentage mass of C in $(CH_3)(CH_2)_3OH = ((12 \times 4) \div 74) \times 100 = 64.86... = 65\%$
- i) M_r of $Pt(SCN)_2(NH_3)_2 = 195 + ((32 + 12 + 14) \times 2) + ((14 + (1 \times 3)) \times 2) = 345$
percentage mass of C in $Pt(SCN)_2(NH_3)_2 = ((12 \times 2) \div 345) \times 100 = 6.956... = 7\%$

Q3 To answer the following questions, calculate the M_r of the compound and then substitute the values into the formula in the grey box:

- a) M_r of $CH_3Br = 12 + (1 \times 3) + 80 = 95$
percentage mass of Br in $CH_3Br = (80 \div 95) \times 100 = 84.210... = 84.2\%$
- b) M_r of $C_6H_5CH_2I = (12 \times 6) + (1 \times 5) + 12 + (1 \times 2) + 127 = 218$
percentage mass of I in $C_6H_5CH_2I = (127 \div 218) \times 100 = 58.256... = 58.3\%$
- c) M_r of $CaCO_3 = 40 + 12 + (16 \times 3) = 100$
percentage mass of Ca in $CaCO_3 = (40 \div 100) \times 100 = 40.0\%$
- d) M_r of $Ni(CO)_4 = 59 + ((12 + 16) \times 4) = 171$
percentage mass of Ni in $Ni(CO)_4 = (59 \div 171) \times 100 = 34.502... = 34.5\%$
- e) M_r of $TeF_6 = 128 + (19 \times 6) = 242$
percentage mass of F in $TeF_6 = ((19 \times 6) \div 242) \times 100 = 47.107... = 47.1\%$
- f) M_r of $C_6H_5Cl = (12 \times 6) + (1 \times 5) + 35.5 = 112.5$
percentage mass of H in $C_6H_5Cl = ((1 \times 5) \div 112.5) \times 100 = 4.444... = 4.4\%$
- g) M_r of $Co(NH_3)_3Cl_3 = 59 + ((14 + (1 \times 3)) \times 3) + (35.5 \times 3) = 216.5$
percentage mass of N in $Co(NH_3)_3Cl_3 = ((14 \times 3) \div 216.5) \times 100 = 19.399... = 19.4\%$
- h) M_r of $Cu(NO_3)_2 = 63.5 + ((14 + (16 \times 3)) \times 2) = 187.5$
percentage mass of O in $Cu(NO_3)_2 = (16 \times 6) \div 187.5 \times 100 = 51.2\%$
- i) M_r of $Fe(C_5H_5)_2 = 56 + (((12 \times 5) + (1 \times 5)) \times 2) = 186$
percentage mass of C in $Fe(C_5H_5)_2 = ((12 \times 10) \div 186) \times 100 = 64.516... = 64.5\%$



Formula Practice Sheet — Answers

Percentage Mass

Q4 To answer the following questions, calculate the percentage mass of the element in bold, for all of the compounds in the list:

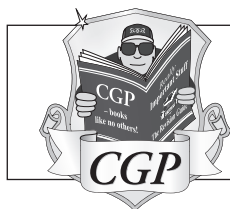
- a) M_r of $\text{CaCl}_2 = 40 + (35.5 \times 2) = 111$
 % mass of Ca in $\text{CaCl}_2 = (40 \div 111) \times 100 = 36.03\%\dots$
 M_r of $\text{CaSO}_4 = 40 + 32 + (16 \times 4) = 136$
 % mass of Ca in $\text{CaSO}_4 = (40 \div 136) \times 100 = 29.41\%\dots$
 M_r of $\text{Ca}_2\text{O}_4\text{Si} = (40 \times 2) + (16 \times 4) + 28 = 172$
 % mass of Ca in $\text{Ca}_2\text{O}_4\text{Si} = ((40 \times 2) \div 172) \times 100 = 46.51\%\dots$
 Largest % mass of Ca = **$\text{Ca}_2\text{O}_4\text{Si}$**
- b) M_r of $\text{LiAlH}_4 = 7 + 27 + (1 \times 4) = 38$
 % mass of Al in $\text{LiAlH}_4 = (27 \div 38) \times 100 = 71.05\%\dots$
 M_r of $\text{Na}_3\text{AlF}_6 = (23 \times 3) + 27 + (19 \times 6) = 210$
 % mass of Al in $\text{Na}_3\text{AlF}_6 = (27 \div 210) \times 100 = 12.85\%\dots$
 M_r of $\text{Al}_2\text{SiO}_5 = (27 \times 2) + 28 + (16 \times 5) = 162$
 % mass of Al in $\text{Al}_2\text{SiO}_5 = ((27 \times 2) \div 162) \times 100 = 33.33\%\dots$
 Largest % mass of Al = **LiAlH_4**
- c) M_r of $\text{KFeS}_2 = 39 + 56 + (32 \times 2) = 159$
 % mass of S in $\text{KFeS}_2 = ((32 \times 2) \div 159) \times 100 = 40.25\%\dots$
 M_r of $(\text{NH}_4)_2\text{S}_2\text{O}_3 = ((14 + (1 \times 4)) \times 2) + (32 \times 2) + (16 \times 3) = 148$
 % mass of S in $(\text{NH}_4)_2\text{S}_2\text{O}_3 = ((32 \times 2) \div 148) \times 100 = 43.24\%\dots$
 M_r of $\text{H}_2\text{SO}_2 = (1 \times 2) + 32 + (16 \times 2) = 66$
 % mass of S in $\text{H}_2\text{SO}_2 = (32 \div 66) \times 100 = 48.48\%\dots$
 Largest % mass of S = **H_2SO_2**
- d) M_r of $\text{C}_6\text{H}_4(\text{NH}_2)_2 = (12 \times 6) + (1 \times 4) + ((14 + (1 \times 2)) \times 2) = 108$
 % mass of N in $\text{C}_6\text{H}_4(\text{NH}_2)_2 = ((14 \times 2) \div 108) \times 100 = 25.92\%\dots$
 M_r of $\text{C}_2\text{H}_5\text{NO}_2 = (12 \times 2) + (1 \times 5) + 14 + (16 \times 2) = 75$
 % mass of N in $\text{C}_2\text{H}_5\text{NO}_2 = (14 \div 75) \times 100 = 18.66\%\dots$
 M_r of $\text{RbNO}_3 = 85 + 14 + (16 \times 3) = 147$
 % mass of N in $\text{RbNO}_3 = (14 \div 147) \times 100 = 9.52\%\dots$
 Largest % mass of N = **$\text{C}_6\text{H}_4(\text{NH}_2)_2$**

- e) M_r of $\text{Cu}_3(\text{PO}_4)_2 = (63.5 \times 3) + ((31 + (16 \times 4)) \times 2) = 380.5$
 % mass of Cu in $\text{Cu}_3(\text{PO}_4)_2 = ((63.5 \times 3) \div 380.5) \times 100 = 50.06\%\dots$
 M_r of $\text{CuI} = 63.5 + 127 = 190.5$
 % mass of Cu in $\text{CuI} = (63.5 \div 190.5) \times 100 = 33.33\%\dots$
 M_r of $\text{Cu}_2(\text{OH})_3\text{Cl} = (63.5 \times 2) + ((16 + 1) \times 3) + 35.5 = 213.5$
 % mass of Cu in $\text{Cu}_2(\text{OH})_3\text{Cl} = ((63.5 \times 2) \div 213.5) \times 100 = 59.48\%\dots$
 Largest % mass of Cu = **$\text{Cu}_2(\text{OH})_3\text{Cl}$**
- f) M_r of $\text{Be}(\text{BH}_4)_2 = 9 + ((11 + (1 \times 4)) \times 2) = 39$
 % mass of B in $\text{Be}(\text{BH}_4)_2 = ((11 \times 2) \div 39) \times 100 = 56.41\%\dots$
 M_r of $\text{Cs}_2\text{B}_{12}\text{H}_{12} = (133 \times 2) + (11 \times 12) + (1 \times 12) = 410$
 % mass of B in $\text{Cs}_2\text{B}_{12}\text{H}_{12} = ((11 \times 12) \div 410) \times 100 = 32.19\%\dots$
 M_r of $\text{B}_2(\text{OH})_4 = (11 \times 2) + ((16 + 1) \times 4) = 90$
 % mass of B in $\text{B}_2(\text{OH})_4 = ((11 \times 2) \div 90) \times 100 = 24.44\%\dots$
 Largest % mass of B = **$\text{Be}(\text{BH}_4)_2$**

- Q5** E.g. calculate the percentage masses of carbon and oxygen in XYCO_3 using the formula in the grey box:
 % mass of C = $(12 \div 84) \times 100 = 14.28\%\dots$
 % mass of O = $((16 \times 3) \div 84) \times 100 = 57.14\%\dots$
 Subtract the known percentage masses from 100% to get the percentage mass of X:
 % mass of X = $100 - (1.2 + 14.28\% + 57.14\%) = 27.37\% = \mathbf{27.4\%}$
(1 d.p)

The percentage masses of all the elements in a compound will always add up to 100% — this is a handy way to check your answers for percentage mass questions.

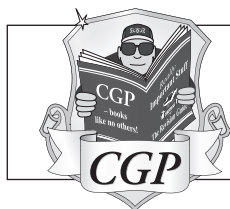
- Q6** E.g. substitute the given values into the formula for the percentage mass of carbon in compound Z:
 % mass of C in Z = $\frac{A_r \text{ of C} \times \text{no. of C atoms in Z}}{M_r \text{ of Z}} \times 100$
 $84\% = \frac{12 \times \text{no. of C atoms in Z}}{100} \times 100$
 Cancel out the two 100s to simplify the equation:
 $84\% = 12 \times \text{no. of C atoms in Z}$
 Rearrange the equation to work out the number of C atoms in compound Z:
 no. of C atoms in Z = $84 \div 12 = 7$ C atoms in Z.
 Find the mass of H in compound Z by subtracting the mass of C from the M_r of the compound:
 The mass of C in the compound is $12 \times 7 = 84$,
 so the mass of H in the compound is $100 - 84 = 16$
 A_r of H = 1, so the number of H atoms is $16 \div 1 = 16$
 Chemical formula = **C_7H_{16}**



