Formula Practice Sheet
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Formula Practice Sheet
Relative Atomic Mass

The relative atomic mass of an element is an average mass that takes into account the mass and relative abundance of all the isotopes of that element.

$$\text{relative atomic mass } (A_r) = \frac{\text{sum of (isotope abundance} \times \text{isotope mass number)}}{\text{sum of abundances of all the isotopes}}$$

Q1 Calculate the missing percentage abundances. All isotopes of each element are listed:

a) Cerium, Ce-136 = 0.2%, Ce-138 = 0.3%, Ce-140 = 88.5%, Ce-142 = ?

b) Iron, Fe-54 = 5.8%, Fe-56 = ?, Fe-57 = 2.1%, Fe-58 = 0.3%

c) Nickel, Ni-58 = 68.08%, Ni-60 = ?, Ni-61 = 1.14%, Ni-62 = 3.63%, Ni-64 = 0.93%

Q2 Calculate the A_r of each element to one decimal place:

a) Bromine, Br-79 = 50.7%, Br-81 = 49.3%

b) Gallium, Ga-69 = 60.1%, Ga-71 = 39.9%

c) Iridium, Ir-191 = 37.3%, Ir-193 = 62.7%

d) Silver, Ag-107 = 51.8%, Ag-109 = 48.2%

e) Europium, Eu-151 = 47.8%, Eu-153 = 52.2%

Q3 Calculate the relative atomic mass of each element to one decimal place:

a) Chromium, Cr-50 = 4.3%, Cr-52 = 83.8%, Cr-53 = 9.5%, Cr-54 = 2.4%

b) Lead, Pb-204 = 1.4%, Pb-206 = 24.1%, Pb-207 = 22.1%, Pb-208 = 52.4%

c) Zinc, Zn-64 = 48.6%, Zn-66 = 27.9%, Zn-67 = 4.1%, Zn-68 = 18.8%, Zn-70 = 0.6%

d) Tungsten, W-180 = 0.1%, W-182 = 26.5%, W-183 = 14.3%, W-184 = 30.7%, W-186 = 28.4%

Q4 Calculate the relative atomic mass of each element to one decimal place:

a) Antimony, Sb-121 = 57.2%, Sb-123 = ?%

b) Silicon, Si-28 = ?%, Si-29 = 4.7%, Si-30 = 3.1%

c) Strontium, Sr-84 = 0.6%, Sr-86 = 9.8%, Sr-87 = 7.0%, Sr-88 = ?%

d) Germanium, Ge-70 = 20.6%, Ge-72 = 27.5%, Ge-73 = ?%, Ge-74 = 36.5%, Ge-76 = ?%. Ge-73 and Ge-76 have the same percentage abundances.

Q5 Neon has three stable isotopes. Use the information in the table on the right to calculate the relative atomic mass of neon to two decimal places:

Chemical symbol	Abundance (%)
$^{20}_{10}Ne$	90.48
$^{21}_{10}Ne$	0.27
$^{22}_{10}Ne$	9.25

Q6 Indium has two stable isotopes. One isotope, In-113, has an abundance of 4.3%. The relative atomic mass of Indium is 114.82. What is the mass number of the other stable isotope?

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Balancing Chemical Equations

Balanced chemical equations have the same number of atoms of each element on both sides of the arrow. In the reaction below, there are two H atoms and two Cl atoms in both the reactants and the products, so it is balanced:

$$H_2 + Cl_2 \rightarrow 2HCl$$

Q1 For each equation, write down the number of each type of atom on each side of the equation and state whether the equation is balanced:

a) $H_2 + O_2 \rightarrow H_2O$
b) $N_2 + 3F_2 \rightarrow 2NF_3$
c) $4C + S_8 \rightarrow 4CS_2$
d) $TiCl_4 + 2H_2O \rightarrow TiO_2 + 2HCl$
e) $CuO + H_2SO_4 \rightarrow CuSO_4 + H_2O$
f) $Fe_2O_3 + 3C \rightarrow 2Fe + 3CO_2$

Q2 Balance the chemical equations below:

a) $Li + S \rightarrow Li_2S$
b) $F_2 + NaCl \rightarrow NaF + Cl_2$
c) $K + Br_2 \rightarrow KBr$
d) $Mg + HCl \rightarrow MgCl_2 + H_2$
e) $Al + Cl_2 \rightarrow AlCl_3$
f) $N_2 + H_2 \rightarrow NH_3$
g) $Fe + O_2 \rightarrow Fe_2O_3$
h) $KClO_3 \rightarrow KCl + O_2$
i) $Ag_2S \rightarrow Ag + S_8$

Q3 Balance the chemical equations below.
In this question, some elements appear in multiple reactants or products.

a) $ZnS + O_2 \rightarrow ZnO + SO_2$
b) $CH_4 + O_2 \rightarrow CO_2 + H_2O$
c) $HClO_2 \rightarrow HClO_3 + HCl$
d) $P_4O_{10} + H_2O \rightarrow H_3PO_4$
e) $C_5H_{12} + O_2 \rightarrow CO_2 + H_2O$
f) $Na + NH_3 \rightarrow NaNH_2 + H_2$

Q4 Balance the chemical equations below.
In this question, some of the chemical formulas include brackets.

a) $(NH_4)_2Cr_2O_7 \rightarrow Cr_2O_3 + N_2 + H_2O$
b) $KBr + Al(ClO_4)_3 \rightarrow AlBr_3 + KClO_4$
c) $Al_2(SO_4)_3 + Ca(OH)_2 \rightarrow Al(OH)_3 + CaSO_4$
d) $CuSO_4 + NH_3 + H_2O \rightarrow Cu(NH_3)_4(H_2O)_2(OH)_2 + H_2SO_4$
e) $Na_3PO_4 + MgCl_2 \rightarrow NaCl + Mg_3(PO_4)_2$
f) $Mg_3Si_2O_5(OH)_4 + CO_2 \rightarrow MgCO_3 + SiO_2 + H_2O$

Q5 Photosynthesis is a chemical reaction in which carbon dioxide and water react to form oxygen gas and glucose ($C_6H_{12}O_6$). Write a balanced symbol equation for photosynthesis.

Q6 When methane (CH_4) is burned with a limited supply of oxygen, it undergoes incomplete combustion. The products of incomplete combustion depend on the amount of oxygen that is available. One possible reaction for the incomplete combustion of methane is:

methane + oxygen gas → carbon monoxide + water

a) Write a balanced symbol equation for the reaction above.
b) If there is even less oxygen available, the products of the incomplete combustion of methane are carbon monoxide, carbon and water.
Write a balanced symbol equation for this reaction.

