**Write your name, centre number and candidate number in the boxes below.**

| Surname | Other names |
|---|---|
| | |

Centre number | | | | | |

Candidate number | | | | |

**STEM** | Exam Builder

# Chemical calculations

Time allowed: 1 hour 25 minutes

**Subject code** **0620**

# Chemistry

## Questions from Paper 4 and Paper 6

**You must have:** a ruler marked in centimetres and millimetres, a protractor, compasses, a pen, an HB pencil and an eraser.

Total marks

**/ 82**

### Instructions

- Answer every question in the space provided on this paper.
- Write in black or dark blue ink. Pencil may be used for diagrams and graphs.
- Fill in your name, centre number and candidate number above.
- Show your working: a correct method can earn marks even if the answer is wrong.

### Information

- This paper has 10 questions worth 82 marks in total.
- The marks for each question or part are shown in brackets, for example [3].

### Advice

- Read every question through once before you write anything.
- Use the marks in brackets to judge how long to spend on each part.
- If you finish early, go back and check your working.

STEM | Exam Builder



Print at 100% (Actual size) so diagrams keep their real measurements.

**1** Nitrates such as ammonium nitrate are used as fertilisers.

The final stage in the production of ammonium nitrate is shown in the equation.

$$Ca(NO_3)_2 + 2NH_3 + CO_2 + H_2O \rightarrow 2NH_4NO_3 + CaCO_3$$

Calculate the maximum mass of ammonium nitrate that can be produced from 820 g of calcium nitrate, $Ca(NO_3)_2$, using the following steps.

The relative formula mass, $M_r$, of calcium nitrate, $Ca(NO_3)_2$, = 164.

- Calculate the number of moles of $Ca(NO_3)_2$ in 820 g.

..... mol

- Deduce the number of moles of $NH_4NO_3$ produced.

..... mol

- Calculate the $M_r$ of $NH_4NO_3$.

$M_r$ of $NH_4NO_3$ = .....

- Calculate the maximum mass of ammonium nitrate produced.

STEM | Exam Builder

..... g
[4]

Moles and chemical calculations Click for more variations

**2** Calcium chloride can be made by reacting calcium carbonate with hydrochloric acid.

$$CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + H_2O(l) + CO_2(g)$$

An excess of calcium carbonate was added to 50.0 $cm^3$ of 0.500 $mol/dm^3$ hydrochloric acid. The solution was filtered to remove the excess calcium carbonate.

**(a)** How many moles of $HCl$ were used in this reaction?

..... mol [2]

**(b)** Deduce the number of moles of carbon dioxide gas made in this reaction.

..... mol [1]

**(c)** Calculate the mass of carbon dioxide made in this reaction.

..... g [2]

**(d)** Calculate the volume, in $dm^3$, of carbon dioxide made in this reaction at room temperature and pressure (r.t.p.).

..... $dm^3$ [1]

[Total: 6]

Moles and chemical calculations Click for more variations

STEM | Exam Builder

**3** Sodium hydrogencarbonate is found in baking powder.

When sodium hydrogencarbonate is heated it forms three products.

$$2NaHCO_3 \rightarrow Na_2CO_3 + H_2O + CO_2$$

**(a)** Name the type of reaction that takes place when sodium hydrogencarbonate reacts in this way.

..... [1]

**(b)** Calculate the volume of carbon dioxide formed at room temperature and pressure when 12.6 g of $NaHCO_3$ is heated using the following steps:

- determine the mass of one mole of $NaHCO_3$

..... g

- calculate the number of moles of $NaHCO_3$ used

..... moles

- determine the number of moles of carbon dioxide formed

..... moles

- calculate the volume of carbon dioxide formed at room temperature and pressure.

..... $dm^3$
[4]

**(c)** Limewater is aqueous calcium hydroxide. Carbon dioxide turns limewater milky because a white precipitate forms.

Write the formula of:

- calcium hydroxide .....
- the white precipitate that forms when limewater turns milky. .....
[2]

[Total: 7]

Moles and chemical calculations Click for more variations

STEM | Exam Builder

**4** **(a)** Define the following

**(i)** the mole

.....

..... [1]

**(ii)** the Avogadro constant

.....

..... [1]

**(b)** Which **two** of the following contain the same number of molecules?
Show how you arrived at your answer.

2.0 g of methane, $CH_4$

8.0 g of oxygen, $O_2$

2.0 g of ozone, $O_3$

8.0 g of sulfur dioxide, $SO_2$

.....