Formula Practice Sheet — Answers

Moles

- Q1** The mass of one mole of any substance is equal to its relative atomic mass or relative formula mass.
- 24 g**
 - $(35.5 \times 2) = \mathbf{71 \text{ g}}$
 - $1 + 80 = \mathbf{81 \text{ g}}$
 - $23 + 35.5 = \mathbf{58.5 \text{ g}}$
 - $65 + 32 = \mathbf{97 \text{ g}}$
 - $59 + (127 \times 2) = \mathbf{313 \text{ g}}$
 - $(1 \times 2) + 32 + (16 \times 4) = \mathbf{98 \text{ g}}$
 - $39 + 14 + (16 \times 3) = \mathbf{101 \text{ g}}$
 - $(23 \times 2) + 52 + (16 \times 4) = \mathbf{162 \text{ g}}$
- Q2** To answer the following questions, calculate the M_r of the compound and substitute the values for mass and M_r into $\text{moles} = \text{mass} \div M_r$:
- $M_r = 14 + (1 \times 3) = 17$
 $\text{moles} = \text{mass} \div M_r = 34 \div 17 = \mathbf{2 \text{ mol}}$
 - $M_r = 12 + (1 \times 4) = 16$
 $\text{moles} = \text{mass} \div M_r = 8 \div 16 = \mathbf{0.5 \text{ mol}}$
 - $M_r = 11 + (19 \times 3) = 68$
 $\text{moles} = \text{mass} \div M_r = 170 \div 68 = \mathbf{2.5 \text{ mol}}$
 - $M_r = (14 \times 2) + (16 \times 5) = 108$
 $\text{moles} = \text{mass} \div M_r = 153 \div 108 = 1.416... = \mathbf{1.42 \text{ mol (3 s.f.)}}$
 - $M_r = 63.5 + (35.5 \times 2) = 134.5$
 $\text{moles} = \text{mass} \div M_r = 92 \div 134.5 = 0.6840... = \mathbf{0.68 \text{ mol (2 s.f.)}}$
 - $M_r = (12 \times 5) + (1 \times 5) + 14 = 79$
 $\text{moles} = \text{mass} \div M_r = 135 \div 79 = 1.708... = \mathbf{1.7 \text{ mol (2 s.f.)}}$
 - $M_r = (39 \times 2) + 52 + (16 \times 4) = 194$
 $\text{moles} = \text{mass} \div M_r = 233 \div 194 = 1.201... = \mathbf{1.20 \text{ mol (3 s.f.)}}$
 - $M_r = (39 \times 2) + (52 \times 2) + (16 \times 7) = 294$
 $\text{moles} = \text{mass} \div M_r = 325.5 \div 294 = 1.107... = \mathbf{1.11 \text{ mol (3 s.f.)}}$
 - $M_r = (12 \times 7) + (1 \times 5) + 7 + (16 \times 2) = 128$
 $\text{moles} = \text{mass} \div M_r = 24.4 \div 128 = 0.190625 = \mathbf{0.191 \text{ mol (3 s.f.)}}$
- Q3** To answer the following questions, calculate the M_r of the compound and substitute the values for moles and M_r into the rearrangement of $\text{moles} = \text{mass} \div M_r$, $\text{mass} = \text{moles} \times M_r$:
- $M_r = 119 + (16 \times 2) = 151$
 $\text{mass} = \text{moles} \times M_r = 2.00 \times 151 = \mathbf{302 \text{ g}}$
 - $M_r = (12 \times 6) + (1 \times 6) = 78$
 $\text{mass} = \text{moles} \times M_r = 0.50 \times 78 = \mathbf{39 \text{ g}}$
 - $M_r = (27 \times 2) + (32 \times 3) = 150$
 $\text{mass} = \text{moles} \times M_r = 0.30 \times 150 = \mathbf{45 \text{ g}}$
 - $M_r = 12 + 1 + (35.5 \times 3) = 119.5$
 $\text{mass} = \text{moles} \times M_r = 0.020 \times 119.5 = 2.39 = \mathbf{2.4 \text{ g (2 s.f.)}}$
- $M_r = 184 + 16 + (35.5 \times 4) = 342$
 $\text{mass} = \text{moles} \times M_r = 1.22 \times 342 = 417.24 = \mathbf{417 \text{ g (3 s.f.)}}$
 - $M_r = 135 + 55 + (16 \times 4) = 256$
 $\text{mass} = \text{moles} \times M_r = 0.27 \times 256 = 69.12 = \mathbf{69 \text{ g (2 s.f.)}}$
 - $M_r = (108 \times 3) + 31 + (16 \times 4) = 419$
 $\text{mass} = \text{moles} \times M_r = 0.215 \times 419 = 90.085 = \mathbf{90.1 \text{ g (3 s.f.)}}$
 - $M_r = (12 \times 6) + (1 \times 13) + 16 + 1 = 102$
 $\text{mass} = \text{moles} \times M_r = 2.11 \times 102 = 215.22 \text{ g} = \mathbf{215 \text{ g (3 s.f.)}}$
 - $M_r = ((14 + (1 \times 4)) \times 3) + 31 + (16 \times 4) = 149$
 $\text{mass} = \text{moles} \times M_r = 0.118 \times 149 = 17.582 = \mathbf{17.6 \text{ g (3 s.f.)}}$
- Q4** To answer the following questions, calculate the M_r of the compound and substitute the known values into the correct rearrangement of $\text{moles} = \text{mass} \div M_r$:
- $M_r = (1 \times 2) + 32 + (16 \times 4) = 98$
 $\text{mass} = \text{moles} \times M_r = 0.50 \times 98 = \mathbf{49 \text{ g}}$
 - $M_r = 108 + 14 + (16 \times 3) = 170$
 $\text{moles} = \text{mass} \div M_r = 97 \div 170 = 0.570... = \mathbf{0.57 \text{ mol (2 s.f.)}}$
 - $M_r = (12 \times 6) + (1 \times 8) + (16 \times 7) = 192$
 $\text{mass} = \text{moles} \times M_r = 0.25 \times 192 = \mathbf{48 \text{ g}}$
 - $M_r = ((14 + (1 \times 4)) \times 2) + 12 + (16 \times 3) = 96$
 $\text{moles} = \text{mass} \div M_r = 36 \div 96 = 0.375 = \mathbf{0.38 \text{ mol (2 s.f.)}}$
 - $M_r = 137 + ((14 + (16 \times 3)) \times 2) = 261$
 $\text{moles} = \text{mass} \div M_r = 12.0 \div 261 = 0.04597... = \mathbf{0.0460 \text{ mol (3 s.f.)}}$
 - $M_r = (65 \times 3) + ((31 + (16 \times 4)) \times 2) = 385$
 $\text{mass} = \text{moles} \times M_r = 0.475 \times 385 = 182.875 = \mathbf{183 \text{ g (3 s.f.)}}$
- Q5**
- M_r of $\text{CaCO}_3 = 40 + 12 + (16 \times 3) = 100$
 $\text{moles} = \text{mass} \div M_r = 140 \div 100 = \mathbf{1.4 \text{ mol}}$
 - M_r of $\text{CaCl}_2 = 40 + (35.5 \times 2) = 111$
 $\text{mass} = \text{moles} \times M_r = 1.15 \times 111 = 127.65 = \mathbf{128 \text{ g (3 s.f.)}}$
- Q6** Calculate the relative formula masses of the reactants:
 M_r of $\text{HNO}_3 = 1 + 14 + (16 \times 3) = 63$
 M_r of $\text{NaOH} = 23 + 16 + 1 = 40$
 Calculate the masses of the reactants using $\text{mass} = \text{moles} \times M_r$:
 $\text{mass of HNO}_3 = 0.375 \times 63 = 23.625 \text{ g}$
 $\text{mass of NaOH} = 0.375 \times 40 = 15 \text{ g}$
 So the total mass of reactants is $23.625 + 15 = 38.625 \text{ g} = \mathbf{39 \text{ g (2 s.f.)}}$



Formula Practice Sheet — Answers

Balancing Equations Using Masses

Q1 To answer the following questions, multiply the ratio of moles of the substance in bold to the moles of oxygen in the symbol equation by 1.5 moles.

- a) $1.5 \times (1 \div 1) = \mathbf{1.5 \text{ mol}}$
- b) $1.5 \times (2 \div 1) = \mathbf{3 \text{ mol}}$
- c) $1.5 \times (1 \div 2) = \mathbf{0.75 \text{ mol}}$
- d) $1.5 \times (4 \div 1) = \mathbf{6 \text{ mol}}$
- e) $1.5 \times (4 \div 3) = \mathbf{2 \text{ mol}}$
- f) $1.5 \times (2 \div 3) = \mathbf{1 \text{ mol}}$
- g) $1.5 \times (1 \div 6) = \mathbf{0.25 \text{ mol}}$
- h) $1.5 \times (3 \div 5) = \mathbf{0.9 \text{ mol}}$

Q2 To answer the following questions, use the number of moles of N_2 from the equation to work out how many moles of the substance in bold are present. Then calculate the mass using the equation, mass = moles $\times M_r$:

- a) moles of $\text{NO} = 2 \times (2 \div 1) = 4$
 M_r of $\text{NO} = 14 + 16 = 30$
 mass of $\text{NO} = 4 \times 30 = \mathbf{120 \text{ g}}$
- b) moles of $\text{H}_2 = 2 \times (3 \div 1) = 6$
 M_r of $\text{H}_2 = 2 \times 1 = 2$
 mass of $\text{H}_2 = 6 \times 2 = \mathbf{12 \text{ g}}$
- c) moles of $\text{Cu} = 2 \times (3 \div 1) = 6$
 A_r of $\text{Cu} = 63.5$
 mass of $\text{Cu} = 6 \times 63.5 = \mathbf{381 \text{ g}}$
- d) moles of $\text{Li} = 2 \times (6 \div 1) = 12$
 A_r of $\text{Li} = 7$
 mass of $\text{Li} = 12 \times 7 = \mathbf{84 \text{ g}}$
- e) moles of $\text{C} = 2 \times (8 \div 2) = 8$
 A_r of $\text{C} = 12$
 mass of $\text{C} = 8 \times 12 = \mathbf{96 \text{ g}}$
- f) moles of $\text{Na} = 2 \times (2 \div 3) = 1.333\dots$
 A_r of $\text{Na} = 23$
 mass of $\text{Na} = 1.3333\dots \times 23 = 30.6666\dots = \mathbf{30.7 \text{ g}}$

Q3 To answer the following questions, follow the four steps for finding a balanced equation using masses:

- a) moles of $\text{Cu} = 127 \div 63.5 = 2$
 moles of $\text{O}_2 = 32 \div 32 = 1$
 moles of $\text{CuO} = 159 \div 79.5 = 2$
 The balanced equation is $\mathbf{2\text{Cu} + \text{O}_2 \rightarrow 2\text{CuO}}$

The smallest number of moles in this step is 1, so you don't need to do step 2, since dividing by 1 will give you the same numbers.

- b) moles of $\text{Na} = 4.6 \div 23 = 0.2$
 moles of $\text{H}_2\text{O} = 3.6 \div 18 = 0.2$
 moles of $\text{NaOH} = 8 \div 40 = 0.2$
 moles of $\text{H}_2 = 0.2 \div 2 = 0.1$
 Divide the moles by the smallest number of moles in the reaction:
 $\text{Na}: 0.2 \div 0.1 = 2$
 $\text{H}_2\text{O}: 0.2 \div 0.1 = 2$
 $\text{NaOH}: 0.2 \div 0.1 = 2$
 $\text{H}_2: 0.1 \div 0.1 = 1$
 The balanced equation is
 $\mathbf{2\text{Na} + 2\text{H}_2\text{O} \rightarrow 2\text{NaOH} + \text{H}_2}$

- c) moles of $\text{Al} = 5.4 \div 27 = 0.2$
 moles of $\text{HCl} = 21.9 \div 36.5 = 0.6$
 moles of $\text{AlCl}_3 = 26.7 \div 133.5 = 0.2$
 moles of $\text{H}_2 = 0.6 \div 2 = 0.3$
 Divide the moles by the smallest number of moles in the reaction:

$$\text{Al}: 0.2 \div 0.2 = 1$$

$$\text{HCl}: 0.6 \div 0.2 = 3$$

$$\text{AlCl}_3: 0.2 \div 0.2 = 1$$

$$\text{H}_2: 0.3 \div 0.2 = 1.5$$

Multiply the numbers by 2 so they all become whole numbers:

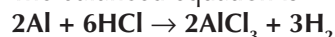
$$\text{Al}: 1 \times 2 = 2$$

$$\text{HCl}: 3 \times 2 = 6$$

$$\text{AlCl}_3: 1 \times 2 = 2$$

$$\text{H}_2: 1.5 \times 2 = 3$$

The balanced equation is



- d) moles of $\text{KClO}_3 = 17.15 \div 122.5 = 0.14$
 moles of $\text{KCl} = 10.43 \div 74.5 = 0.14$
 moles of $\text{O}_2 = 6.72 \div 32 = 0.21$
 Divide the moles by the smallest number of moles in the reaction:

$$\text{KClO}_3: 0.14 \div 0.14 = 1$$

$$\text{KCl}: 0.14 \div 0.14 = 1$$

$$\text{O}_2: 0.21 \div 0.14 = 1.5$$

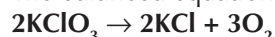
Multiply the numbers by 2 so they all become whole numbers:

$$\text{KClO}_3: 1 \times 2 = 2$$

$$\text{KCl}: 1 \times 2 = 2$$

$$\text{O}_2: 1.5 \times 2 = 3$$

The balanced equation is



- e) moles of $\text{Fe}_2\text{O}_3 = 16.0 \div 160 = 0.1$
 moles of $\text{C} = 1.8 \div 12 = 0.15$
 moles of $\text{Fe} = 11.2 \div 56 = 0.2$
 moles of $\text{CO}_2 = 6.6 \div 44 = 0.15$
 Divide the moles by the smallest number of moles in the reaction:

$$\text{Fe}_2\text{O}_3: 0.1 \div 0.1 = 1$$

$$\text{C}: 0.15 \div 0.1 = 1.5$$

$$\text{Fe}: 0.2 \div 0.1 = 2$$

$$\text{CO}_2: 0.15 \div 0.1 = 1.5$$

Multiply the numbers by 2 so they all become whole numbers:

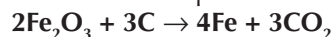
$$\text{Fe}_2\text{O}_3: 1 \times 2 = 2$$

$$\text{C}: 1.5 \times 2 = 3$$

$$\text{Fe}: 4 \times 2 = 4$$

$$\text{CO}_2: 1.5 \times 2 = 3$$

The balanced equation is





Formula Practice Sheet — Answers

Balancing Equations Using Masses

- f) moles of $C_2H_6 = 1.2 \div 30 = 0.04$
 moles of $O_2 = 4.48 \div 32 = 0.14$
 moles of $CO_2 = 3.52 \div 44 = 0.08$
 moles of $H_2O = 2.16 \div 18 = 0.12$
 Divide the moles by the smallest number of moles in the reaction:

$$C_2H_6: 0.04 \div 0.04 = 1$$

$$O_2: 0.14 \div 0.04 = 3.5$$

$$CO_2: 0.08 \div 0.04 = 2$$

$$H_2O: 0.12 \div 0.04 = 3$$

Multiply the numbers by 2 so they all become whole numbers:

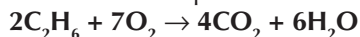
$$C_2H_6: 1 \times 2 = 2$$

$$O_2: 3.5 \times 2 = 7$$

$$CO_2: 2 \times 2 = 4$$

$$H_2O: 3 \times 2 = 6$$

The balanced equation is:



- Q4** Calculate the moles of the reactants and products:

$$\text{moles of } Na_3PO_4 = 16.4 \div 164 = 0.1$$

$$\text{moles of } CaCl_2 = 16.65 \div 111 = 0.15$$

$$\text{moles of } Ca_3(PO_4)_2 = 15.5 \div 310 = 0.05$$

$$\text{moles of } NaCl = 17.55 \div 58.5 = 0.3$$

Divide the moles by the smallest number of moles in the reaction:

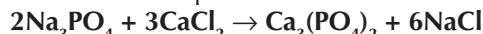
$$Na_3PO_4: 0.1 \div 0.05 = 2$$

$$CaCl_2: 0.15 \div 0.05 = 3$$

$$Ca_3(PO_4)_2: 0.05 \div 0.05 = 1$$

$$NaCl: 0.3 \div 0.05 = 6$$

The balanced equation is:



- Q5** Mass of $SiCl_4$ that did react = $20.0 - 4.70 = 15.3$ g

Calculate the moles of reactants and products:

$$\text{moles of } SiCl_4 = 15.30 \div 170 = 0.09$$

$$\text{moles of } H_2O = 3.24 \div 18 = 0.18$$

$$\text{moles of } SiO_2 = 5.40 \div 60 = 0.09$$

$$\text{moles of } HCl = 13.14 \div 36.5 = 0.36$$

Divide the moles by the smallest number of moles in the reaction:

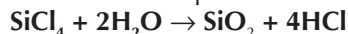
$$SiCl_4: 0.09 \div 0.09 = 1$$

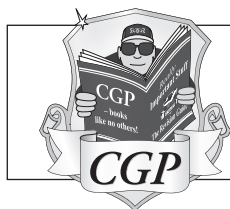
$$H_2O: 0.18 \div 0.09 = 2$$

$$SiO_2: 0.09 \div 0.09 = 1$$

$$HCl: 0.36 \div 0.09 = 4$$

The balanced equation is:





Formula Practice Sheet — Answers

Calculating the Mass of a Product

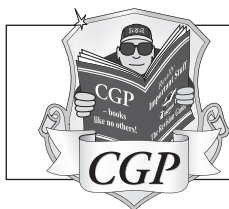
- Q1** To answer the following questions, look at the ratio of moles in the equation:
- 1 mol CO_2 produces 1 mol CaCO_3 , so
0.6 mol CO_2 produces **0.6 mol CaCO_3** .
 - 2 mol Ca produces 2 mol CaO, so
0.6 mol Ca produces **0.6 mol CaO**.
 - 2 mol K produces 2 mol KCl, so
0.6 mol K produces **0.6 mol KCl**.
2 mol K produces 1 mol Mg, so
0.6 mol K produces $(0.6 \div 2) =$ **0.3 mol Mg**.
 - 3 mol O_2 produces 2 mol O_3 , so
0.6 mol O_2 produces $(0.6 \div 3) \times 2 =$ **0.4 mol O_3** .
 - 6 mol HCl produces 2 mol FeCl_3 , so
0.6 mol HCl produces $(0.6 \div 6) \times 2 =$ **0.2 mol FeCl_3** .
6 mol HCl produces 3 mol H_2 , so
0.6 mol HCl produces $(0.6 \div 6) \times 3 =$ **0.3 mol H_2** .
 - 2 mol $\text{Pb}(\text{NO}_3)_2$ produces 2 mol PbO, so
0.6 mol $\text{Pb}(\text{NO}_3)_2$ produces **0.6 mol PbO**.
2 mol $\text{Pb}(\text{NO}_3)_2$ produces 4 mol NO_2 , so
0.6 mol $\text{Pb}(\text{NO}_3)_2$ produces $(0.6 \div 2) \times 4 =$ **1.2 mol NO_2** .
2 mol $\text{Pb}(\text{NO}_3)_2$ produces 1 mol O_2 , so
0.6 mol $\text{Pb}(\text{NO}_3)_2$ produces $(0.6 \div 2) =$ **0.3 mol O_2** .
- Q2** To answer the following questions, calculate the moles of the limiting reactant and use the balanced equation to work out how much of each product is formed:
- M_r of $\text{O}_2 = (16 \times 2) = 32$
moles of $\text{O}_2 = 8.0 \div 32 = 0.25$ mol
1 mol O_2 produces 2 mol H_2O , so 0.25 mol O_2 produces 0.5 mol H_2O .
 M_r of $\text{H}_2\text{O} = (1 \times 2) + 16 = 18$
mass of $\text{H}_2\text{O} = 0.5 \times 18 =$ **9 g**
 - M_r of $\text{CH}_4 = 12 + (1 \times 4) = 16$
moles of $\text{CH}_4 = 8.0 \div 16 = 0.5$ mol
1 mol CH_4 produces 1 mol CCl_4 , so 0.5 mol CH_4 produces 0.5 mol CCl_4 .
 M_r of $\text{CCl}_4 = 12 + (35.5 \times 4) = 154$
mass of $\text{CCl}_4 = 0.5 \times 154 =$ **77 g**
1 mol CH_4 produces 4 mol HCl, so 0.5 mol CH_4 produces $0.5 \times 4 = 2$ mol HCl.
 M_r of HCl = $1 + 35.5 = 36.5$
mass of HCl = $2 \times 36.5 =$ **73 g**
 - M_r of $\text{Mg}_3\text{N}_2 = (24 \times 3) + (14 \times 2) = 100$
moles of $\text{Mg}_3\text{N}_2 = 8.0 \div 100 = 0.08$ mol
1 mol Mg_3N_2 produces 3 mol $\text{Mg}(\text{OH})_2$, so 0.08 mol Mg_3N_2 produces $0.08 \times 3 = 0.24$ mol $\text{Mg}(\text{OH})_2$.
 M_r of $\text{Mg}(\text{OH})_2 = 24 + ((16 + 1) \times 2) = 58$
mass of $\text{Mg}(\text{OH})_2 = 0.24 \times 58 = 13.92 =$ **14 g (2 s.f.)**
1 mol Mg_3N_2 produces 2 mol NH_3 , so 0.08 mol Mg_3N_2 produces $0.08 \times 2 = 0.16$ mol NH_3 .
 M_r of $\text{NH}_3 = 14 + (1 \times 3) = 17$
mass of $\text{NH}_3 = 0.16 \times 17 = 2.72 =$ **2.7 g (2 s.f.)**

- M_r of KOH = $39 + 16 + 1 = 56$
moles of KOH = $8.0 \div 56 = 0.142\dots$ mol
3 mol KOH produces 1 mol K_3PO_4 , so
 $0.142\dots$ mol KOH produces
 $(0.142\dots \div 3) = 0.0476\dots$ mol K_3PO_4 .
 M_r of $\text{K}_3\text{PO}_4 = (39 \times 3) + 31 + (16 \times 4) = 212$
mass of $\text{K}_3\text{PO}_4 = 0.0476\dots \times 212 = 10.095\dots =$ **10 g (2 s.f.)**
3 mol KOH produces 3 mol H_2O , so
 $0.142\dots$ mol KOH produces $0.142\dots$ mol H_2O
 M_r of $\text{H}_2\text{O} = (1 \times 2) + 16 = 18$
mass of $\text{H}_2\text{O} = 0.142\dots \times 18 = 2.571\dots =$ **2.6 g (2 s.f.)**

It's important not to round any numbers in a calculation until you get to your final answer, so you don't introduce any rounding errors.

- M_r of $\text{Mg}(\text{NO}_3)_2 = 24 + ((14 + (16 \times 3)) \times 2) = 148$
moles of $\text{Mg}(\text{NO}_3)_2 = 8.0 \div 148 = 0.0540\dots$ mol
1 mol $\text{Mg}(\text{NO}_3)_2$ produces 1 mol Mg, so
 $0.0540\dots$ mol $\text{Mg}(\text{NO}_3)_2$ produces $0.0540\dots$ mol Mg.
mass of Mg = $0.0540\dots \times 24 = 1.297\dots$ **1.3 g (2 s.f.)**
1 mol $\text{Mg}(\text{NO}_3)_2$ produces 2 mol LiNO_3 , so $0.0540\dots$ mol $\text{Mg}(\text{NO}_3)_2$ produces
 $(2 \times 0.0540\dots) = 0.108\dots$ mol LiNO_3 .
 M_r of $\text{LiNO}_3 = 7 + 14 + (16 \times 3) = 69$
mass of $\text{LiNO}_3 = 0.108\dots \times 69 = 7.459\dots =$ **7.5 g (2 s.f.)**
- M_r of $\text{C}_4\text{H}_8 = (12 \times 4) + (1 \times 8) = 56$
moles of $\text{C}_4\text{H}_8 = 8.0 \div 56 = 0.142\dots$ mol
1 mol C_4H_8 produces 4 mol CO_2 , so $0.142\dots$ mol C_4H_8 produces
 $(4 \times 0.142\dots) = 0.571\dots$ mol CO_2 .
 M_r of $\text{CO}_2 = 12 + (16 \times 2) = 44$
mass of $\text{CO}_2 = 0.571\dots \times 44 = 25.14\dots =$ **25 g (2 s.f.)**
1 mol C_4H_8 produces 4 mol H_2O , so $0.142\dots$ mol C_4H_8 produces
 $(4 \times 0.142\dots) = 0.571\dots$ mol H_2O .
 M_r of $\text{H}_2\text{O} = (1 \times 2) + 16 = 18$
mass of $\text{H}_2\text{O} = 0.571\dots \times 18 = 10.28\dots$ **10 g (2 s.f.)**

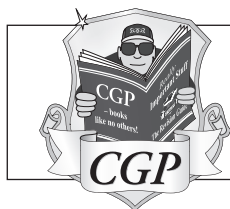
- Q3** To answer the following questions, balance the equation and calculate the moles of limiting reactant, then work out how much of the product is formed:
- The balanced equation for the reaction is:
 $\text{Mg} + 2\text{HCl} \rightarrow \text{MgCl}_2 + \text{H}_2$
The limiting reactant is Mg ($A_r = 24$).
moles of Mg = $6.0 \div 24 = 0.25$ mol
1 mol Mg produces 1 mol MgCl_2 , so 0.25 mol Mg produces 0.25 mol MgCl_2 .
 M_r of $\text{MgCl}_2 = 24 + (35.5 \times 2) = 95$
mass of $\text{MgCl}_2 = 0.25 \times 95 = 23.75 =$ **24 g (2 s.f.)**



Formula Practice Sheet — Answers

Calculating the Mass of a Product

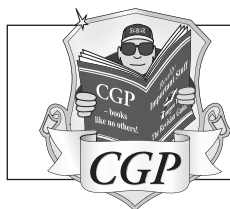
- b) The balanced equation for the reaction is:
 $\text{Zn} + 2\text{NaOH} + 2\text{H}_2\text{O} \rightarrow \text{Na}_2\text{Zn(OH)}_4 + \text{H}_2$
 The limiting reactant is Zn ($A_r = 65$).
 moles of Zn = $6.0 \div 65 = 0.0923\dots$ mol
 1 mol Zn produces 1 mol $\text{Na}_2\text{Zn(OH)}_4$, so
 0.0923... mol Zn produces
 0.0923... mol $\text{Na}_2\text{Zn(OH)}_4$.
 M_r of $\text{Na}_2\text{Zn(OH)}_4 = (23 \times 2) + 65 + ((16 + 1) \times 4) = 179$
 mass of $\text{Na}_2\text{Zn(OH)}_4 = 0.0923\dots \times 179$
 $= 16.52\dots = \mathbf{17\text{ g (2 s.f.)}}$
- c) The balanced equation for the reaction is:
 $\text{S} + 3\text{F}_2 \rightarrow \text{SF}_6$
 The limiting reactant is S ($A_r = 32$).
 moles of S = $6.0 \div 32 = 0.1875$ mol
 1 mol S produces 1 mol SF_6 , so 0.1875 mol S
 produces 0.1875 mol SF_6 .
 M_r of $\text{SF}_6 = 32 + (19 \times 6) = 146$
 moles of $\text{SF}_6 = 0.1875 \times 146 = 27.375 = \mathbf{27\text{ g (2 s.f.)}}$
- d) The balanced equation for the reaction is:
 $\text{Al}_2\text{O}_3 + 6\text{HCl} \rightarrow 2\text{AlCl}_3 + \text{H}_2\text{O}$
 The limiting reactant is Al_2O_3 .
 M_r of $\text{Al}_2\text{O}_3 = (27 \times 2) + (16 \times 3) = 102$
 moles of $\text{Al}_2\text{O}_3 = 6.0 \div 102 = 0.0588\dots$ mol
 1 mol Al_2O_3 produces 2 mol AlCl_3 , so
 0.0588... mol Al_2O_3 produces 0.117... mol AlCl_3 .
 M_r of $\text{AlCl}_3 = 27 + (35.5 \times 3) = 133.5$
 mass of $\text{AlCl}_3 = 0.117\dots \times 133.5$
 $= 15.70\dots = \mathbf{16\text{ g (2 s.f.)}}$
- e) The balanced equation for the reaction is:
 $2\text{HgO} \rightarrow 2\text{Hg} + \text{O}_2$
 The limiting reactant is HgO.
 M_r of HgO = $201 + 16 = 217$
 moles of HgO = $6.0 \div 217 = 0.0276\dots$ mol
 2 mol HgO produces 2 mol Hg, so
 0.0276...mol HgO produces 0.0276...mol Hg.
 mass of Hg = $0.0276\dots \times 201 = 5.55\dots$
 $= \mathbf{5.6\text{ g (2 s.f.)}}$
- f) The balanced equation for the reaction is:
 $2\text{Fe} + 3\text{Cl}_2 \rightarrow 2\text{FeCl}_3$
 The limiting reactant is Fe ($A_r = 56$).
 moles of Fe = $6.0 \div 56 = 0.107\dots$ mol
 2 mol Fe produces 2 mol FeCl_3 , so
 0.107... mol Fe produces 0.107... mol FeCl_3 .
 M_r of $\text{FeCl}_3 = 56 + (35.5 \times 3) = 162.5$
 mass of $\text{FeCl}_3 = 0.107\dots \times 162.5$
 $= 17.41\dots = \mathbf{17\text{ g (2 s.f.)}}$
- Q4** To answer the following questions, write a balanced equation for the reaction and calculate the moles of limiting reactant. Then use these to work out how much of the product is formed:
- a) The balanced equation for the reaction is:
 $\text{N}_2 + 2\text{O}_2 \rightarrow 2\text{NO}_2$
 M_r of $\text{O}_2 = 16 \times 2 = 32$
 moles of $\text{O}_2 = 21 \div 32 = 0.656\dots$ mol
 2 mol O_2 produces 2 mol NO_2 , so
 0.656... mol O_2 produces 0.656... mol NO_2 .
 M_r of $\text{NO}_2 = 14 + (16 \times 2) = 46$
 mass of $\text{NO}_2 = 0.656\dots \times 46$
 $= 30.1\dots = \mathbf{30\text{ g (2 s.f.)}}$
- b) The balanced equation for the reaction is:
 $\text{PCl}_5 + 4\text{H}_2\text{O} \rightarrow \text{H}_3\text{PO}_4 + 5\text{HCl}$
 M_r of $\text{PCl}_5 = 31 + (35.5 \times 5) = 208.5$
 moles of $\text{PCl}_5 = 4.17 \div 208.5 = 0.02$ mol
 1 mol PCl_5 produces 5 mol HCl, so 0.02 mol PCl_5
 produces $(5 \times 0.02) = 0.1$ mol HCl.
 M_r of HCl = $1 + 35.5 = 36.5$
 mass of HCl = $0.1 \times 36.5 = \mathbf{3.65\text{ g}}$
- c) The balanced equation for the reaction is:
 $2\text{Al} + 3\text{CuCl}_2 \rightarrow 2\text{AlCl}_3 + 3\text{Cu}$
 A_r of Al = 27
 moles of Al = $(810 \div 1000) \div 27 = 0.03$ mol
 2 mol Al produces 3 mol Cu, so 0.03 mol Al
 produces $(0.03 \div 2) \times 3 = 0.045$ mol Cu
 A_r of Cu = 63.5
 mass of Cu = $0.045 \times 63.5 = 2.8575 = \mathbf{2.9\text{ g (2 s.f.)}}$
- Q5**
- a) $2\text{Fe}_2\text{O}_3 + 3\text{C} \rightarrow 4\text{Fe} + 3\text{CO}_2$
- b) Carbon is in excess, so iron oxide is the limiting reactant.
 M_r of $\text{Fe}_2\text{O}_3 = (56 \times 2) + (16 \times 3) = 160$
 moles of $\text{Fe}_2\text{O}_3 = (2.4 \times 1000) \div 160 = 15$ mol
 2 mol Fe_2O_3 produces 4 mol Fe, so 15 mol Fe_2O_3
 produces $(15 \div 2) \times 4 = 30$ mol Fe.
 A_r of Fe = 56
 mass of Fe = $30 \times 56 = 1680\text{ g}$
 $= 1.680\text{ kg} = \mathbf{1.7\text{ kg (2 s.f.)}}$
- Q6**
- a) Work out the number of moles of copper and nitric acid in the mixture:
 A_r of Cu = 63.5
 moles of Cu = $57.15 \div 63.5 = 0.90$ mol
 M_r of $\text{HNO}_3 = 1 + 14 + (16 \times 3) = 63$
 moles of $\text{HNO}_3 = 63.0 \div 63 = 1.0$ mol
 The balanced equation tells you every 1 mol Cu
 reacts with 4 mol HNO_3 . So 0.90 mol Cu will
 react with $0.90 \times 4 = 3.6$ mol HNO_3 .
 But there is only 1 mol HNO_3 in the reaction
 mixture, so **HNO_3** is the limiting reactant.
- b) The balanced equation tells you that 4 mol HNO_3
 produces 1 mol $\text{Cu(NO}_3)_2$. Therefore, 1 mol HNO_3
 produces $1 \div 4 = 0.25$ mol $\text{Cu(NO}_3)_2$.
 M_r of $\text{Cu(NO}_3)_2 = 63.5 + ((14 + (16 \times 3)) \times 2) = 187.5$
 mass of $\text{Cu(NO}_3)_2 = 0.25 \times 187.5$
 $= 46.875 = \mathbf{47\text{ g (2 s.f.)}}$