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Relative Formula Mass

The relative formula mass (M_r) of a compound is the sum of the relative atomic masses (A_r) of the all the atoms in that compound. For example:

Fe_2O_3

A_r of Fe = 56
A_r of O = 16
M_r of Fe_2O_3 = (56 × 2) + (16 × 3) = 160

If you're not given them in the question, you can find relative atomic masses in the periodic table. There's one on p.394 of the Chemistry Student Book.

Q1 Use a periodic table to find the relative atomic masses of the following elements.

a) Carbon (C)
b) Oxygen (O)
c) Phosphorus (P)
d) Potassium (K)
e) Magnesium (Mg)
f) Gold (Au)
g) Tin (Sn)
h) Copper (Cu)
i) Tungsten (W)

Q2 Calculate the relative formula masses of the following compounds.

a) LiF
b) NaCl
c) $CaBr_2$
d) C_2H_4
e) RbI
f) KNO_3
g) Al_2O_3
h) H_2SO_4
i) NH_4NO_3

Q3 Calculate the M_r of the following chemicals. Their chemical formulas contain brackets.

a) $Pb(OH)_2$
b) $Cu(NO_3)_2$
c) $Al_2(SO_4)_3$
d) $(NH_4)_2CO_3$
e) $Fe(C_6H_5COO)_3$
f) $(CH_3(CH_2)_{16}COO)_3C_3H_5$
g) $Pt(NO_2)(NH_3)_2Cl$
h) $[Zn(NH_3)_4]SO_4$
i) $[Co(NH_3)_5(H_2O)]Cl_3$

Q4 For each chemical reaction below, work out which reactant or product has the largest M_r.

a) $3H_2 + N_2 \rightarrow 2NH_3$
b) $CuSO_4 + Zn \rightarrow ZnSO_4 + Cu$
c) $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$
d) $2FeSO_4 \rightarrow Fe_2O_3 + SO_2 + SO_3$
e) $KCN + HBr \rightarrow KBr + HCN$
f) $2HNO_3 + Na_2CO_3 \rightarrow 2NaNO_3 + H_2O + CO_2$
g) $Cu + 2AgNO_3 \rightarrow 2Ag + Cu(NO_3)_2$
h) $Pb(NO_3)_2 + 2KI \rightarrow PbI_2 + 2KNO_3$

Q5 A scientist carries out the following reaction between $X(NO_3)_2$ and H_2CO_3, where X is an unknown element:

$$X(NO_3)_2 + H_2CO_3 \rightarrow XCO_3 + 2HNO_3$$

XCO_3 has a relative formula mass of 197.

a) What is the relative atomic mass of X?
b) What element is X?
c) Calculate the relative formula mass of $X(NO_3)_2$.

Q6 Iodic acid contains hydrogen, iodine and oxygen, and has an M_r of 176. When iodic acid is heated, an oxide of iodine is formed, with an M_r of 334.

a) One molecule of iodic acid contains one iodine atom and one hydrogen atom. Work out the chemical formula of iodic acid.
b) What is the chemical formula of the iodine oxide formed when iodic acid is heated?

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Formula Practice Sheet
Percentage Mass

The percentage mass of an element in a compound is the proportion of the mass of the compound that is due to the atoms of that element. You can calculate it using the following formula:

$$\text{Percentage mass of an element in a compound} = \frac{A_r \times \text{number of atoms of that element}}{M_r \text{ of compound}} \times 100$$

Remember, the M_r of a compound is the sum of the relative atomic masses (A_r) of all its atoms. You can find values for A_r in the periodic table.

Q1 Calculate the percentage mass of oxygen in the following compounds. Give your answers to the nearest whole number.

a) H_2O
b) SO_2
c) Fe_2O_3
d) CH_3CH_2OH
e) CH_3COOH
f) $Ca(OH)_2$
g) $Al(OH)_3$
h) $Mg(HCO_3)_2$
i) $Ca_5(PO_4)_3OH$

Q2 Calculate the percentage mass of carbon in the following compounds. Give your answers to the nearest whole number.

a) CS_2
b) C_2H_6
c) $MgCO_3$
d) $CHCl_3$
e) $Ca(HCO_3)_2$
f) $C_5H_6N_2O_2$
g) $(CH_3)_2CNH$
h) $(CH_3)(CH_2)_3OH$
i) $Pt(SCN)_2(NH_3)_2$

Q3 Calculate the percentage mass of the named element for each of the following compounds. Give your answers to 1 decimal place.

a) bromine (Br) in CH_3Br
b) iodine (I) in $C_6H_5CH_2I$
c) calcium (Ca) in $CaCO_3$
d) nickel (Ni) in $Ni(CO)_4$
e) fluorine (F) in TeF_6
f) hydrogen in C_6H_5Cl
g) nitrogen (N) in $Co(NH_3)_3Cl_3$
h) oxygen (O) in $Cu(NO_3)_2$
i) carbon (C) in $Fe(C_5H_5)_2$

Q4 For each of the following groups of compounds, work out which compound has the largest percentage mass of the element in bold.

a) **Ca**Cl_2, **Ca**SO_4, **Ca**$_2O_4Si$
b) Li**Al**H_4, Na_3**Al**F_6, **Al**$_2SiO_5$
c) KFe**S**$_2$, $(NH_4)_2$**S**$_2O_3$, H_2**S**O_2
d) C_6H_4(**N**$H_2)_2$, C_2H_5**N**O_2, Rb**N**O_3
e) **Cu**$_3(PO_4)_2$, **Cu**I, **Cu**$_2(OH)_3Cl$
f) Be(**B**$H_4)_2$, Cs_2**B**$_{12}H_{12}$, **B**$_2(OH)_4$

Q5 Compound $XYCO_3$ has an M_r of 84. The percentage mass of Y in the compound is 1.2%. Work out the percentage mass of X. Give your answer to one decimal place.

Q6 Compound Z has a relative formula mass of 100 and contains only carbon (C) and hydrogen (H) atoms. The percentage mass of carbon in compound Z is 84%.

Work out the chemical formula of compound Z.

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Moles

Moles are used in chemistry to measure amounts of substances — one mole is the amount of a substance that contains 6.02×10^{23} particles. The number of moles a sample contains can be calculated by the following formula:

$$\text{moles} = \frac{\text{mass in g (of element or compound)}}{M_r \text{ (of element or compound) or } A_r \text{ (of element)}}$$

You'll need a periodic table to answer these questions.

