Stoichiometry Practice

Limiting and excess reagents | Gas volume | Percentage yield | Titration | Water of crystallisation | Atom economy

Contents	4 sets x 5 questions (20 questions) with full worked answers
Level	Closely matched to the methods and numerical level in the supplied examples
Suggested use	Complete Sets A-D in order, then check the worked answers at the back

Reference data

$R = 8.314\ J\ mol^{-1}\ K^{-1}$; $1\ m^3 = 10^6\ cm^3$
Relative atomic masses: H 1.01, C 12.01, O 16.00, Na 22.99, Mg 24.31, Al 26.98, Cl 35.45, K 39.10, Ca 40.08, Fe 55.85, Zn 65.38
Use $PV = nRT$ where required. Give answers to 3 significant figures unless stated otherwise.

Name: _______________________________ Date: ____________________

Practice Set A

Core practice

1. Limiting reagent, gas volume and yield

$Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$
0.623 g of magnesium is reacted with 27.3 cm^3 of 1.25 mol dm^{-3} hydrochloric acid. (a) Identify the limiting reagent. (b) Calculate the maximum volume of hydrogen at 273 K and 1.00×10^5 Pa, in cm^3. (c) The actual volume collected is 342 cm^3. Calculate the percentage yield.

2. Acid-base titration

25.00 cm^3 of sodium hydroxide solution requires 23.65 cm^3 of 0.100 mol dm^{-3} hydrochloric acid for complete neutralisation. Calculate the concentration of the sodium hydroxide solution.
$NaOH + HCl \rightarrow NaCl + H_2O$

3. Back titration and percentage by mass

A 2.016 g eggshell sample is treated with 50.0 cm^3 of 1.00 mol dm^{-3} HCl. After reaction, the mixture is made up to 100 cm^3. A 10.0 cm^3 portion requires 11.40 cm^3 of 0.100 mol dm^{-3} NaOH for neutralisation. Calculate the percentage by mass of $CaCO_3$ in the eggshell.
$CaCO_3 + 2HCl \rightarrow CaCl_2 + CO_2 + H_2O$

4. Water of crystallisation

12.402 g of $(COOH)_2.xH_2O$ crystals is dissolved and made up to 200 cm^3. A 20.0 cm^3 portion requires 19.68 cm^3 of 0.100 mol dm^{-3} NaOH for neutralisation. Oxalic acid is dibasic. Determine x.

5. Atom economy

For $2Al + Fe_2O_3 \rightarrow 2Fe + Al_2O_3$, calculate the atom economy when iron is the desired product.

Checklist

Did you use the balanced equation? Did you convert cm3 to dm3? In back titration, did you scale the excess acid to the full solution volume?

Practice Set B

Core variation

1. Limiting reagent, gas volume and yield

$Zn(s) + 2HCl(aq) \rightarrow ZnCl_2(aq) + H_2(g)$
1.31 g of zinc is reacted with 45.0 cm^3 of 0.800 mol dm^{-3} HCl. (a) Identify the limiting reagent. (b) Calculate the maximum volume of hydrogen at 298 K and 1.00×10^5 Pa. (c) The actual volume is 410 cm^3. Calculate the percentage yield.

2. Acid-base titration

20.00 cm^3 of sulfuric acid requires 18.40 cm^3 of 0.150 mol dm^{-3} NaOH for complete neutralisation. Calculate the concentration of H_2SO_4.
$H_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2H_2O$

3. Back titration and percentage by mass

A 0.650 g chalk sample is treated with 25.0 cm^3 of 1.00 mol dm^{-3} HCl. The mixture is made up to 250 cm^3. A 25.0 cm^3 portion requires 12.60 cm^3 of 0.100 mol dm^{-3} NaOH. Calculate the percentage by mass of $CaCO_3$ in the chalk.

4. Water of crystallisation

9.453 g of $(COOH)_2.xH_2O$ is dissolved and made up to 150 cm^3. A 25.0 cm^3 portion requires 25.00 cm^3 of 0.100 mol dm^{-3} NaOH. Determine x.

5. Atom economy

For $CaCO_3 \rightarrow CaO + CO_2$, calculate the atom economy when CaO is the desired product.

Checklist

Did you use the balanced equation? Did you convert cm3 to dm3? In back titration, did you scale the excess acid to the full solution volume?

Practice Set C

Intermediate

1. Limiting reagent, gas volume and yield

$2Al(s) + 6HCl(aq) \rightarrow 2AlCl_3(aq) + 3H_2(g)$
0.540 g of aluminium is reacted with 40.0 cm^3 of 1.20 mol dm^{-3} HCl. (a) Identify the limiting reagent. (b) Calculate the maximum hydrogen volume at 293 K and 1.05×10^5 Pa. (c) The actual volume is 525 cm^3. Calculate the percentage yield.

2. Acid-base titration

25.00 cm^3 of sulfuric acid requires 24.80 cm^3 of 0.200 mol dm^{-3} NaOH. Calculate the concentration of H_2SO_4.

3. Back titration and percentage by mass

A 1.20 g impure $MgCO_3$ sample is treated with 40.0 cm^3 of 0.800 mol dm^{-3} HCl. The mixture is made up to 200 cm^3. A 20.0 cm^3 portion requires 14.20 cm^3 of 0.100 mol dm^{-3} NaOH. Calculate the percentage by mass of $MgCO_3$.

4. Water of crystallisation

15.755 g of $(COOH)_2 \cdot xH_2O$ is dissolved and made up to 250 cm^3. A 25.0 cm^3 portion requires 25.00 cm^3 of 0.100 mol dm^{-3} NaOH. Determine x.

5. Atom economy

For $2KClO_3 \rightarrow 2KCl + 3O_2$, calculate the atom economy when oxygen is the desired product.

Checklist

Did you use the balanced equation? Did you convert cm3 to dm3? In back titration, did you scale the excess acid to the full solution volume?

Practice Set D

Mixed review

1. Limiting reagent, gas volume and yield

$Fe(s) + 2HCl(aq) \rightarrow FeCl_2(aq) + H_2(g)$
1.12 g of iron is reacted with 30.0 cm^3 of 1.50 mol dm^{-3} HCl. (a) Identify the limiting reagent. (b) Calculate the maximum hydrogen volume at 298 K and 9.80×10^4 Pa. (c) The actual volume is 465 cm^3. Calculate the percentage yield.

2. Acid-base titration

20.00 cm^3 of HCl requires 16.80 cm^3 of 0.100 mol dm^{-3} Na_2CO_3 for complete neutralisation. Calculate the concentration of HCl.
$Na_2CO_3 + 2HCl \rightarrow 2NaCl + CO_2 + H_2O$

3. Back titration and percentage by mass

A 1.50 g antacid sample is treated with 60.0 cm^3 of 0.500 mol dm^{-3} HCl. The mixture is made up to 250 cm^3. A 25.0 cm^3 portion requires 8.00 cm^3 of 0.100 mol dm^{-3} NaOH. Assuming $CaCO_3$ is the active ingredient, calculate its percentage by mass.

4. Water of crystallisation

10.802 g of $(COOH)_2.xH_2O$ is dissolved and made up to 200 cm^3. A 20.0 cm^3 portion requires 20.00 cm^3 of 0.100 mol dm^{-3} NaOH. Determine x.

5. Atom economy

For $2NaHCO_3 \rightarrow Na_2CO_3 + CO_2 + H_2O$, calculate the atom economy when Na_2CO_3 is the desired product.

Checklist

Did you use the balanced equation? Did you convert cm3 to dm3? In back titration, did you scale the excess acid to the full solution volume?