Formula Practice Sheet — Answers

Calculating Volumes of Gases

- Q1** To answer the following questions, calculate the M_r of the gas, then substitute the mass and M_r into the formula,
 volume of gas = (mass of gas \div M_r of gas) \times 24:
- M_r of $H_2 = 1 \times 2 = 2$
 volume = $(5 \div 2) \times 24 = \mathbf{60 \text{ dm}^3}$
 - M_r of $O_2 = 16 \times 2 = 32$
 volume = $(12 \div 32) \times 24 = \mathbf{9 \text{ dm}^3}$
 - M_r of $N_2 = 14 \times 2 = 28$
 volume = $(42 \div 28) \times 24 = \mathbf{36 \text{ dm}^3}$
 - M_r of $CO_2 = 12 + (16 \times 2) = 44$
 volume = $(11 \div 44) \times 24 = \mathbf{6 \text{ dm}^3}$
 - M_r of $Cl_2 = 35.5 \times 2 = 71$
 volume = $(35.5 \div 71) \times 24 = \mathbf{12 \text{ dm}^3}$
 - M_r of $NH_3 = 14 + (1 \times 3) = 17$
 volume = $(37.4 \div 17) \times 24 = \mathbf{52.8 \text{ dm}^3}$
 - M_r of $CH_4 = 12 + (1 \times 4) = 16$
 volume = $(19.2 \div 16) \times 24 = \mathbf{28.8 \text{ dm}^3}$
 - M_r of $CO = 12 + 16 = 28$
 volume = $(24.5 \div 28) \times 24 = \mathbf{21 \text{ dm}^3}$
- Q2** To answer the following questions, calculate the M_r of the gas, then substitute the mass and M_r into the rearrangement of the formula,
 mass of gas = (volume of gas \times M_r of gas) \div 24:
- A_r of He = 4
 mass = $(3 \times 4) \div 24 = \mathbf{0.5 \text{ g}}$
 - A_r of Ar = 40
 mass = $(18 \times 40) \div 24 = \mathbf{30 \text{ g}}$
 - M_r of $O_2 = 16 \times 2 = 32$
 mass = $(12 \times 32) \div 24 = \mathbf{16 \text{ g}}$
 - M_r of $F_2 = 19 \times 2 = 38$
 mass = $(3.6 \times 38) \div 24 = \mathbf{5.7 \text{ g}}$
 - M_r of $CH_4 = 12 + (1 \times 4) = 16$
 mass = $(14.1 \times 16) \div 24 = \mathbf{9.4 \text{ g}}$
 - M_r of $NO_2 = 14 + (16 \times 2) = 46$
 mass = $(22 \times 46) \div 24 = 42.16\dots = \mathbf{42 \text{ g (2 s.f.)}}$
 - M_r of $CO_2 = 12 + (16 \times 2) = 44$
 mass = $(9.6 \times 44) \div 24 = \mathbf{17.6 \text{ g}}$
 - M_r of $NH_3 = 14 + (1 \times 3) = 17$
 mass = $(52.8 \times 17) \div 24 = \mathbf{37.4 \text{ g}}$
- Q3** To answer the following questions, substitute the volume and mass into the rearrangement of the formula,
 M_r of gas = (mass of gas \times 24) \div volume of gas:
- $M_r = (7.0 \times 24) \div 6.0 = \mathbf{28}$
 - $M_r = (10 \times 24) \div 7.5 = \mathbf{32}$
 - $M_r = (33 \times 24) \div 18 = \mathbf{44}$
 - $M_r = (9 \times 24) \div 108 = \mathbf{2}$
 - $M_r = (8.5 \times 24) \div 12 = \mathbf{17}$
 - $M_r = (16.8 \times 24) \div 100.8 = \mathbf{4}$
 - $M_r = (14 \times 24) \div 16.8 = \mathbf{20}$
 - $M_r = (48.4 \times 24) \div 26.4 = \mathbf{44}$
- Q4** To answer the following questions, substitute the given values into the correct rearrangement of the formula:
- You're given mass and M_r , so you need to use
 volume of gas = (mass of gas \div M_r of gas) \times 24:
 volume = $(5.6 \div 28) \times 24 = \mathbf{4.8 \text{ dm}^3}$
 - You're given M_r and volume so you need to use
 mass of gas = (volume of gas \times M_r of gas) \div 24:
 mass = $(36 \times 2) \div 24 = \mathbf{3 \text{ g}}$
 - You're given mass and volume, so you need to use
 M_r of gas = (mass of gas \times 24) \div volume of gas:
 $M_r = (22.1 \times 24) \div 31.2 = \mathbf{17}$
 - You're given M_r and volume so you need to use
 mass of gas = (volume of gas \times M_r of gas) \div 24:
 mass = $(9.6 \times 40) \div 24 = \mathbf{16 \text{ g}}$
- Q5** a) Substitute the mass and M_r into the formula,
 volume of gas = (mass of gas \div M_r of gas) \times 24:
 M_r of $SO_3 = 32 + (16 \times 3) = 80$
 volume = $(16 \div 80) \times 24 = \mathbf{4.8 \text{ dm}^3}$
- b) E.g. calculate the volume of oxygen using the formula, volume of gas =
 (mass of gas \div M_r of gas) \times 24:
 M_r of $O_2 = 16 \times 2 = 32$
 Volume of oxygen = $(25 \div 32) \times 24 = 18.75 \text{ dm}^3$
 The ratio of O_2 to SO_3 in the reaction is 1:2, so the volume of sulfur trioxide is $18.75 \times 2 = \mathbf{37.5 \text{ dm}^3}$
- Q6** E.g. first convert the volume to dm^3 :
 $1800 \text{ cm}^3 = 1800 \div 1000 = 1.8 \text{ dm}^3$
 Then calculate the mass using the rearrangement of the formula,
 mass of gas = (volume of gas \times M_r of gas) \div 24:
 A_r of He = 4
 Mass of helium for one balloon: $(1.8 \times 4) \div 24 = 0.3 \text{ g}$
 Mass of helium for 12 balloons: $0.3 \times 12 = \mathbf{3.6 \text{ g}}$



Formula Practice Sheet — Answers

Concentration, Mass and Volume

Q1 To answer the following questions, substitute the values for m and V into $c = m \div V$:

- $c = m \div V = 40 \div 5 = \mathbf{8 \text{ g/dm}^3}$
- $c = m \div V = 24 \div 8 = \mathbf{3 \text{ g/dm}^3}$
- $c = m \div V = 2 \div 2 = \mathbf{1 \text{ g/dm}^3}$
- $c = m \div V = 18 \div 3 = \mathbf{6 \text{ g/dm}^3}$
- $c = m \div V = 3.2 \div 8 = \mathbf{0.4 \text{ g/dm}^3}$
- $c = m \div V = 54 \div 9.0 = \mathbf{6.0 \text{ g/dm}^3}$
- $c = m \div V = 1.3 \div (103 \div 1000)$
 $= 12.62\dots = \mathbf{13 \text{ g/dm}^3}$ (2 s.f.)
- $c = m \div V = 10.2 \div (19 \div 1000)$
 $= 536.8\dots = \mathbf{540 \text{ g/dm}^3}$ (2 s.f.)
- $c = m \div V = 1.3 \div (110 \div 1000)$
 $= 11.81\dots = \mathbf{12 \text{ g/dm}^3}$ (2 s.f.)

Remember that you should give your answer to the lowest number of significant figures that was used in the calculation.

Q2 To answer the following questions, substitute the values for c and V into the rearrangement of $c = m \div V$, $m = cV$:

- $m = cV = 0.60 \times 70 = \mathbf{42 \text{ g}}$
- $m = cV = 3.6 \times 1.0 = \mathbf{3.6 \text{ g}}$
- $m = cV = 27 \times 7.0 = 189 = \mathbf{190 \text{ g}}$ (2 s.f.)
- $m = cV = 8.0 \times 0.048 = 0.384 = \mathbf{0.38 \text{ g}}$ (2 s.f.)
- $m = cV = 6.9 \times 3.8 = 26.22 = \mathbf{26 \text{ g}}$ (2 s.f.)
- $m = cV = 7.1 \times 2.0 = 14.2 = \mathbf{14 \text{ g}}$ (2 s.f.)
- $m = cV = (0.080 \times 1000) \times 0.046$
 $= 3.68 = \mathbf{3.7 \text{ g}}$ (2 s.f.)

To convert the from g/cm^3 to g/dm^3 , you need to multiply by 1000.

- $m = cV = 0.70 \times (760 \div 1000)$
 $= 0.532 = \mathbf{0.53 \text{ g}}$ (2 s.f.)

Q3 To answer the following questions, substitute the values for c and m into the rearrangement of $c = m \div V$, $V = m \div c$:

- $V = m \div c = 5 \div 10 = \mathbf{0.5 \text{ dm}^3}$
- $V = m \div c = 14 \div 3.5 = \mathbf{4.0 \text{ dm}^3}$
- $V = m \div c = 30.4 \div 38 = \mathbf{0.80 \text{ dm}^3}$
- $V = m \div c = 0.126 \div 3.0 = \mathbf{0.042 \text{ dm}^3}$
- $V = m \div c = 0.0968 \div 1.1 = \mathbf{0.088 \text{ dm}^3}$
- $V = m \div c = 36.9 \div 4.1 = \mathbf{9.0 \text{ dm}^3}$
- $V = m \div c = 11 \div 2.2 = \mathbf{5.0 \text{ dm}^3}$
- $V = m \div c = 0.15 \div 2.0 = \mathbf{0.075 \text{ dm}^3}$

Q4 To answer the following questions, substitute the given values into the correct rearrangement of $c = m \div V$:

- You're given c and V , so you need to use $m = cV$:
 $m = cV = 8.0 \times 0.091 = 0.728 = \mathbf{0.73 \text{ g}}$ (2 s.f.)
- You're given m and V , so you need to use $c = m \div V$:
 $c = m \div V = 0.2 \div 0.01 = \mathbf{20 \text{ g/dm}^3}$
- You're given m and c , so you need to use $V = m \div c$:
 $V = m \div c = 14.4 \div 1.6 = \mathbf{9.0 \text{ dm}^3}$
- You're given m and c , so you need to use $V = m \div c$:
 $V = m \div c = (439 \div 1000) \div 9.0$
 $= 0.04877\dots = \mathbf{0.049 \text{ dm}^3}$ (2 s.f.)
- You're given m and V , so you need to use $c = m \div V$:
 $c = m \div V = (24010 \div 1000) \div 4.92$
 $= 4.8800\dots = \mathbf{4.88 \text{ g/dm}^3}$ (3 s.f.)
- You're given c and V , so you need to use $m = cV$:
 $m = cV = (0.00630 \times 1000) \times 6.21$
 $= 39.123 = \mathbf{39.1 \text{ g}}$ (3 s.f.)

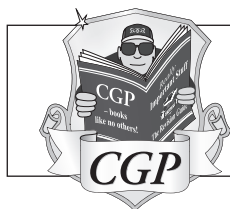
Q5 Calculate the mass of solute in each solution by substituting the given values into the rearrangement of $c = m \div V$, $m = cV$:

$$\text{mass of solute in A} = (0.21 \times 1000) \times 0.050 = 6.0 \text{ g}$$

$$\text{mass of solute in B} = 60 \times 0.070 = 4.2 \text{ g}$$

The student is incorrect because the mass of solute in solution A is 6.0 g and the mass of solute in solution B is 4.2 g.