Q1 Calculate the mass of 1 mole of each of the following substances.

a) Mg
b) Cl_2
c) HBr
d) NaCl
e) ZnS
f) NiI_2
g) H_2SO_4
h) KNO_3
i) Na_2CrO_4

Q2 Calculate the number of moles of the following compounds.

a) 34 g of NH_3
b) 8 g of CH_4
c) 170 g of BF_3
d) 153 g of N_2O_5
e) 92 g of $CuCl_2$
f) 135 g of C_5H_5N
g) 233 g of K_2CrO_4
h) 325.5 g of $K_2Cr_2O_7$
i) 24.4 g of $C_7H_5LiO_2$

Q3 Calculate the mass in grams of the following compounds.

a) 2.00 moles of SnO_2
b) 0.50 moles of C_6H_6
c) 0.30 moles of Al_2S_3
d) 0.020 moles of $CHCl_3$
e) 1.22 moles of $WOCl_4$
f) 0.27 moles of $BaMnO_4$
g) 0.215 moles of Ag_3PO_4
h) 2.11 moles of $C_6H_{13}OH$
i) 0.118 moles of $(NH_4)_3PO_4$

Q4 Calculate the amount for each of the following compounds.

a) mass in g of 0.50 moles of H_2SO_4
b) number of moles in 97 g of $AgNO_3$
c) mass in g of 0.25 moles of $C_6H_8O_7$
d) number of moles in 36 g of $(NH_4)_2CO_3$
e) number of moles in 12.0 g of $Ba(NO_3)_2$
f) mass in g of 0.475 moles of $Zn_3(PO_4)_2$

Q5 A student reacts hydrochloric acid and calcium carbonate in the equation show below:

$$2HCl + CaCO_3 \rightarrow CaCl_2 + H_2O + CO_2$$

a) The student uses 140 g of calcium carbonate. How many moles is this?
b) The reaction forms 1.15 moles of calcium chloride. How much is this in grams?

Q6 A scientist carries out the following reaction with 0.375 mol of nitric acid (HNO_3) and 0.375 mol of sodium hydroxide (NaOH):

$$HNO_3 + NaOH \rightarrow NaNO_3 + H_2O$$

What is the total mass of the reactants?

Formula Practice Sheet

Balancing Equations Using Masses

If you know the balanced equation for a reaction, you can work out the mass (or number of moles) of any product or reactant as long as you know the mass of one product or reactant. If you know the mass of every reactant and product, you can use the following method to balance the equation:

1. Divide the mass of each substance by its M_r (or A_r) to find the number of moles.
2. Divide the moles of each substance by the smallest number of moles in the reaction.
3. If necessary, multiply all the numbers by the same amount to make them all whole numbers.
4. Write the balanced symbol equation by putting the numbers from step 3 in front of the chemical formulas.

Q1 Calculate how many moles of the substance in bold are formed if there are 1.5 moles of oxygen in the reaction. Assume everything reacts completely.

a) $S + O_2 \rightarrow \mathbf{SO_2}$
b) $2H_2 + O_2 \rightarrow \mathbf{2H_2O}$
c) $\mathbf{H_2O_2} + O_3 \rightarrow H_2O + 2O_2$
d) $\mathbf{4Tl} + O_2 \rightarrow 2Tl_2O$
e) $\mathbf{4Al} + 3O_2 + \rightarrow 2Al_2O_3$
f) $3O_2 \rightarrow \mathbf{2O_3}$
g) $6CO_2 + 6H_2O \rightarrow \mathbf{C_6H_{12}O_6} + 6O_2$
h) $C_3H_8 + 5O_2 \rightarrow \mathbf{3CO_2} + 4H_2O$

Q2 Calculate the mass of the substance in bold if there are 2 moles of nitrogen in the reaction. Assume everything reacts completely.

a) $\mathbf{2NO} + 2H_2 \rightarrow N_2 + 2H_2O$
b) $N_2 + \mathbf{3H_2} \rightarrow 2NH_3$
c) $3CuO + 2NH_3 \rightarrow N_2 + \mathbf{3Cu} + 3H_2O$
d) $\mathbf{6Li} + N_2 \rightarrow 2Li_3N$
e) $2Na_2CO_3 + \mathbf{8C} + 2N_2 \rightarrow 4NaCN + 6CO$
f) $2NaN_3 \rightarrow \mathbf{2Na} + 3N_2$

Q3 Use the masses provided to write balanced equations for each set of reactants and products given below. Assume everything reacts completely.

a) Reactants: 127 g Cu, 32 g O_2. Products: 159 g CuO.
b) Reactants: 4.6 g Na, 3.6 g H_2O. Products: 8.0 g NaOH, 0.2 g H_2.
c) Reactants: 5.4 g Al, 21.9 g HCl. Products: 26.7 g $AlCl_3$, 0.6 g H_2.
d) Reactants: 17.15 g $KClO_3$. Products: 10.43 g KCl, 6.72 g O_2.
e) Reactants: 16.0 g Fe_2O_3, 1.8 g C. Products: 11.2 g Fe, 6.6 g CO_2.
f) Reactants: 1.20 g C_2H_6, 4.48 g O_2. Products: 3.52 g CO_2, 2.16 g H_2O.

Q4 16.40 g of sodium phosphate (Na_3PO_4) reacts completely with 16.65 g of calcium chloride ($CaCl_2$) in a displacement reaction. The reaction produces 15.50 g of calcium phosphate ($Ca_3(PO_4)_2$) and 17.55 g of sodium chloride (NaCl). Use the masses of reactants and products to write a balanced symbol equation for this reaction.

Q5 A chemist reacted 20.0 g of $SiCl_4$ with 3.24 g of water to form 5.40 g of SiO_2 and 13.14 g of HCl. 4.70 g of $SiCl_4$ was left unreacted. Use the masses of reactants and products to write a balanced equation for this reaction.

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Formula Practice Sheet
Calculating the Mass of a Product

To calculate the mass of a product, you need to know the balanced equation for the reaction and the amount of the limiting reactant. The limiting reactant is the one that is used up completely in the reaction — it limits the amount of product that forms. The amount of any other reactants is not important because they will be in excess.

Before working through these questions, make sure you know how to calculate the M_r of a compound, how to balance chemical equations and how to calculate moles.