.....

..... [2]

STEM | Exam Builder

**(c)** 4.8 g of calcium is added to 3.6 g of water. The following reaction occurs.

$$Ca + 2H_2O \rightarrow Ca(OH)_2 + H_2$$

**(i)** the number of moles of Ca = .....

the number of moles of $H_2O$ = ..... [1]

**(ii)** Which reagent is in excess? Explain your choice.

.....

..... [2]

**(iii)** Calculate the mass of the reagent named in **(ii)** which remained at the end of the experiment.

.....

..... [1]

[Total: 8]

STEM | Exam Builder

Moles and chemical calculations Click for more variations

**5** Dilute hydrochloric acid reacts with sodium carbonate solution.

$$2HCl(aq) + Na_2CO_3(aq) \rightarrow 2NaCl(aq) + H_2O(l) + CO_2(g)$$

**(a)** Explain why effervescence is seen during the reaction.

.....

..... [1]

**(b)** Dilute hydrochloric acid was titrated with sodium carbonate solution.

- 10.0 $cm^3$ of 0.100 mol / $dm^3$ hydrochloric acid were placed in a conical flask.
- A few drops of methyl orange indicator were added to the dilute hydrochloric acid.
- The mixture was titrated with sodium carbonate solution.
- 16.2 $cm^3$ of sodium carbonate solution were required to react completely with the acid.

**(i)** What colour would the methyl orange indicator be in the hydrochloric acid?

..... [1]

**(ii)** Calculate how many moles of hydrochloric acid were used.

..... mol [1]

**(iii)** Use your answer to **(b)(ii)** and the equation for the reaction to calculate the number of moles of sodium carbonate that reacted.

..... mol [1]

**(iv)** Use your answer to **(b)(iii)** to calculate the concentration of the sodium carbonate solution in mol / $dm^3$.

..... mol / $dm^3$ [2]

**(c)** In another experiment, 0.020 mol of sodium carbonate were reacted with excess hydrochloric acid.

Calculate the maximum volume (at r.t.p.) of carbon dioxide gas that could be made in this reaction.

STEM | Exam Builder

..... $dm^3$ [3]

[Total: 9]

Moles and chemical calculations Click for more variations

**6** Copper(II) oxide reacts with dilute hydrochloric acid.

$$CuO(s) + 2HCl(aq) \rightarrow CuCl_2(aq) + H_2O(l)$$

6.00 g of copper(II) oxide were added to 50.0 $cm^3$ of 1.00 mol / $dm^3$ hydrochloric acid. This was an excess of copper(II) oxide.

**(a)** The rate of the reaction can be increased by increasing the concentration of the hydrochloric acid or by heating it.

**(i)** In terms of collisions, explain why increasing the concentration of the hydrochloric acid increases the rate of the reaction.

.....

.....

.....

..... [2]

**(ii)** In terms of collisions, explain why heating the hydrochloric acid increases the rate of the reaction.

.....

.....

.....

..... [2]

STEM | Exam Builder

**(b) (i)** Calculate the number of moles of copper(II) oxide added to the hydrochloric acid.

moles of copper(II) oxide = ..... mol [2]

**(ii)** Calculate the number of moles of hydrochloric acid used.

moles of hydrochloric acid = ..... mol [1]

**(iii)** Calculate the mass of copper(II) oxide that did **not** react.

mass of copper(II) oxide that did **not** react = ..... g [2]

**(c)** Crystals of hydrated copper(II) chloride were obtained from the solution at the end of the reaction.

The crystals had the following composition by mass: C*l*, 41.52%; Cu, 37.43%; H, 2.34%; O, 18.71%.

Calculate the empirical formula of the crystals.

empirical formula = ..... [2]

[Total: 11]

Rates of reaction Click for more variations

STEM | Exam Builder

**7** A sample of muddy river water contains water, dissolved solids and insoluble solid mud.

Plan an investigation to find the concentration of dissolved solids, in g / $dm^3$, in the river water.

In your answer state how you will work out the concentration of the dissolved solids in g / $dm^3$.

You are provided with a small sample (less than 1 $dm^3$) of muddy river water and common laboratory apparatus.
(1 $dm^3$ = 1000 $cm^3$)

..........................................................................................................................................