- Q6**
- Convert the volume into dm^3 :
 $100 \text{ millilitres} = (100 \div 1000) = 0.1 \text{ litres} = 0.1 \text{ dm}^3$
Substitute the values for mass and volume into the equation for concentration, $c = m \div V$:
 $c = m \div V = 45 \div 0.1 = \mathbf{450 \text{ g/dm}^3}$
 - Calculate the new volume of the solution and convert it to dm^3 :
 $V = 100 + 20 = 120 \text{ millilitres} = (120 \div 1000) = 0.12 \text{ dm}^3$
Calculate the remaining mass of sodium hydroxide by substituting the new volume and concentration into the rearrangement of $c = m \div V$, $m = cV$:
 $m = cV = 360 \times 0.12 = \mathbf{37.2 \text{ g}}$



Formula Practice Sheet — Answers

Concentration, Moles and Volume

- Q1** To answer the following questions, substitute the values for n and V into $c = n \div V$:
- $c = n \div V = 1.6 \div 2 = \mathbf{0.8 \text{ mol/dm}^3}$
 - $c = n \div V = 0.90 \div 0.20 = \mathbf{4.5 \text{ mol/dm}^3}$
 - $c = n \div V = 3.6 \div 9 = \mathbf{0.4 \text{ mol/dm}^3}$
 - $c = n \div V = 0.36 \div 0.4 = \mathbf{0.9 \text{ mol/dm}^3}$
 - $c = n \div V = 0.45 \div 9 = \mathbf{0.05 \text{ mol/dm}^3}$
 - $c = n \div V = 4.68 \div 0.52 = \mathbf{9.0 \text{ mol/dm}^3}$
 - $c = n \div V = 7.12 \div (800 \div 1000) = \mathbf{8.9 \text{ mol/dm}^3}$
 - $c = n \div V = 3.01 \div (700 \div 1000) = \mathbf{4.3 \text{ mol/dm}^3}$

If one of the units in the question doesn't match the unit that you need for the answer, you'll have to convert it. Parts g) and h) ask for an answer in mol/dm^3 , but you're given the volumes in cm^3 — so you need to divide by 1000 to convert them to dm^3 .

- Q2** To answer the following questions, substitute the values for c and V into the rearrangement of $c = n \div V$, $n = cV$:
- $n = cV = 0.8 \times 7.0 = \mathbf{5.6 \text{ mol}}$
 - $n = cV = 8 \times 0.1 = \mathbf{0.8 \text{ mol}}$
 - $n = cV = 0.6 \times 6.0 = \mathbf{3.6 \text{ mol}}$
 - $n = cV = 0.80 \times 0.30 = \mathbf{0.24 \text{ mol}}$
 - $n = cV = 2.4 \times 0.10 = \mathbf{0.24 \text{ mol}}$
 - $n = cV = 0.07 \times 5.9 = 0.413 \text{ mol} = \mathbf{0.4 \text{ (1 s.f.)}}$
 - $n = cV = 4.0 \times (460 \div 1000) = 1.84 \text{ mol}$
 $= \mathbf{1.8 \text{ mol (2 s.f.)}}$

Dividing 460 cm^3 by 1000 converts it to dm^3 .

$$\text{h) } n = cV = (0.0090 \times 1000) \times 0.36 = 3.24 \text{ mol} \\ = \mathbf{3.2 \text{ mol (2 s.f.)}}$$

Multiplying 0.009 mol/cm^3 by 1000 converts it to mol/dm^3 .

- Q3** To answer the following questions, substitute the values for n and c into the rearrangement of $c = n \div V$, $V = n \div c$:
- $V = n \div c = 0.6 \div 0.6 = \mathbf{1 \text{ dm}^3}$
 - $V = n \div c = 1.5 \div 0.5 = \mathbf{3 \text{ dm}^3}$
 - $V = n \div c = 0.21 \div 0.7 = \mathbf{0.3 \text{ dm}^3}$
 - $V = n \div c = 0.092 \div 0.010 = \mathbf{9.2 \text{ dm}^3}$
 - $V = n \div c = 2.72 \div 3.4 = \mathbf{0.80 \text{ dm}^3}$
 - $V = n \div c = 1.98 \div 3.3 = \mathbf{0.60 \text{ dm}^3}$
 - $V = n \div c = 1.08 \div 9.0 = \mathbf{0.12 \text{ dm}^3}$
 - $V = n \div c = 4.76 \div (0.0070 \times 1000) = \mathbf{0.68 \text{ dm}^3}$

Multiplying 0.0070 mol/cm^3 by 1000 converts it to mol/dm^3 .

- Q4** To answer the following questions, substitute the given values into the correct rearrangement of $c = n \div V$:
- You're given n and c , so you need to use $V = n \div c$:
 $V = n \div c = 3.5 \div 0.7 = \mathbf{5 \text{ dm}^3}$
 - You're given c and V , so you need to use $n = cV$:
 $n = cV = 0.40 \times 4.0 = \mathbf{1.6 \text{ mol}}$
 - You're given n and c , so you need to use $V = n \div c$:
 $V = n \div c = 0.05 \div 0.1 = \mathbf{0.5 \text{ dm}^3}$
 - You're given n and V , so you need to use $c = n \div V$:
 $c = n \div V = 3.8 \div 0.40 = \mathbf{9.5 \text{ mol/dm}^3}$
 - You're given c and V , so you need to use $n = cV$:
 $n = cV = 1.8 \times 2.0 = \mathbf{3.6 \text{ mol}}$
 - You're given c and V , so you need to use $n = cV$:
 $n = cV = 9.0 \times 0.42 = 3.78 \text{ mol} = \mathbf{3.8 \text{ mol (2 s.f.)}}$
 - You're given n and V , so you need to use $c = n \div V$:
 $c = n \div V = 0.102 \div (342 \div 1000) = 0.29824\dots$
 $= \mathbf{0.298 \text{ mol/dm}^3 \text{ (3 s.f.)}}$

Dividing 340 cm^3 by 1000 converts it to dm^3 .

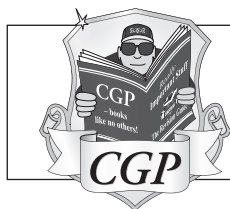
$$\text{h) You're given } c \text{ and } V, \text{ so you need to use } n = cV: \\ n = cV = (0.0074 \times 1000) \times 6.0 = 44.4 \text{ mol} \\ = \mathbf{44 \text{ mol (2 s.f.)}}$$

Multiplying 0.0074 mol/cm^3 by 1000 converts it to mol/dm^3 .

- Q5** You're given c and V , so you need to use $n = cV$:
 $n = cV = 0.91 \times (640 \div 1000) = 0.5824 \text{ mol}$
 $= \mathbf{0.58 \text{ mol (2 s.f.)}}$

Dividing 640 cm^3 by 1000 converts it to dm^3 .

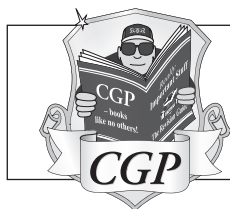
- Q6** a) You're given c and V , so you need to use $n = cV$:
 $n = cV = 0.45 \times 1.2 = 0.54 \text{ mol}$
- b) Volume = $1.2 + 0.5 = 1.7 \text{ dm}^3$
You have n and V , so you need to use $c = n \div V$:
 $c = n \div V = 0.54 \div 1.7 = 0.317\dots \text{ mol/dm}^3$
 $= \mathbf{0.32 \text{ mol/dm}^3 \text{ (2 s.f.)}}$



Formula Practice Sheet — Answers

Converting Concentrations

- Q1** To answer the following questions, substitute the values for concentration in g/dm^3 and M_r into concentration (mol/dm^3) = concentration (g/dm^3) \div M_r :
- concentration (mol/dm^3) = $2.0 \div 40 = \mathbf{0.05 \text{ mol/dm}^3}$
 - concentration (mol/dm^3) = $16 \div 160 = \mathbf{0.1 \text{ mol/dm}^3}$
 - concentration (mol/dm^3) = $246 \div 82 = \mathbf{3 \text{ mol/dm}^3}$
 - concentration (mol/dm^3) = $36 \div 120 = \mathbf{0.3 \text{ mol/dm}^3}$
 - $0.258 \text{ kg/L} = (0.258 \times 1000 =) 258 \text{ g/L} = 258 \text{ g/dm}^3$
concentration (mol/dm^3) = $258 \div 86 = \mathbf{3 \text{ mol/dm}^3}$
 - $0.185 \text{ g/cm}^3 = (0.185 \times 1000 =) 185 \text{ g/dm}^3$
concentration (mol/dm^3) = $185 \div 74 = \mathbf{2.5 \text{ mol/dm}^3}$
- Q2** To answer the following questions, substitute the values for concentration in mol/dm^3 and M_r into the rearrangement of the formula for molar concentration, concentration (g/dm^3) = concentration (mol/dm^3) \times M_r :
- concentration (g/dm^3) = $0.10 \times 42 = \mathbf{4.2 \text{ g/dm}^3}$
 - concentration (g/dm^3) = $1.5 \times 56 = \mathbf{84 \text{ g/dm}^3}$
 - concentration (g/dm^3) = $0.040 \times 97 = 3.88 = \mathbf{3.9 \text{ g/dm}^3 (2 \text{ s.f.})}$
 - concentration (g/dm^3) = $0.500 \times 119 = \mathbf{59.5 \text{ g/dm}^3}$
 - concentration (g/dm^3) = $5.0 \times 127 = 635 = \mathbf{640 \text{ g/dm}^3 (2 \text{ s.f.})}$
 - $0.0045 \text{ mol/cm}^3 = (0.0045 \times 1000) = 4.5 \text{ mol/dm}^3$
concentration (g/dm^3) = $4.5 \times 88 = 396 = \mathbf{400 \text{ g/dm}^3 (2 \text{ s.f.})}$
- Q3** To answer the following questions, calculate the M_r of the solute and substitute the values for concentration in g/dm^3 and M_r into concentration (mol/dm^3) = concentration (g/dm^3) \div M_r :
- M_r of $\text{NaOH} = 23 + 16 + 1 = 40$
concentration (mol/dm^3) = $8 \div 40 = \mathbf{0.2 \text{ mol/dm}^3}$
 - M_r of $\text{NH}_4\text{NO}_3 = 14 + (1 \times 4) + 14 + (16 \times 3) = 80$
concentration (mol/dm^3) = $120 \div 80 = \mathbf{1.5 \text{ mol/dm}^3}$
 - M_r of $\text{NaCl} = 23 + 35.5 = 58.5$
concentration (mol/dm^3) = $35 \div 58.5 = 0.5982... = \mathbf{0.60 \text{ mol/dm}^3 (2 \text{ s.f.})}$
 - M_r of $\text{NaNO}_3 = 23 + 14 + (16 \times 3) = 85$
concentration (mol/dm^3) = $96 \div 85 = 1.129... = \mathbf{1.1 \text{ mol/dm}^3 (2 \text{ s.f.})}$
 - M_r of $\text{Ba(OH)}_2 = 137 + ((16 + 1) \times 2) = 171$
concentration (mol/dm^3) = $3.4 \div 171 = 0.01988... = \mathbf{0.020 \text{ mol/dm}^3 (2 \text{ s.f.})}$
 - M_r of $\text{ZnSO}_4 = 65 + 32 + (16 \times 4) = 161$
concentration (mol/dm^3) = $1.75 \div 161 = 0.01086... = \mathbf{0.0109 \text{ mol/dm}^3 (3 \text{ s.f.})}$
 - M_r of $\text{KIO}_3 = 39 + 127 + (16 \times 3) = 214$
concentration (mol/dm^3) = $9.25 \div 214 = 0.04322... = \mathbf{0.0432 \text{ mol/dm}^3 (3 \text{ s.f.})}$
 - M_r of $\text{K}_2\text{CO}_3 = (39 \times 2) + 12 + (16 \times 3) = 138$
concentration (mol/dm^3) = $111 \div 138 = 0.8043... = \mathbf{0.804 \text{ mol/dm}^3 (3 \text{ s.f.})}$
 - M_r of $\text{MgCl}_2 = 24 + (35.5 \times 2) = 95$
concentration (mol/dm^3) = $305 \div 95 = 3.2105... = \mathbf{3.21 \text{ mol/dm}^3 (3 \text{ s.f.})}$
- Q4** To answer the following questions, use the correct rearrangement of the formula, concentration (mol/dm^3) = concentration (g/dm^3) \div M_r :
- concentration (mol/dm^3) = concentration (g/dm^3) \div M_r
 $= 12 \div 87 = 0.1379... = \mathbf{0.14 \text{ mol/dm}^3 (2 \text{ s.f.})}$
 - concentration (mol/dm^3) = concentration (g/dm^3) \div M_r
 $= 25 \div 101 = 0.2475... = \mathbf{0.25 \text{ mol/dm}^3 (2 \text{ s.f.})}$
 - concentration (g/dm^3) = concentration (mol/dm^3) \times M_r
 $= 0.80 \times 127 = 101.6 = \mathbf{100 \text{ g/dm}^3 (2 \text{ s.f.})}$
 - concentration (g/dm^3) = concentration (mol/dm^3) \times M_r
 $= 0.35 \times 136 = 47.6 = \mathbf{48 \text{ g/dm}^3 (2 \text{ s.f.})}$
 - concentration (mol/dm^3) = concentration (g/dm^3) \div M_r
 $= 90 \div 166 = 0.5421... = \mathbf{0.54 \text{ mol/dm}^3 (2 \text{ s.f.})}$
 - concentration (g/dm^3) = concentration (mol/dm^3) \times M_r
 $= 0.10 \times 74.5 = 7.45 = \mathbf{7.5 \text{ g/dm}^3 (2 \text{ s.f.})}$
- Q5**
- M_r of $\text{CaBr}_2 = 40 + (2 \times 80) = 200$
concentration (g/dm^3) = concentration (mol/dm^3) \times M_r
 $= 0.40 \times 200 = \mathbf{80 \text{ g/dm}^3}$
 - $250 \text{ cm}^3 = (250 \div 1000 =) 0.25 \text{ dm}^3$
mass of $\text{CaBr}_2 = 80 \times 0.25 = \mathbf{20 \text{ g}}$
- Q6**
- $100 \text{ cm}^3 = (100 \div 1000 =) 0.1 \text{ dm}^3$
concentration (mol/dm^3) = $37 \div 0.1 = \mathbf{370 \text{ mol/dm}^3}$
 - M_r of $\text{Mg(NO}_3)_2 = 24 + ((14 + (16 \times 3)) \times 2) = 148$
concentration (mol/dm^3) = concentration (g/dm^3) \div M_r
 $= 370 \div 148 = \mathbf{2.5 \text{ mol/dm}^3}$
 - E.g. convert the concentration of the required solution in g/dm^3 using the formula concentration (g/dm^3) = concentration (mol/dm^3) \times M_r :
concentration (g/dm^3) = $1.25 \times 148 = 185 \text{ g/dm}^3$
Multiply this concentration by the volume of water (in dm^3) to calculate the mass of magnesium nitrate that the student needs to dissolve:
 $100 \text{ cm}^3 = (100 \div 1000 =) 0.1 \text{ dm}^3$
mass = $185 \times 0.1 = \mathbf{18.5 \text{ g}}$