Q1 Use the following balanced equations to calculate the number of moles of each product. In each case, there are 0.6 moles of the limiting reactant (shown in bold).

a) $CaO + \mathbf{CO_2} \rightarrow CaCO_3$
b) $2\mathbf{Ca} + O_2 \rightarrow 2CaO$
c) $2\mathbf{K} + MgCl_2 \rightarrow 2KCl + Mg$
d) $3\mathbf{O_2} \rightarrow 2O_3$
e) $2Fe + 6\mathbf{HCl} \rightarrow 2FeCl_3 + 3H_2$
f) $2\mathbf{Pb(NO_3)_2} \rightarrow 2PbO + 4NO_2 + O_2$

Q2 Use the following balanced equations to calculate the mass of each product. In each case, there are 8.0 g of the limiting reactant (shown in bold).

a) $2H_2 + \mathbf{O_2} \rightarrow 2H_2O$
b) $\mathbf{CH_4} + 4Cl_2 \rightarrow CCl_4 + 4HCl$
c) $\mathbf{Mg_3N_2} + 6H_2O \rightarrow 3Mg(OH)_2 + 2NH_3$
d) $3\mathbf{KOH} + H_3PO_4 \rightarrow K_3PO_4 + 3H_2O$
e) $\mathbf{Mg(NO_3)_2} + 2Li \rightarrow Mg + 2LiNO_3$
f) $\mathbf{C_4H_8} + 6O_2 \rightarrow 4CO_2 + 4H_2O$

Q3 Balance the following equations and use them to calculate the mass of the product in bold. In each case, there is 6.0 g of the limiting reactant. The limiting reactant is the solid.

a) $Mg_{(s)} + HCl_{(aq)} \rightarrow \mathbf{MgCl_{2(aq)}} + H_{2(g)}$
b) $Zn_{(s)} + NaOH_{(aq)} + H_2O_{(l)} \rightarrow \mathbf{Na_2Zn(OH)_{4(aq)}} + H_{2(g)}$
c) $S_{(s)} + F_{2(g)} \rightarrow \mathbf{SF_{6(g)}}$
d) $Al_2O_{3(s)} + HCl_{(aq)} \rightarrow \mathbf{AlCl_{3(aq)}} + H_2O_{(l)}$
e) $HgO_{(s)} \rightarrow \mathbf{Hg_{(s)}} + O_{2(g)}$
f) $Fe_{(s)} + Cl_{2(g)} \rightarrow \mathbf{FeCl_{3(s)}}$

Q4 Use the information provided to calculate the mass of the product in bold, in g.

a) Excess nitrogen reacts with 21 g of oxygen to produce nitrogen dioxide ($\mathbf{NO_2}$).
b) 4.17 g of PCl_5 reacts with excess water to produce H_3PO_4 and **HCl**.
c) 810 mg of aluminium reacts with excess copper chloride ($CuCl_2$) to produce aluminium chloride ($AlCl_3$) and **copper**.

Q5 Iron (Fe) can be extracted from its iron oxide (Fe_2O_3) ore by a reaction with carbon (C). The reaction also produces carbon dioxide.

a) Write a balanced equation for the reaction.
b) How much iron is produced when 2.4 kg of iron oxide is reacted with excess carbon? Give your answer in kg, to an appropriate number of significant figures.

Q6 A scientist heats a mixture of 57.15 g of copper and 63.0 g of nitric acid. The balanced equation for the reaction between copper and nitric acid is:

$$Cu + 4HNO_3 \rightarrow Cu(NO_3)_2 + 2H_2O + 2NO_2$$

a) Use the information above to work out the limiting reactant in this reaction.
b) Calculate the mass of $Cu(NO_3)_2$ produced.

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Formula Practice Sheet
Calculating Volumes of Gases

At room temperature and pressure (r.t.p.), one mole of any gas occupies 24 dm^3.
You can find the volume of a known mass of any gas at r.t.p. using the formula below:

$$\text{Volume of gas } (dm^3) = \frac{\text{Mass of gas (g)}}{M_r \text{ of gas}} \times 24$$

The relative formula mass (M_r) of a compound is the sum of the relative atomic masses (A_r) of the all the atoms in that compound.

Q1 Calculate the volume, in dm^3, of each of the gases below (at r.t.p.).

a) 5 g of hydrogen (H_2)
b) 12 g of oxygen (O_2)
c) 42 g of nitrogen (N_2)
d) 11 g of carbon dioxide (CO_2)
e) 35.5 g of chlorine (Cl_2)
f) 37.4 g of ammonia (NH_3)
g) 19.2 g of methane (CH_4)
h) 24.5 g of carbon monoxide (CO)

Q2 Calculate the mass, in grams, of each of the gases below (at r.t.p.).

a) 3 dm^3 of helium (He)
b) 18 dm^3 of argon (Ar)
c) 12 dm^3 of oxygen (O_2)
d) 3.6 dm^3 of fluorine (F_2)
e) 14.1 dm^3 of methane (CH_4)
f) 22 dm^3 of nitrogen dioxide (NO_2)
g) 9.6 dm^3 of carbon dioxide (CO_2)
h) 52.8 dm^3 of ammonia (NH_3)

Q3 Calculate the M_r of each of the gases below (at r.t.p.).

a) volume = 6.0 dm^3, mass = 7.0 g
b) volume = 7.5 dm^3, mass = 10 g
c) mass = 33 g, volume = 18 dm^3
d) volume = 108 dm^3, mass = 9 g
e) volume = 12 dm^3, mass = 8.5 g
f) mass = 16.8 g, volume = 100.8 dm^3
g) mass = 14 g, volume = 16.8 dm^3
h) volume = 26.4 dm^3, mass = 48.4 g

Q4 Find the missing variable in each set of variables for the gases given below (at r.t.p.).

a) mass = 5.6 g, M_r = 28, volume = ?
b) M_r = 2, volume = 36 dm^3, mass = ?
c) mass = 22.1 g, volume = 31.2 dm^3, M_r = ?
d) volume = 9.6 dm^3, M_r = 40, mass = ?

Q5 Sulfur dioxide reacts with oxygen to form sulfur trioxide.
The balanced equation for this reaction is:

$$2SO_{2(g)} + O_{2(g)} \rightarrow 2SO_{3(g)}$$

a) Calculate the volume of 16 g of sulfur trioxide at r.t.p.
b) What volume of sulfur trioxide is produced if 25 g of oxygen reacts with an excess of sulfur dioxide?

Q6 Twelve balloons are being filled with 1800 cm^3 of helium (He) each.
Calculate the total mass of helium needed to fill all twelve balloons at r.t.p.

Formula Practice Sheet
Concentration, Mass and Volume

Concentration is the amount of solute that is dissolved in a solution. You can calculate it from the volume of the solution and the mass of solute that has been dissolved using this equation:

$$c = \frac{m}{V}$$

c = concentration (g/dm^3)
m = mass of solute (g)
V = volume of solution (dm^3)

You might need to convert the units to the ones shown on the left. Remember: 1 litre = 1 dm^3 = 1000 cm^3.

Q1 Calculate the concentration of the solution, in g/dm^3, for each mass and volume given below.

a) m = 40 g, V = 5 dm^3
b) V = 8 dm^3, m = 24 g
c) m = 2 g, V = 2 dm^3
d) V = 3 dm^3, m = 18 g
e) m = 3.2 g, V = 8 dm^3
f) V = 9.0 litres, m = 54 g
g) m = 1.3 g, V = 103 cm^3
h) V = 19 cm^3, m = 10.2 g
i) V = 110 cm^3, m = 1.3 g

Q2 Calculate the mass of solute, in g, for each concentration and volume given below.

a) c = 0.60 g/dm^3, V = 70 dm^3
b) V = 1.0 dm^3, c = 3.6 g/dm^3
c) V = 7.0 dm^3, c = 27 g/dm^3
d) V = 0.048 dm^3, c = 8.0 g/dm^3
e) c = 6.9 g/dm^3, V = 3.8 dm^3
f) c = 7.1 g/dm^3, V = 2.0 dm^3
g) c = 0.080 g/cm^3, V = 0.046 litres
h) V = 760 cm^3, c = 0.70 g/dm^3

Q3 Calculate the volume of solution, in dm^3, for each mass and concentration given below.

a) c = 10 g/dm^3, m = 5 g
b) c = 3.5 g/dm^3, m = 14 g
c) m = 30.4 g, c = 38 g/dm^3
d) m = 0.126 g, c = 3.0 g/dm^3
e) c = 1.1 g/dm^3, m = 0.0968 g
f) m = 36.9 g, c = 4.1 g/dm^3
g) c = 2.2 g/dm^3, m = 11 g
h) c = 2.0 g/dm^3, m = 0.15 g

Q4 Find the missing variable in each set of variables given below.

a) c = 8.0 g/dm^3, V = 0.091 dm^3, m = ?
b) m = 0.2 g, V = 0.01 dm^3, c = ?
c) m = 14.4 g, c = 1.6 g/dm^3, V = ?
d) c = 9.0 g/dm^3, m = 439 mg, V = ?
e) V = 4.92 dm^3, m = 24010 mg, c = ?
f) c = 0.00630 g/cm^3, V = 6.21 litres, m = ?

Q5 A teacher makes two solutions of the same solute. Solution A has a concentration of 0.12 g/cm^3 and a volume of 0.050 dm^3. Solution B has a concentration of 60 g/dm^3 and a volume of 0.070 dm^3 A student says that solution B contains more solute than solution A. Is the student correct? Explain your answer.

Q6 45.0 g of sodium hydroxide was dissolved in 100 ml of water.

a) Calculate the concentration of the sodium hydroxide solution in g/dm^3.

20.0 ml of hydrochloric acid was added to the solution, neutralising some of the alkali. The new concentration of the alkali solution is 310 g/dm^3.

b) What is the mass of dissolved sodium hydroxide left in the solution?

Formula Practice Sheet
Concentration, Moles and Volume

The concentration of a solution can be measured in mol/dm^3.
This tells you the number of moles of solute in one dm^3 of the solution.

$$c = \frac{n}{V}$$

c = concentration (mol/dm^3)
n = amount of solute (mol)
V = volume of solution (dm^3)

You might need to convert the units to the ones shown on the left. Remember: 1 litre = 1 dm^3 = 1000 cm^3.

Q1 Calculate the concentration, in mol/dm^3, for each set of values below.

a) V = 2 dm^3, n = 1.6 mol
b) n = 0.90 mol, V = 0.20 dm^3
c) V = 9 dm^3, n = 3.6 mol
d) V = 0.40 dm^3, n = 0.36 mol
e) V = 9 dm^3, n = 0.45 mol
f) n = 4.68 mol, V = 0.52 litres
g) V = 800 cm^3, n = 7.12 mol
h) n = 3.01 mol, V = 700 cm^3

Q2 Calculate the amount of solute, in moles, for each set of values below.

a) V = 7.0 dm^3, c = 0.8 mol/dm^3
b) V = 0.1 dm^3, c = 8 mol/dm^3
c) c = 0.6 mol/dm^3, V = 6.0 dm^3
d) V = 0.30 dm^3, c = 0.80 mol/dm^3
e) V = 0.10 dm^3, c = 2.4 mol/dm^3
f) V = 5.9 dm^3, c = 0.07 mol/dm^3
g) c = 4.0 mol/dm^3, V = 460 cm^3
h) c = 0.0090 mol/cm^3, V = 0.36 litres

Q3 Calculate the volume of solution, in dm^3, for each set of values below.

a) c = 0.6 mol/dm^3, n = 0.6 mol
b) n = 1.5 mol, c = 0.5 mol/dm^3
c) c = 0.7 mol/dm^3, n = 0.21 mol
d) n = 0.092 mol, c = 0.010 mol/dm^3
e) n = 2.72 mol, c = 3.4 mol/dm^3
f) n = 1.98 mol, c = 3.3 mol/dm^3
g) n = 1.08 mol, c = 9.0 mol/dm^3
h) n = 4.76 mol, c = 0.0070 mol/cm^3

Q4 Find the missing variable in each set of variables given below.

a) c = 0.7 mol/dm^3, n = 3.5 mol, V = ?
b) V = 4.0 dm^3, c = 0.40 mol/dm^3, n = ?
c) n = 0.05 mol, c = 0.1 mol/dm^3, V = ?
d) V = 0.40 dm^3, n = 3.8 mol, c = ?
e) c = 1.8 mol/dm^3, V = 2.0 dm^3, n = ?
f) c = 9.0 mol/dm^3, V = 0.42 dm^3, n = ?
g) V = 342 cm^3, n = 0.102 mol, c = ?
h) c = 0.0074 mol/cm^3, V = 6.0 litres, n = ?

Q5 How many moles of potassium chloride are needed to make 640 cm^3 of a 0.91 mol/dm^3 solution?

Q6 A scientist makes 1.2 dm^3 of a 0.45 mol/dm^3 solution of a salt and water.

a) How many moles of salt are in the solution?
b) The scientist adds an extra 0.5 dm^3 of water to the solution. Use your answer from part a) to calculate the concentration of the diluted solution, in mol/dm^3.

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Formula Practice Sheet
Converting Concentrations

The concentration of a solution can be expressed in terms of moles or mass.
You can convert from a concentration in g/dm^3 to mol/dm^3 using the formula:

$$\text{concentration (mol/dm}^3\text{)} = \frac{\text{concentration (g/dm}^3\text{)}}{M_r}$$

For questions where you need to calculate the M_r of the solute, you'll need a periodic table. You can find one on page 394 of the Chemistry Student Book.