Formula Practice Sheet — Answers

Atom Economy

Q1 To answer the following questions, calculate the relative formula masses of the reactants and desired products, and substitute these values into the formula for atom economy:

a) M_r of $\text{CaCO}_3 = 40 + 12 + (16 \times 3) = 100$
 M_r of $\text{CaO} = 40 + 16 = 56$
 atom economy = $(56 \div 100) \times 100 = \mathbf{56\%}$

b) All atoms in the reactants end up in the only product ($\text{C}_2\text{H}_5\text{OH}$), so the reaction has an atom economy of **100%**.

c) M_r of $\text{SnO}_2 = 119 + (16 \times 2) = 151$
 A_r of C = 12
 total M_r of reactants = $151 + 12 = 163$
 A_r of Sn = 119
 atom economy = $(119 \div 163) \times 100 = 73.00\dots = \mathbf{73\% (2 s.f.)}$

d) M_r of CO = $12 + 16 = 28$
 M_r of $\text{H}_2\text{O} = (1 \times 2) + 16 = 18$
 total M_r of reactants = $28 + 18 = 46$
 M_r of $\text{H}_2 = 1 \times 2 = 2$
 atom economy = $(2 \div 46) \times 100 = 4.347\dots = \mathbf{4.3\% (2 s.f.)}$

e) M_r of KOH = $39 + 16 + 1 = 56$
 M_r of HCl = $1 + 35.5 = 36.5$
 total M_r of reactants = $56 + 36.5 = 92.5$
 M_r of KCl = $39 + 35.5 = 74.5$
 atom economy = $(74.5 \div 92.5) \times 100 = 80.54\dots = \mathbf{81\% (2 s.f.)}$

f) M_r of $\text{C}_{10}\text{H}_{22} = (12 \times 10) + (1 \times 22) = 142$
 M_r of $\text{C}_2\text{H}_4 = (12 \times 2) + (1 \times 4) = 28$
 atom economy = $(28 \div 142) \times 100 = 19.71\dots = \mathbf{20\% (2 s.f.)}$

g) M_r of CuO = $63.5 + 16 = 79.5$
 M_r of $\text{H}_2\text{SO}_4 = (1 \times 2) + 32 + (16 \times 4) = 98$
 total M_r of reactants = $79.5 + 98 = 177.5$
 M_r of $\text{CuSO}_4 = 63.5 + 32 + (16 \times 4) = 159.5$
 atom economy = $(159.5 \div 177.5) \times 100 = 89.85\dots = \mathbf{90\% (2 s.f.)}$

h) M_r of $\text{Zn}(\text{OH})_2 = 65 + ((16 + 1) \times 2) = 99$
 M_r of ZnO = $65 + 16 = 81$
 atom economy = $(81 \div 99) \times 100 = 81.81\dots = \mathbf{82\% (2 s.f.)}$

Q2 To answer the following questions, calculate the relative formula masses of the reactants and desired products, and substitute these values into the formula for atom economy:

a) All atoms in the reactants end up in the only product ($(\text{NH}_4)_2\text{SO}_4$), so the reaction has an atom economy of **100%**.

b) M_r of CuO = $63.5 + 16 = 79.5$
 M_r of HCl = $1 + 35.5 = 36.5$
 total M_r of reactants = $79.5 + (2 \times 36.5) = 152.5$
 M_r of $\text{CuCl}_2 = 63.5 + (35.5 \times 2) = 134.5$
 atom economy = $(134.5 \div 152.5) \times 100 = 88.19\dots = \mathbf{88\% (2 s.f.)}$

c) M_r of $\text{CaCl}_2 = 40 + (35.5 \times 2) = 111$
 A_r of Cs = 133
 total M_r of reactants = $111 + (133 \times 2) = 377$
 A_r of Ca = 40
 atom economy = $(40 \div 377) \times 100 = 10.61\dots = \mathbf{11\% (2 s.f.)}$

d) M_r of $\text{MgCl}_2 = 24 + (35.5 \times 2) = 95$
 M_r of NaOH = $23 + 16 + 1 = 40$
 total M_r of reactants = $95 + (2 \times 40) = 175$
 M_r of $\text{Mg}(\text{OH})_2 = 24 + ((16 \times 1) \times 2) = 58$
 atom economy = $(58 \div 175) \times 100 = 33.14\dots = \mathbf{33\% (2 s.f.)}$

e) M_r of $\text{TiCl}_4 = 48 + (35.5 \times 4) = 190$
 A_r of Na = 23
 total mass of reactants = $190 + (23 \times 4) = 282$
 A_r of Ti = 48
 atom economy = $(48 \div 282) \times 100 = 17.02\dots = \mathbf{17\% (2 s.f.)}$

f) M_r of $\text{Al}_2\text{O}_3 = (27 \times 2) + (16 \times 3) = 102$
 total M_r of reactants = $2 \times 102 = 204$
 A_r of Al = 27
 total A_r of desired products = $27 \times 4 = 108$
 atom economy = $(108 \div 204) \times 100 = 52.94\dots = \mathbf{53\% (2 s.f.)}$

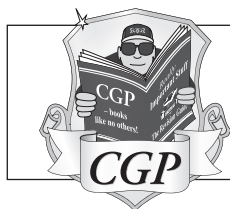
g) M_r of $\text{Fe}_2\text{O}_3 = (56 \times 2) + (16 \times 3) = 160$
 M_r of CO = $12 + 16 = 28$
 total M_r of reactants = $160 + (3 \times 28) = 244$
 A_r of Fe = 56
 total A_r of desired products = $2 \times 56 = 112$
 atom economy = $(112 \div 244) \times 100 = 45.90\dots = \mathbf{46\% (2 s.f.)}$

h) M_r of $\text{CoCl}_2 = 59 + (35.5 \times 2) = 130$
 M_r of $\text{Na}_3\text{PO}_4 = (23 \times 3) + 31 + (16 \times 4) = 164$
 total M_r of reactants = $(3 \times 130) + (2 \times 164) = 718$
 M_r of $\text{Co}_3(\text{PO}_4)_2 = (59 \times 3) + ((31 + (16 \times 4)) \times 2) = 367$
 atom economy = $(367 \div 718) \times 100 = 51.11\dots = \mathbf{51\% (2 s.f.)}$

Q3 a) Reaction 1:
 M_r of $\text{KClO}_3 = 39 + 35.5 + (16 \times 3) = 122.5$
 total M_r of reactants = $2 \times 122.5 = 245$
 M_r of KCl = $39 + 35.5 = 74.5$
 total M_r of desired product = $74.5 \times 2 = 149$
 atom economy of reaction 1 = $(149 \div 245) \times 100 = 60.81\dots = 61\% (2 s.f.)$

Reaction 2:
 M_r of KOH = $39 + 16 + 1 = 56$
 M_r of HCl = $1 + 35.5 = 36.5$
 total M_r of reactants = $56 + 36.5 = 92.5$
 M_r of KCl = $39 + 35.5 = 74.5$
 atom economy of reaction 2 = $(74.5 \div 92.5) \times 100 = 80.54\dots = 81\% (2 s.f.)$

Reaction 2 has the higher atom economy.



Formula Practice Sheet — Answers

Atom Economy

b) Reaction 1:

$$M_r \text{ of } \text{CH}_4 = 12 + (1 \times 4) = 16$$

$$M_r \text{ of } \text{H}_2\text{O} = (1 \times 2) + 16 = 18$$

$$\text{total } M_r \text{ of reactants} = 16 + 18 = 34$$

$$M_r \text{ of } \text{H}_2 = (1 \times 2) = 2$$

$$\text{total } M_r \text{ of desired product} = 3 \times 2 = 6$$

$$\text{atom economy of reaction 1} =$$

$$(6 \div 34) \times 100 = 17.64\dots = 18\% \text{ (2 s.f.)}$$

Reaction 2:

$$M_r \text{ of } \text{H}_2\text{O} = (1 \times 2) + 16 = 18$$

$$\text{total } M_r \text{ of reactants} = 2 \times 18 = 36$$

$$M_r \text{ of } \text{H}_2 = (1 \times 2) = 2$$

$$\text{total } M_r \text{ of desired product} = 2 \times 2 = 4$$

$$\text{atom economy of reaction 2} =$$

$$(4 \div 36) \times 100 = 11.11\dots = 11\% \text{ (2 s.f.)}$$

Reaction 1 has a higher atom economy.

c) Reaction 1:

$$M_r \text{ of } \text{C}_2\text{H}_5\text{Br} = (12 \times 2) + (1 \times 5) + 80 = 109$$

$$M_r \text{ of } \text{H}_2\text{O} = (1 \times 2) + 16 = 18$$

$$\text{total } M_r \text{ of reactants} = 109 + 18 = 127$$

$$M_r \text{ of } \text{C}_2\text{H}_5\text{OH} = (12 \times 2) + (1 \times 5) + 16 + 1 = 46$$

$$\text{atom economy of reaction 1} =$$

$$(46 \div 127) \times 100 = 36.22\dots = 36\% \text{ (2 s.f.)}$$

Reaction 2:

$$M_r \text{ of } \text{C}_6\text{H}_{12}\text{O}_6 = (12 \times 6) + (1 \times 12) + (16 \times 6) = 180$$

$$M_r \text{ of } \text{C}_2\text{H}_5\text{OH} = (12 \times 2) + (1 \times 5) + 16 + 1 = 46$$

$$\text{total } M_r \text{ of desired product} = 46 \times 2 = 92$$

$$\text{atom economy of reaction 2} =$$

$$(92 \div 180) \times 100 = 51.11\dots = 51\% \text{ (2 s.f.)}$$

Reaction 2 has a higher atom economy.

d) Reaction 1:

$$M_r \text{ of } \text{CuO} = 63.5 + 16 = 79.5$$

$$M_r \text{ of } \text{H}_2 = (1 \times 2) = 2$$

$$\text{total } M_r \text{ of reactants} = 79.5 + 2 = 81.5$$

$$A_r \text{ of } \text{Cu} = 63.5$$

$$\text{atom economy of reaction 1} =$$

$$(63.5 \div 81.5) \times 100 = 77.91\dots = 78\% \text{ (2 s.f.)}$$

Reaction 2:

$$M_r \text{ of } \text{CuO} = 63.5 + 16 = 79.5$$

$$M_r \text{ of } \text{CH}_4 = 12 + (1 \times 4) = 16$$

$$\text{total } M_r \text{ of reactants} = (4 \times 79.5) + 16 = 334$$

$$A_r \text{ of } \text{Cu} = 63.5$$

$$\text{total } A_r \text{ of desired product} = 4 \times 63.5 = 254$$

$$\text{atom economy of reaction 2} =$$

$$(254 \div 334) \times 100 = 76.04\dots = 76\% \text{ (2 s.f.)}$$

Reaction 1 has a higher atom economy.

e) Reaction 1:

$$M_r \text{ of } \text{Al}(\text{OH})_3 = 27 + ((16 + 1) \times 3) = 78$$

$$M_r \text{ of } \text{HCl} = 1 + 35.5 = 36.5$$

$$\text{total } M_r \text{ of reactants} = 78 + (3 \times 36.5) = 187.5$$

$$M_r \text{ of } \text{AlCl}_3 = 27 + (35.5 \times 3) = 133.5$$

$$\text{atom economy of reaction 1} =$$

$$(133.5 \div 187.5) \times 100 = 71.2 = 71\% \text{ (2 s.f.)}$$

Reaction 2:

$$A_r \text{ of } \text{Al} = 27$$

$$M_r \text{ of } \text{ZnCl}_2 = 65 + (35.5 \times 2) = 136$$

$$\text{total } M_r \text{ of reactants} = (27 \times 2) + (136 \times 3) = 462$$

$$M_r \text{ of } \text{AlCl}_3 = 27 + (35.5 \times 3) = 133.5$$

$$\text{total } M_r \text{ of desired product} = 133.5 \times 2 = 267$$

$$\text{atom economy of reaction 2} =$$

$$(267 \div 462) \times 100 = 57.79\dots = 58\% \text{ (2 s.f.)}$$

Reaction 1 has a higher atom economy.