Q1 Calculate the concentration of the following solutions in mol/dm^3.

a) concentration = 2.0 g/dm^3, M_r = 40
b) concentration = 16 g/dm^3, M_r = 160
c) concentration = 246 g/dm^3, M_r = 82
d) concentration = 36 g/dm^3, M_r = 120
e) concentration = 0.258 kg/L, M_r = 86
f) concentration = 0.185 g/cm^3, M_r = 74

Q2 Calculate the concentration of the following solutions in g/dm^3.
Give your answers to an appropriate number of significant figures.

a) concentration = 0.10 mol/dm^3, M_r = 42
b) concentration = 1.5 mol/dm^3, M_r = 56
c) concentration = 0.040 mol/dm^3, M_r = 97
d) concentration = 0.500 mol/L, M_r = 119
e) concentration = 5.0 mol/dm^3, M_r = 127
f) concentration = 0.0045 mol/cm^3, M_r = 88

Q3 Calculate the concentration of the following solutions in mol/dm^3.
Give your answers to an appropriate number of significant figures.

a) 8 g/dm^3 NaOH
b) 120 g/dm^3 NH_4NO_3
c) 35 g/dm^3 NaCl
d) 96 g/dm^3 $NaNO_3$
e) 3.4 g/dm^3 $Ba(OH)_2$
f) 1.75 g/dm^3 $ZnSO_4$
g) 9.25 g/dm^3 KIO_3
h) 111 g/dm^3 K_2CO_3
i) 305 g/dm^3 $MgCl_2$

Q4 Find the missing concentration for the following solutions.
Give your answers to 2 significant figures.

a) concentration = 12 g/dm^3, M_r = 87
b) M_r = 101, concentration = 25 g/dm^3
c) M_r = 127, concentration = 0.80 mol/dm^3
d) concentration = 0.35 mol/dm^3, M_r = 136
e) concentration = 90 g/dm^3, M_r = 166
f) M_r = 74.5, concentration = 0.10 mol/dm^3

Q5 A scientist prepared a solution of 0.40 mol/dm^3 calcium bromide ($CaBr_2$).

a) Calculate the concentration of the solution in g/dm^3.
b) Use your answer to part a) to work out the mass of $CaBr_2$ that the scientist added to 250 cm^3 water to make the solution.

Q6 A student dissolves 37 g of magnesium nitrate ($Mg(NO_3)_2$) in 100 cm^3 water.

a) Calculate the concentration of the solution in g/dm^3.
b) Convert your answer from part a) to mol/dm^3.
c) How much magnesium nitrate would the student have to dissolve in 100 cm^3 of water to make a solution with a concentration of 1.25 mol/dm^3?

Formula Practice Sheet
Atom Economy

The atom economy of a reaction is the percentage of the mass of the reactants that ends up as useful products. A higher atom economy means less waste. You can calculate it using the formula below:

$$\text{atom economy} = \frac{M_r \text{ of desired products}}{M_r \text{ of all reactants}} \times 100$$

Remember, the M_r of a compound is the sum of the relative atomic masses of its atoms.

Q1 Calculate the atom economy for the chemical reactions below. The desired products are in bold. Give your answer to 2 significant figures.

a) $CaCO_3 \rightarrow \mathbf{CaO} + CO_2$
b) $C_2H_4 + H_2O \rightarrow \mathbf{C_2H_5OH}$
c) $SnO_2 + C \rightarrow \mathbf{Sn} + CO_2$
d) $CO + H_2O \rightarrow CO_2 + \mathbf{H_2}$
e) $KOH + HCl \rightarrow \mathbf{KCl} + H_2O$
f) $C_{10}H_{22} \rightarrow C_8H_{18} + \mathbf{C_2H_4}$
g) $CuO + H_2SO_4 \rightarrow \mathbf{CuSO_4} + H_2O$
h) $Zn(OH)_2 \rightarrow \mathbf{ZnO} + H_2O$

Q2 Calculate the atom economy for the chemical reactions below. The desired products are in bold. Give your answer to 2 significant figures.

a) $2NH_3 + H_2SO_4 \rightarrow \mathbf{(NH_4)_2SO_4}$
b) $CuO + 2HCl \rightarrow \mathbf{CuCl_2} + H_2O$
c) $2Cs + CaCl_2 \rightarrow \mathbf{Ca} + 2CsCl$
d) $MgCl_2 + 2NaOH \rightarrow \mathbf{Mg(OH)_2} + 2NaCl$
e) $TiCl_4 + 4Na \rightarrow \mathbf{Ti} + 4NaCl$
f) $2Al_2O_3 \rightarrow 4\mathbf{Al} + 3O_2$
g) $Fe_2O_3 + 3CO \rightarrow 2\mathbf{Fe} + 3CO_2$
h) $3CoCl_2 + 2Na_3PO_4 \rightarrow \mathbf{Co_3(PO_4)_2} + 6NaCl$

Q3 Below are pairs of reactions that make the same desired product (shown in bold). For each pair, work out which reaction has the higher atom economy:

a) 1. $2KClO_3 \rightarrow 2\mathbf{KCl} + 3O_2$ 2. $KOH + HCl \rightarrow \mathbf{KCl} + H_2O$
b) 1. $CH_4 + H_2O \rightarrow CO + 3\mathbf{H_2}$ 2. $2H_2O \rightarrow 2\mathbf{H_2} + O_2$
c) 1. $C_2H_5Br + H_2O \rightarrow \mathbf{C_2H_5OH} + HBr$ 2. $C_6H_{12}O_6 \rightarrow 2\mathbf{C_2H_5OH} + 2CO_2$
d) 1. $CuO + H_2 \rightarrow \mathbf{Cu} + H_2O$ 2. $4CuO + CH_4 \rightarrow 4\mathbf{Cu} + 2H_2O + CO_2$
e) 1. $Al(OH)_3 + 3HCl \rightarrow \mathbf{AlCl_3} + 3H_2O$ 2. $2Al + 3ZnCl_2 \rightarrow 3Zn + 2\mathbf{AlCl_3}$

Q4 Hydrazine (N_2H_4) is a chemical used for many applications, including rocket fuel. Two methods used to produce hydrazine are shown below. Which of these hydrazine production methods has the highest atom economy?

1. $NaOCl + 2NH_3 \rightarrow N_2H_4 + NaCl + H_2O$

2. $H_2O_2 + 2NH_3 \rightarrow N_2H_4 + 2H_2O$

Q5 Element X can be used to make copper (Cu) from copper sulfate ($CuSO_4$) in the following reaction:

$$X + CuSO_4 \rightarrow XSO_4 + Cu$$

The reaction has an atom economy of 28.285%. Identify element X.

Formula Practice Sheet
Percentage Yield

The percentage yield is a comparison between the theoretical yield of a reaction and the yield you actually get. You can work it out using this formula:

$$\text{percentage yield} = \frac{\text{mass of product actually made (g)}}{\text{maximum theoretical mass of product (g)}} \times 100$$

The masses shown in this formula are measured in grams, but they can have any units as long as the units are the same.

Q1 Calculate the percentage yield of the following reactions.

a) theoretical mass of product = 10.0 g, mass of product made = 6.0 g
b) mass of product made = 5.46 g, theoretical mass of product = 8.4 g
c) theoretical mass of product = 1.51 kg, mass of product made = 630 g
d) theoretical mass of product = 450 mg, mass of product made = 0.377 g

Q2 Calculate the mass of product actually made, in grams, in the following reactions.

a) percentage yield = 20%, theoretical mass of product = 85 g
b) theoretical mass of product = 1.6 g, percentage yield = 35%
c) percentage yield = 89.4%, theoretical mass of product = 75.3 mg
d) percentage yield = 41.2%, theoretical mass of product = 0.104 kg

Q3 Calculate the theoretical mass of product, in grams, for the following reactions.

a) percentage yield = 20%, mass of product made = 15 g
b) mass of product made = 45 g, percentage yield = 42%
c) mass of product made = 366 mg, percentage yield = 77.1%
d) percentage yield = 68.8%, mass of product made = 0.432 kg

Q4 Calculate the missing variable for the following reactions.

a) theoretical yield = 35 g, actual yield = 24.6 g, percentage yield = ?
b) actual yield = 14 g, percentage yield = 60.4%, theoretical yield = ?
c) theoretical yield = 13.6 g, percentage yield = 91.3%, actual yield = ?
d) theoretical yield = 847 mg, actual yield = 665 mg, percentage yield = ?

Q5 A scientist carried out the following reaction three times, with different masses of reactants.

$Zn + I_2 \rightarrow ZnI_2$

The table on the right shows some of the results.

Complete the table.

Experiment	theoretical ZnI_2 (g)	actual ZnI_2 (g)	yield (%)
1	15.6		76.2
2		18.7	83.5
3	26.2	20.0	

Q6 A student heated some calcium carbonate and produced 9.00 g of calcium oxide in the reaction below. The percentage yield for the reaction was 45.0%.

$$CaCO_3 \rightarrow CaO + CO_2$$

a) Calculate the maximum theoretical yield for the reaction.
b) The student repeated the experiment with the same amount of $CaCO_3$, but was more careful when removing the product from the reaction vessel. This increased the percentage yield to 52.0%. How much CaO did the student produce this time?

Formula Practice Sheet
Effect of Acid Strength on pH

The pH of a solution is a measure of its concentration of H^+ ions. The following formula links the change in concentration of H^+ ions of a solution to its change in pH:

Factor H^+ ion concentration changes by $= 10^{-x}$ $\quad x$ = change in pH

Remember, the more acidic a solution is, the higher the concentration of H^+ ions and the lower the pH.

Q1 Calculate the factor by which the H^+ ion concentration changes for the following reactions.

a) change in pH = 2
b) change in pH = –1
c) change in pH = –7
d) change in pH = 4
e) change in pH = 3
f) change in pH = –3
g) change in pH = 8
h) change in pH = –6

Q2 Calculate the factor by which the H^+ ion concentration changes for the following reactions.

a) initial pH = 2, final pH = 4
b) initial pH = 3, final pH = 2
c) initial pH = 5, final pH = 8
d) final pH = 3, initial pH = 7
e) initial pH = 12, final pH = 7
f) final pH = 1, initial pH = 5
g) final pH = 3, initial pH = 6
h) initial pH = 7, final pH = 11

Q3 Work out the missing pH for the following reactions.

a) initial pH = 3, final pH = ?, factor H^+ ion concentration changes by = 10
b) initial pH = ?, final pH = 7, factor H^+ ion concentration changes by = 1000
c) initial pH = ?, final pH = 2, factor H^+ ion concentration changes by = 0.1
d) initial pH = 9, final pH = ?, factor H^+ ion concentration changes by = 100
e) initial pH = 6, final pH = ?, factor H^+ ion concentration changes by = 0.01

Q4 Find the missing quantity for each of the following reactions.

a) initial pH = 1, final pH = 6, factor H^+ ion concentration changes by = ?
b) initial pH = 7, final pH = ?, factor H^+ ion concentration changes by = 100
c) initial pH = ?, final pH = 2, factor H^+ ion concentration changes by = 10 000
d) initial pH = 10, final pH = 8, factor H^+ ion concentration changes by = ?
e) initial pH = 11, final pH = ?, factor H^+ ion concentration changes by = 0.01

Q5 A student has one acid and one alkali solution. The acid has a pH of 3. If the student adds the alkali to the acid to make a neutral solution, what factor will the H^+ ion concentration change by?

Q6 A chemist has a sample of a strong acid in which the concentration of H^+ ions is 0.020 mol/dm^3. The pH of the solution is 1.70. The chemist adds some alkali to make a new solution with a pH of 2.00.

a) Calculate the factor that the H^+ ion has changed by to two significant figures.
b) Use your answer to part a to calculate the concentration of H^+ ions in the new solution.

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Formula Practice Sheet
Bond Energy Calculations

Every chemical bond has a particular energy associated with it. You can use bond energies to calculate the overall energy change for a chemical reaction using the formula below:

Energy change	=	Energy of bond breaking	–	Energy of bond making

Remember, the overall energy change for a reaction can be positive or negative, but bond energies are always positive.

Q1 Use the bond energies in the table at the bottom of the page to calculate the overall energy changes for the following reactions:

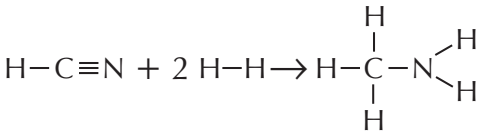
a) $N_2 + O_2 \rightarrow 2NO$
b) $2HBr \rightarrow H_2 + Br_2$
c) $CH_4 + I_2 \rightarrow CH_3I + HI$
d) $2CH_3I + Cl_2 \rightarrow 2CH_3Cl + I_2$
e) $N_2 + 3H_2 \rightarrow 2NH_3$
f) $4NH_3 + 5O_2 \rightarrow 4NO + 6H_2O$

Q2 Use the table at the bottom of the page to calculate the overall energy changes for the following reactions and state whether they are exothermic or endothermic:

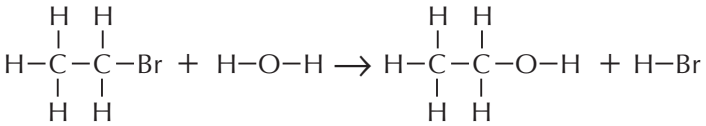
a) $H_2 + F_2 \rightarrow 2HF$
b) $CH_4 + 3Cl_2 \rightarrow CHCl_3 + 3HCl$
c) $CH_4 + 2H_2O \rightarrow CO_2 + 4H_2$
d) $4NH_3 + 3O_2 \rightarrow 2N_2 + 6H_2O$
e) $SO_2 + 3H_2 \rightarrow H_2S + 2H_2O$
f) $2H_2S + 3O_2 \rightarrow 2H_2O + 2SO_2$