Q4 Calculate the atom economy of reaction 1:

$$M_r \text{ of } \text{NaOCl} = 23 + 16 + 35.5 = 74.5$$

$$M_r \text{ of } \text{NH}_3 = 14 + (1 \times 3) = 17$$

$$\text{total } M_r \text{ of reactants} = 74.5 + (17 \times 2) = 108.5$$

$$M_r \text{ of } \text{N}_2\text{H}_4 = (14 \times 2) + (1 \times 4) = 32$$

$$\text{atom economy of reaction 1} =$$

$$(32 \div 108.5) \times 100 = 29.49\dots\%$$

Calculate the atom economy of reaction 2:

$$M_r \text{ of } \text{H}_2\text{O}_2 = (1 \times 2) + (16 \times 2) = 34$$

$$\text{total } M_r \text{ of reactants} = 34 + (17 \times 2) = 68$$

$$\text{atom economy of reaction 2} =$$

$$(32 \div 68) \times 100 = 47.05\dots\%$$

Reaction 2 has the highest atom economy.

Q5 M_r of $\text{CuSO}_4 = 63.5 + 32 + (16 \times 4) = 159.5$

$$\text{total } M_r \text{ of reactants} = 159.5 + A_r \text{ of } \text{X}$$

Cu is the desired product.

$$A_r \text{ of } \text{Cu} = 63.5$$

$$\text{atom economy} =$$

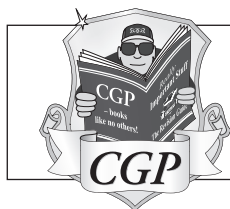
$$28.285\% = \frac{63.5}{159.5 + (A_r \text{ of } \text{X})} \times 100$$

Rearrange the equation to work out the A_r of X:

$$A_r \text{ of } \text{X} = \frac{63.5}{(28.285 \div 100)} - 159.5$$

$$A_r \text{ of } \text{X} = 65.00\dots = 65 \text{ (2 s.f.)}$$

Element X is zinc (Zn).



Formula Practice Sheet — Answers

Percentage Yield

- Q1** To answer the following questions, substitute the values for mass of product and theoretical mass into the formula for percentage yield:
- $\% \text{ yield} = (6.0 \div 10.0) \times 100 = \mathbf{60\%}$
 - $\% \text{ yield} = (5.46 \div 8.4) \times 100 = \mathbf{65\%}$
 - $1.51 \text{ kg} = 1.51 \times 1000 = 1510 \text{ g}$
 $\% \text{ yield} = (630 \div 1510) \times 100 = 41.721... = \mathbf{42.7\% (3 s.f.)}$
 - $450 \text{ mg} = 450 \div 1000 = 0.450 \text{ g}$
 $\% \text{ yield} = (0.377 \div 0.450) \times 100 = 83.77... = \mathbf{83.8\% (3 s.f.)}$
- Q2** To answer the following questions, substitute the values for percentage yield and theoretical mass into the rearrangement of the formula for percentage yield, product made = ($\% \text{ yield} \times \text{theoretical yield}$) \div 100:
- product made = $(20 \times 85) \div 100 = \mathbf{17 \text{ g}}$
 - product made = $(35 \times 1.6) \div 100 = \mathbf{0.56 \text{ g}}$
 - $75.3 \text{ mg} = 75.3 \div 1000 = 0.0753 \text{ g}$
product made = $(89.4 \times 0.0753) \div 100 = 0.06731... = \mathbf{0.0673 \text{ g (3 s.f.)}}$
 - $0.104 \text{ kg} = 0.104 \times 1000 = 104 \text{ g}$
product made = $(41.2 \times 104) \div 100 = 42.848 \text{ g} = \mathbf{42.8 \text{ g (3 s.f.)}}$
- Q3** To answer the following questions, substitute the values for mass of product and percentage yield into the rearrangement of the equation for percentage yield, theoretical yield = product made \div ($\% \text{ yield} \div 100$):
- theoretical yield = $15 \div (20 \div 100) = \mathbf{75 \text{ g}}$
 - theoretical yield = $45 \div (42 \div 100) = 107.14... = \mathbf{110 \text{ g (2 s.f.)}}$
 - $366 \text{ mg} = 366 \div 1000 = 0.366 \text{ g}$
theoretical yield = $0.366 \div (77.1 \div 100) = 0.4747... = \mathbf{0.475 \text{ g (3 s.f.)}}$
 - $0.432 \text{ kg} = 0.432 \times 1000 = 432 \text{ g}$
theoretical yield = $432 \div (68.8 \div 100) = 627.90... = \mathbf{628 \text{ g (3 s.f.)}}$
- Q4** To answer the following questions, substitute the given values into the correct rearrangement of the percentage mass formula:
- $\% \text{ yield} = (24.6 \div 35) \times 100 = 70.2... = \mathbf{70\% (2 s.f.)}$
 - theoretical yield = $14 \div (60.4 \div 100) = 23.1... = \mathbf{23\% (2 s.f.)}$
 - actual yield = $(91.3 \times 13.6) \div 100 = 12.416... = \mathbf{12.4 \text{ g (3 s.f.)}}$
 - $\% \text{ yield} = (665 \div 847) \times 100 = 78.51... = \mathbf{78.5\% (3 s.f.)}$

In part e, both masses are given in mg, so can be substituted straight into the formula without converting them to grams.

- Q5** Complete the table by substituting the known values into the correct rearrangement of the formula for percentage yield:

Experiment 1: actual mass of $\text{ZnI}_2 =$

$$(76.2 \times 15.6) \div 100 = 11.88... = \mathbf{11.9 \text{ g (3 s.f.)}}$$

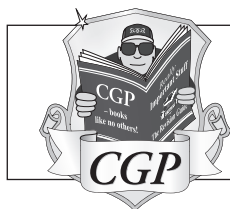
Experiment 2: theoretical yield of $\text{ZnI}_2 =$

$$18.7 \div (83.5 \div 100) = 22.39... = \mathbf{22.4 \text{ g (3 s.f.)}}$$

Experiment 3: $\% \text{ yield} =$

$$(20.0 \div 26.2) \times 100 = 76.33... = \mathbf{76.3\% (3 s.f.)}$$

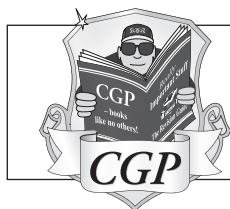
- Q6** a) theoretical yield = $9.00 \div (45.0 \div 100) = \mathbf{20.0 \text{ g}}$
b) Repeating the experiment with the same amount of reactant means the theoretical yield will remain the same.
amount of CaO produced = $(52.0 \times 20.0) \div 100 = \mathbf{10.4 \text{ g}}$



Formula Practice Sheet — Answers

Effect of Acid Strength on pH

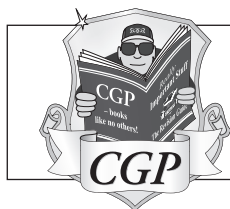
- Q1** To answer the following questions, substitute the change in pH into the formula for the factor of H^+ ion concentration change:
- factor H^+ ion concentration changes by $= 10^{-2} = \mathbf{0.01}$
 - factor H^+ ion concentration changes by $= 10^{-(1)} = \mathbf{10}$
 - factor H^+ ion concentration changes by $= 10^{-(7)} = \mathbf{10\ 000\ 000}$
 - factor H^+ ion concentration changes by $= 10^{-4} = \mathbf{0.0001}$
 - factor H^+ ion concentration changes by $= 10^{-3} = \mathbf{0.001}$
 - factor H^+ ion concentration changes by $= 10^{-(3)} = \mathbf{1000}$
 - factor H^+ ion concentration changes by $= 10^{-8} = \mathbf{0.00000001}$
 - factor H^+ ion concentration changes by $= 10^{-(6)} = \mathbf{1\ 000\ 000}$
- Q2** To answer the following questions, calculate the change in pH and substitute this into the formula for the factor of H^+ ion concentration change:
- change in pH = $4 - 2 = 2$
factor H^+ ion concentration changes by $= 10^{-2} = \mathbf{0.01}$
 - change in pH = $2 - 3 = -1$
factor H^+ ion concentration changes by $= 10^{-(1)} = \mathbf{10}$
 - change in pH = $8 - 5 = 3$
factor H^+ ion concentration changes by $= 10^{-3} = \mathbf{0.001}$
 - change in pH = $3 - 7 = -4$
factor H^+ ion concentration changes by $= 10^{-(4)} = \mathbf{10\ 000}$
 - change in pH = $7 - 12 = -5$
factor H^+ ion concentration changes by $= 10^{-(5)} = \mathbf{100\ 000}$
 - change in pH = $1 - 5 = -4$
factor H^+ ion concentration changes by $= 10^{-(4)} = \mathbf{10\ 000}$
 - change in pH = $3 - 6 = -3$
factor H^+ ion concentration changes by $= 10^{-(3)} = \mathbf{1000}$
 - change in pH = $11 - 7 = 4$
factor H^+ ion concentration changes by $= 10^{-4} = \mathbf{0.0001}$
- Q3** To answer the following questions, work out the value of x and rearrange the formula, change in pH = final pH – initial pH, to calculate the missing pH:
- factor H^+ ion concentration changes by = 10
 $= 10^1 = 10^{-x}$
 $x = -1 = \text{final pH} - \text{initial pH} = \text{final pH} - 3$
final pH = **2**
 - factor H^+ ion concentration changes by = 1000
 $= 10^3 = 10^{-x}$
 $x = -3 = \text{final pH} - \text{initial pH} = 7 - \text{initial pH}$
initial pH = **10**
 - factor H^+ ion concentration changes by = 0.1
 $= 10^{-1} = 10^{-x}$
 $x = 1 = \text{final pH} - \text{initial pH} = 2 - \text{initial pH}$
initial pH = **1**
 - factor H^+ ion concentration changes by = 100
 $= 10^2 = 10^{-x}$
 $x = -2 = \text{final pH} - \text{initial pH} = \text{final pH} - 9$
final pH = **7**
 - factor H^+ ion concentration changes by = 0.01
 $= 10^{-2} = 10^{-x}$
 $x = 2 = \text{final pH} - \text{initial pH} = \text{final pH} - 6$
final pH = **8**
- Q4**
- change in pH = $6 - 1 = 5$
factor H^+ ion concentration changes by = $10^{-5} = \mathbf{0.00001}$
 - factor H^+ ion concentration changes by = 100
 $= 10^2 = 10^{-x}$
 $x = -2 = \text{final pH} - \text{initial pH} = \text{final pH} - 7$
final pH = **5**
 - factor H^+ ion concentration changes by = 10 000
 $= 10^4 = 10^{-x}$
 $x = -4 = \text{final pH} - \text{initial pH} = 2 - \text{initial pH}$
initial pH = **6**
 - change in pH = $8 - 10 = -2$
factor H^+ ion concentration changes by = $10^{-(2)} = \mathbf{100}$
 - factor H^+ ion concentration changes by = 0.01
 $= 10^{-2} = 10^{-x}$
 $x = 2 = \text{final pH} - \text{initial pH} = \text{final pH} - 11$
final pH = **13**
- Q5** initial pH = 3
final pH = pH of neutral solution = 7
change in pH = $7 - 3 = 4$
factor H^+ ion concentration changes by = $10^{-4} = \mathbf{0.0001}$
- Q6**
- Change in pH = final pH – initial pH
 $= 2.00 - 1.70 = 0.30$
factor H^+ ion concentration changes by = $10^{-0.30} = 0.5011\dots = \mathbf{0.50\ (2\ s.f.)}$
 - final H^+ ion concentration = concentration of new acid solution = $0.50 \times 0.020 = \mathbf{0.010\ mol/dm^3}$