Q3 Calculate the specified bond energy in kJ/mol using the table at the bottom of the page and the overall energy change for the reaction:

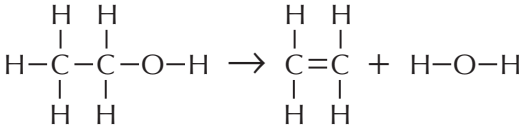
a) C≡N bond
energy change = –148 kJ/mol



b) C–Br bond
energy change = +33 kJ/mol



c) C=C bond
energy change = +43 kJ/mol



Q4 The complete combustion of ethyne (C_2H_2) in oxygen produces carbon dioxide and water. The energy change for the reaction is –2478 kJ/mol. Write a balanced equation for the reaction and use it to calculate the energy of one C≡C bond in kJ/mol. The structure of ethyne is shown on the right: H−C≡C−H

Bond	C–H	C–C	C–N	C–O	C–Cl	C–I	H–H	H–F	H–Cl	H–Br	H–I
Energy (kJ/mol)	413	348	305	358	346	240	436	565	431	363	297

Bond	F–F	Cl–Cl	Br–Br	I–I	O–H	N–H	S–H	C=O	O=O	N=O	S=O	N≡N
Energy (kJ/mol)	156	242	193	150	464	391	349	805	498	631	523	945

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Formula Practice Sheet
Mean Rate of Reaction

The rate of a reaction is how quickly the reactants are changed into products.
You can calculate the mean rate of a reaction using the formula below:

$$\text{Mean rate of reaction} = \frac{\text{Quantity of reactant used or product formed}}{\text{Time}}$$

The units of rate depend on the units of the other two variables — they should be in the form 'units of amount of substance' / 'units of time'.

Q1 Calculate the mean rate of reaction for each quantity and time given below.

a) time = 8 s, mass of reactant used = 3.2 g
b) mass of product = 22.8 g, time = 40 s
c) time = 0.71 s, volume of product = 4.26 cm^3
d) volume of product = 10.89 cm^3, time = 0.33 mins

Q2 Calculate the time taken for the reaction to occur in seconds, given the mass of reactant used and the mean rate of reaction.

a) rate = 0.4 g/s, mass = 1.6 g
b) mass = 6.7 g, rate = 1.0 g/s
c) mass = 22.4 g, rate = 3.2 g/s
d) mass = 0.392 g, rate = 0.70 g/s
e) mass = 0.936 g, rate = 0.180 g/min
f) mass = 8.28 g, rate = 3.60 g/min
g) mass = 3.4 g, rate = 1.2 g/s
h) mass = 4.24 g, rate = 0.90 g/s

Q3 Calculate the volume of product formed in cm^3, for each time and rate given below.

a) time = 50 s, rate = 0.8 cm^3/s
b) rate = 1.8 cm^3/s, time = 3.0 s
c) time = 0.019 s, rate = 1.0 cm^3/s
d) rate = 0.16 cm^3/s, time = 30 s
e) rate = 1.10 cm^3/s, time = 1.30 s
f) time = 0.10 min, rate = 5 cm^3/s
g) time = 44 s, rate = 0.52 cm^3/s
h) time = 5.05 s, rate = 9.15 cm^3/s

Q4 Find the missing variable in each set of variables given below.

a) rate = 0.30 g/s, time = 90 s, mass of product = ?
b) time = 20 s, volume = 4 cm^3, rate = ?
c) rate = 0.4 cm^3/min, time = 90 s, volume = ?
d) rate = 0.52 dm^3/min, volume = 255 cm^3, time = ?

Q5 Some magnesium metal was reacted with hydrochloric acid in a conical flask. The change in mass of the reaction vessel was measured with a mass balance. In the first 15.0 seconds, the mass decreased from 126.35 g to 123.44 g. Calculate the mean rate of reaction.

Q6 A student investigated the following reaction between sodium thiosulfate and hydrochloric acid:

$$Na_2S_2O_{3(aq)} + 2HCl_{(aq)} \rightarrow 2NaCl_{(aq)} + S_{(s)} + SO_{2(g)} + H_2O_{(l)}$$

The student measured the amount of sulfur dioxide gas produced.
The mean rate of reaction over 63 seconds was 0.095 cm^3/s.
Calculate the volume of gas that was produced during this time.

Formula Practice Sheet
Calculating R_f Values

In chromatography, the R_f value of a substance is the ratio between the distance travelled by the dissolved substance and the distance travelled by the solvent. R_f values can be calculated using the formula:

$$R_f \text{ value} = \frac{\text{distance travelled by substance}}{\text{distance travelled by solvent}}$$

R_f values are always between 0 and 1. They don't have units.

Q1 Calculate the R_f values for each of the substances below.

a) distance travelled by substance = 1.2 cm, distance travelled by solvent = 6.0 cm
b) distance travelled by substance = 3.7 cm, distance travelled by solvent = 5.0 cm
c) distance travelled by substance = 6.58 cm, distance travelled by solvent = 7.0 cm
d) distance travelled by substance = 58.2 mm, distance travelled by solvent = 9.7 cm
e) distance travelled by substance = 5.5 cm, distance travelled by solvent = 0.11 m

Q2 Calculate the distance travelled by the substance, in cm, for each set of values below.

a) distance travelled by solvent = 5.0 cm, R_f value = 0.50
b) distance travelled by solvent = 7.0 cm, R_f value = 0.20
c) distance travelled by solvent = 9.0 cm, R_f value = 0.51
d) distance travelled by solvent = 60 mm, R_f value = 0.40
e) distance travelled by solvent = 0.13 m, R_f value = 0.60

Q3 Calculate the distance travelled by the solvent, in cm, for each set of values below.

a) distance travelled by substance = 3.0 cm, R_f value = 0.40
b) distance travelled by substance = 1.8 cm, R_f value = 0.30
c) distance travelled by substance = 2.96 cm, R_f value = 0.74
d) distance travelled by substance = 32.4 mm, R_f value = 0.40
e) distance travelled by substance = 0.15 m, R_f value = 0.75

Q4 The component dyes in a sample of ink are separated by paper chromatography.

a) A dye with an R_f value of 0.20 travelled 17 mm up the chromatogram. Calculate how far the solvent travelled up the chromatogram in cm.
b) Another dye travelled 51 mm up the same chromatogram. Use your answer from part a) to calculate the R_f value of this dye.
c) A third dye has an R_f value of 0.48. Using your answer from part a), calculate how far the dye travelled up the chromatogram in cm.

Q5 A finished chromatogram is shown on the right.

a) Which substance has a higher R_f value — substance A or substance B? Explain how you know.
b) Substance A travelled 8.1 cm from the baseline. Calculate the R_f value of substance A.