Formula Practice Sheet — Answers

Bond Energy Calculations

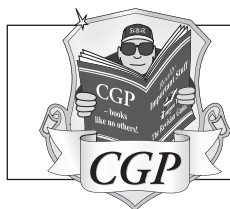
- Q1** To answer the following questions, work out the energy used in bond breaking and energy released in bond making, and substitute these values into the formula, Energy change = Energy of bond breaking – Energy of bond making:
- a) energy of bond breaking = $\text{N}\equiv\text{N} + \text{O}=\text{O} = 945 + 498 = 1443$
 energy of bond making = $2 \times \text{N}=\text{O} = 2 \times 631 = 1262$
 overall energy change = $1443 - 1214 = +181 \text{ kJ/mol}$
- b) energy of bond breaking = $2 \times \text{H}-\text{Br} = 2 \times 363 = 726$
 energy of bond making = $\text{H}-\text{H} + \text{Br}-\text{Br} = 436 + 193 = 629$
 overall energy change = $726 - 629 = +97 \text{ kJ/mol}$
- c) energy of bond breaking = $(4 \times \text{C}-\text{H}) + \text{I}-\text{I} = (4 \times 413) + 150 = 1802$
 energy of bond making = $(3 \times \text{C}-\text{H}) + \text{C}-\text{I} + \text{H}-\text{I} = (3 \times 413) + 240 + 297 = 1776$
 overall energy change = $1802 - 1776 = +26 \text{ kJ/mol}$
- d) energy of bond breaking = $(6 \times \text{C}-\text{H}) + (2 \times \text{C}-\text{I}) + \text{Cl}-\text{Cl} = (6 \times 413) + (2 \times 240) + 242 = 3200$
 energy of bond making = $(6 \times \text{C}-\text{H}) + (2 \times \text{C}-\text{Cl}) + \text{I}-\text{I} = (6 \times 413) + (2 \times 346) + 150 = 3320$
 overall energy change = $3200 - 3320 = -120 \text{ kJ/mol}$
- e) energy of bond breaking = $\text{N}\equiv\text{N} + (3 \times \text{H}-\text{H}) = 945 + (3 \times 436) = 2253$
 energy of bond making = $6 \times \text{N}-\text{H} = 6 \times 391 = 2346$
 overall energy change = $2253 - 2346 = -93 \text{ kJ/mol}$
- f) energy of bond breaking = $(12 \times \text{N}-\text{H}) + (5 \times \text{O}=\text{O}) = (12 \times 391) + (5 \times 498) = 7182$
 energy of bond making = $(4 \times \text{N}=\text{O}) + (12 \times \text{O}-\text{H}) = (4 \times 631) + (12 \times 464) = 8092$
 overall energy change = $7182 - 8092 = -910 \text{ kJ/mol}$
- Q2** To answer the following questions, work out the energy used in bond breaking and energy released in bond making, and substitute these values into the formula, Energy change = Energy of bond breaking – Energy of bond making. Remember that exothermic reactions have a negative energy change and endothermic reactions have a positive energy change:
- a) energy of bond breaking = $\text{H}-\text{H} + \text{F}-\text{F} = 436 + 156 = 592$
 energy of bond making = $2 \times \text{H}-\text{F} = 2 \times 565 = 1130$
 overall energy change = $592 - 1130 = -538 \text{ kJ/mol}$
The reaction is exothermic.
- b) energy of bond breaking = $(4 \times \text{C}-\text{H}) + (3 \times \text{Cl}-\text{Cl}) = (4 \times 413) + (3 \times 242) = 2378$
 energy of bond making = $\text{C}-\text{H} + (3 \times \text{C}-\text{Cl}) + (3 \times \text{H}-\text{Cl}) = 413 + (3 \times 346) + (3 \times 431) = 2744$
 overall energy change = $2378 - 2744 = -366 \text{ kJ/mol}$
The reaction is exothermic.
- c) energy of bond breaking = $(4 \times \text{C}-\text{H}) + (4 \times \text{O}-\text{H}) = (4 \times 413) + (4 \times 464) = 3508$
 energy of bond making = $(2 \times \text{C}=\text{O}) + (4 \times \text{H}-\text{H}) = (2 \times 805) + (4 \times 436) = 3354$
 overall energy change = $3508 - 3354 = +154 \text{ kJ/mol}$
The reaction is endothermic.
- d) energy of bond breaking = $(12 \times \text{N}-\text{H}) + (3 \times \text{O}=\text{O}) = (12 \times 391) + (3 \times 498) = 6186$
 energy of bond making = $(2 \times \text{N}\equiv\text{N}) + (12 \times \text{O}-\text{H}) = (2 \times 945) + (12 \times 464) = 7458$
 overall energy change = $6186 - 7458 = -1272 \text{ kJ/mol}$
The reaction is exothermic.
- e) energy of bond breaking = $(2 \times \text{S}=\text{O}) + (3 \times \text{H}-\text{H}) = (2 \times 523) + (3 \times 436) = 2354$
 energy of bond making = $(2 \times \text{S}-\text{H}) + (4 \times \text{O}-\text{H}) = (2 \times 349) + (4 \times 464) = 2554$
 overall energy change = $2354 - 2554 = -200 \text{ kJ/mol}$
The reaction is exothermic.
- f) energy of bond breaking = $(4 \times \text{S}-\text{H}) + (3 \times \text{O}=\text{O}) = (4 \times 349) + (3 \times 498) = 2890$
 energy of bond making = $(4 \times \text{O}-\text{H}) + (4 \times \text{S}=\text{O}) = (4 \times 464) + (4 \times 523) = 3948$
 overall energy change = -1058 kJ/mol
The reaction is exothermic.



Formula Practice Sheet — Answers

Bond Energy Calculations

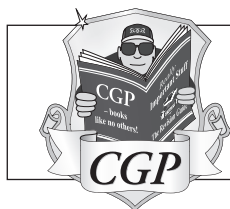
- Q3** To answer the following questions, work out the energy used in bond breaking and energy released in bond making, and substitute into the formula for the overall energy change. Rearrange the result to calculate the missing bond energy:
- a) energy of bond breaking = $C-H + C\equiv N + (2 \times H-H) = 413 + C\equiv N + (2 \times 436) = 1285 + C\equiv N$
 energy of bond making = $(3 \times C-H) + C-N + (2 \times N-H) = (3 \times 413) + 305 + (2 \times 391) = 2326$
 energy of bond breaking = overall energy change + energy of bond making
 $1285 + C\equiv N = -148 + 2326$
 $C\equiv N = -148 + 2326 - 1285 = \mathbf{893 \text{ kJ/mol}}$
- b) energy of bond breaking = $(5 \times C-H) + C-C + C-Br + (2 \times O-H) = (5 \times 413) + 348 + C-Br + (2 \times 464) = 3341 + C-Br$
 energy of bond making = $(5 \times C-H) + C-C + C-O + O-H + H-Br = (5 \times 413) + 348 + 358 + 464 + 363 = 3598$
 energy of bond breaking = overall energy change + energy of bond making
 $3341 + C-Br = 3598 + 33$
 $C-Br = 3598 + 33 - 3341 = \mathbf{290 \text{ kJ/mol}}$
- c) energy of bond breaking = $(5 \times C-H) + C-C + C-O + O-H = (5 \times 413) + 348 + 358 + 464 = 3235$
 energy of bond making = $C=C + (4 \times C-H) + (2 \times O-H) = C=C + (4 \times 413) + (2 \times 464) = C=C + 2580$
 energy of bond making = energy of bond breaking – overall energy change
 $C=C + 2580 = 3235 - (+43)$
 $C=C = 3235 - 43 - 2580 = \mathbf{612 \text{ kJ/mol}}$
- Q4** Balanced equation: $2C_2H_2 + 5O_2 \rightarrow 4CO_2 + 2H_2O$
 energy of bond breaking = $(4 \times C-H) + (2 \times C\equiv C) + (5 \times O=O) = (4 \times 413) + (2 \times C\equiv C) + (5 \times 498) = 4142 + (2 \times C\equiv C)$
 energy of bond making = $(8 \times C=O) + (4 \times O-H) = (8 \times 805) + (4 \times 464) = 8296$
 energy of bond breaking = energy change + energy of bond making
 $4142 + (2 \times C\equiv C) = -2478 + 8296$
 $2 \times C\equiv C = 1676$
 $C\equiv C = 1676 \div 2 = \mathbf{838 \text{ kJ/mol}}$
- Your balanced equation could be different e.g. $C_2H_2 + 2\frac{1}{2}O_2 \rightarrow 2CO_2 + H_2O$ is also correctly balanced. This will mean the numbers in your working will be different, but your final answer should still be the same.



Formula Practice Sheet — Answers

Mean Rate of Reaction

- Q1** To answer the following questions, substitute the values for quantity and time into the formula, rate = quantity of reactant or product ÷ time:
- rate = quantity ÷ time = $3.2 \div 8 = \mathbf{0.4 \text{ g/s}}$
 - rate = quantity ÷ time = $22.8 \div 40 = \mathbf{0.57 \text{ g/s}}$
 - rate = quantity ÷ time = $4.26 \div 0.71 = \mathbf{6 \text{ cm}^3/\text{s}}$
 - rate = quantity ÷ time
= $10.89 \div 0.33 = \mathbf{33 \text{ cm}^3/\text{min}}$
- Q2** To answer the following questions, substitute the values for mass of reactant and rate into the rearrangement of rate = mass of reactant ÷ time, time = mass of reactant ÷ rate:
- time = mass ÷ rate = $1.6 \div 0.4 = \mathbf{4 \text{ s}}$
 - time = mass ÷ rate = $6.7 \div 1.0 = \mathbf{6.7 \text{ s}}$
 - time = mass ÷ rate = $22.4 \div 3.2 = \mathbf{7.0 \text{ s}}$
 - time = mass ÷ rate = $0.392 \div 0.70 = \mathbf{0.56 \text{ s}}$
 - time = mass ÷ rate = $0.936 \div 0.180$
= 5.20 minutes = $5.20 \times 60 = \mathbf{312 \text{ s}}$
 - time = mass ÷ rate = $8.28 \div 3.60$
= 2.30 minutes = $2.30 \times 60 = \mathbf{138 \text{ s}}$
 - time = mass ÷ rate = $3.4 \div 1.2 = 2.83\dots$
= $\mathbf{2.8 \text{ s (2 s.f.)}}$
 - time = mass ÷ rate = $4.24 \div 0.90$
= $4.71\dots = \mathbf{4.7 \text{ s (2 s.f.)}}$
- Q3** To answer the following questions, substitute the values for rate and time into the rearrangement of rate = volume of product ÷ time, volume of product = rate × time:
- volume = rate × time = $0.8 \times 50 = \mathbf{40 \text{ cm}^3}$
 - volume = rate × time = $1.8 \times 3.0 = \mathbf{5.4 \text{ cm}^3}$
 - volume = rate × time = $1.0 \times 0.019 = \mathbf{0.019 \text{ cm}^3}$
 - volume = rate × time = $0.16 \times 30 = \mathbf{4.8 \text{ cm}^3}$
 - volume = rate × time
= $1.10 \times 1.30 = \mathbf{1.43 \text{ cm}^3}$
 - volume = rate × time = $5 \times (0.10 \times 60) = \mathbf{30 \text{ cm}^3}$
 - volume = rate × time
= $0.52 \times 44 = 22.88 \text{ cm}^3 = \mathbf{23 \text{ cm}^3 (2 \text{ s.f.})}$
 - volume = rate × time
= $9.15 \times 5.05 = 46.20\dots \text{ cm}^3 = \mathbf{46.2 \text{ cm}^3 (3 \text{ s.f.})}$
- Q4** To answer the following questions, substitute the given values into the correct rearrangement of rate = quantity of reactant or product ÷ time:
- You're given rate and time, so you need to use mass of product = rate × time:
mass of product = rate × time = $0.30 \times 90 = \mathbf{27 \text{ g}}$
 - You're given volume of product and time, so you need to use rate = volume of product ÷ time:
rate = volume of product ÷ time = $4 \div 20$
= $\mathbf{0.2 \text{ cm}^3/\text{s}}$
 - You're given rate and time, so you need to use volume of product = rate × time:
volume of product = rate × time = $0.4 \times (90 \div 60)$
= $\mathbf{0.6 \text{ cm}^3}$
 - You're given rate and volume of product, so you need to use time = volume of product ÷ rate:
time = volume of product ÷ rate =
 $(255 \times 1000) \div 0.52 = 0.490\dots = \mathbf{0.50 \text{ mins (2 s.f.)}}$
- Q5** Calculate the change in mass during the reaction:
 $126.35 - 123.44 = 2.91 \text{ g}$
Substitute the values into the formula for the mean rate of reaction:
mean rate = $2.91 \div 15.0 = \mathbf{0.194 \text{ g/s}}$
- Q6** Substitute the values into the rearrangement of rate = volume of product ÷ time,
volume of product = rate × time:
volume = $0.095 \times 63 = 5.985 = \mathbf{6.0 \text{ cm}^3 (2 \text{ s.f.})}$



Formula Practice Sheet — Answers

Calculating R_f Values

Q1 To answer the following questions, substitute the distances into the formula,
 R_f value = distance travelled by substance \div distance travelled by solvent:

- a) $1.2 \div 6.0 = \mathbf{0.20}$
- b) $3.7 \div 5.0 = \mathbf{0.74}$
- c) $6.58 \div 7.0 = \mathbf{0.94}$
- d) First, convert mm to cm: $58.2 \div 10 = 5.82$ cm
 Then substitute the values in: $5.82 \div 9.7 = \mathbf{0.60}$
- e) First, convert m to cm: $0.11 \times 100 = 11$ cm
 Then substitute the values in: $5.5 \div 11 = \mathbf{0.50}$

When the two units for distance don't match, it doesn't matter which one you convert as long as they match when you put them into the equation.

Q2 To answer the following questions, substitute the R_f value and the distance travelled by the solvent into the rearrangement of the R_f value formula, distance travelled by substance = distance travelled by solvent $\times R_f$ value:

- a) $5.0 \times 0.50 = \mathbf{2.5\text{ cm}}$
- b) $7.0 \times 0.20 = \mathbf{1.4\text{ cm}}$
- c) $9.0 \times 0.51 = 4.59$ cm = $\mathbf{4.6\text{ cm (2 s.f.)}}$
- d) First, convert mm to cm: $60 \div 10 = 6.0$ cm
 Then substitute the values in: $6.0 \times 0.40 = \mathbf{2.4\text{ cm}}$
- e) First, convert m to cm: $0.13 \times 100 = 13$ cm
 Then substitute the values in: $13 \times 0.60 = \mathbf{7.8\text{ cm}}$

Q3 To answer the following questions, substitute the R_f value and the distance travelled by the substance into the rearrangement of the R_f value formula, distance travelled by solvent = distance travelled by substance $\div R_f$ value:

- a) $3.0 \div 0.40 = \mathbf{7.5\text{ cm}}$
- b) $1.8 \div 0.30 = \mathbf{6.0\text{ cm}}$
- c) $2.96 \div 0.74 = \mathbf{4.0\text{ cm}}$
- d) First, convert mm to cm: $32.4 \div 10 = 3.24$ cm
 Then substitute the values in: $3.24 \div 0.40 = \mathbf{8.1\text{ cm}}$
- e) First, convert m to cm: $0.15 \times 100 = 15$ cm
 Then substitute the values in: $15 \div 0.75 = \mathbf{20\text{ cm}}$

Q4 a) Distance travelled by solvent is given by distance travelled by substance $\div R_f$ value.

First, convert mm to cm: $17 \div 10 = 1.7$ cm

Then substitute the values in: $1.7 \div 0.20 = \mathbf{8.5\text{ cm}}$

b) R_f value is given by distance travelled by substance \div distance travelled by solvent.

First, convert mm to cm: $51 \div 10 = 5.1$ cm

Then substitute the values in: $5.1 \div 8.5 = \mathbf{0.60}$

c) Distance travelled by substance is given by distance travelled by solvent $\times R_f$ value.

Substitute the values into the formula:

$8.5 \times 0.48 = 4.08 = \mathbf{4.1\text{ cm (2 s.f.)}}$

Q5 a) **Substance A** has a higher R_f value because it has travelled further on the chromatogram.

b) R_f value is given by distance travelled by substance \div distance travelled by solvent.

Substitute the values in: $8.1 \div 9 = \mathbf{0.9}$