..........................................................................................................................................

..........................................................................................................................................

..........................................................................................................................................

..........................................................................................................................................

..........................................................................................................................................

..........................................................................................................................................

..........................................................................................................................................

..........................................................................................................................................

..........................................................................................................................................

..........................................................................................................................................

..........................................................................................................................................

..........................................................................................................................................

..........................................................................................................................................

..........................................................................................................................................

..........................................................................................................................................

..........................................................................................................................................

..........................................................................................................................................

..........................................................................................................................................

..........................................................................................................................................

..........................................................................................................................................

.................................................................................................................................... [6]

Practical skills: planning, apparatus, measuring and results Click for more variations

STEM | Exam Builder

**8** A mixture contains three solid compounds:

- aluminium oxide
- calcium carbonate
- calcium chloride.

Table 4.1 gives some information about the three compounds in the mixture.

**Table 4.1**

| name of compound | solubility in water | effect of adding aqueous sodium hydroxide |
|---|---|---|
| aluminium oxide | insoluble | reacts to form a soluble compound |
| calcium carbonate | insoluble | no effect |
| calcium chloride | soluble | reacts to form an insoluble compound |

Plan an experiment to find the percentage by mass of calcium carbonate in the mixture. Your plan must include how you will calculate the percentage by mass of calcium carbonate in the mixture.

You are provided with a sample of the mixture, distilled water, aqueous sodium hydroxide and common laboratory apparatus.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

..... [6]

Practical skills: planning, apparatus, measuring and results Click for more variations

STEM Exam Builder

**9** This question is about masses, volumes and moles.

**(a)** Which term is defined by the following statement?

*The average mass of naturally occurring atoms of an element on a scale where the $^{12}C$ atom has a mass of exactly 12 units.*

..... [1]

**(b)** Butane, $C_4H_{10}$, has a relative **molecular** mass of 58.
Potassium fluoride, KF, has a relative **formula** mass of 58.

Explain why the term relative molecular mass can be used for butane but **cannot** be used for potassium fluoride.

.....

..... [2]

**(c)** A 0.095 g sample of gaseous element **Y** occupies 60.0 $cm^3$ at room temperature and pressure.

- Determine the number of moles of element **Y** in 60.0 $cm^3$.

moles of element **Y** = ..... mol

- Calculate the relative molecular mass of element **Y** and hence suggest the identity of element **Y**.

relative molecular mass = .....

identity of element **Y** = .....
[3]

STEM | Exam Builder

**(d)** A 1.68 g sample of phosphorus was burned and formed 3.87 g of an oxide of phosphorus.

Calculate the empirical formula of this oxide of phosphorus.

empirical formula = ..... [4]

**(e)** Another oxide of phosphorus has the empirical formula $P_2O_3$.
One molecule of this oxide of phosphorus contains four atoms of phosphorus.

Calculate the mass of **one** mole of this oxide of phosphorus.

mass = ..... g [2]

[Total: 12]

Moles and chemical calculations Click for more variations

STEM | Exam Builder

**10** Calcium chlorate(V), $Ca(ClO_3)_2$, is made by reacting calcium hydroxide with chlorine gas.

$$6Ca(OH)_2 + 6Cl_2 \rightarrow Ca(ClO_3)_2 + 5CaCl_2 + 6H_2O$$

**(a)** 8.88 g of calcium hydroxide and 7200 $cm^3$ of chlorine gas are mixed together.

**(i)** How many moles is 8.88 g of calcium hydroxide?

..... mol [2]

**(ii)** How many moles of chlorine gas is 7200 $cm^3$?

..... mol [1]

**(iii)** What is the maximum **number of moles** of calcium chlorate(V) that can be made from 8.88 g of calcium hydroxide and 7200 $cm^3$ of chlorine gas?

..... mol [1]

**(iv)** What is the maximum **mass** of calcium chlorate(V) that can be made from 8.88 g of calcium hydroxide and 7200 $cm^3$ of chlorine gas?

..... g [2]

The experiment is repeated using different amounts of calcium hydroxide and chlorine gas. The maximum mass of calcium chlorate(V) that can be made in the experiment is 4.84 g.

**(v)** The actual mass of calcium chlorate(V) made in the experiment is 3.63 g.

Calculate the percentage yield.

percentage yield = ..... % [1]

**(b)** Calcium chlorate(V) undergoes thermal decomposition.

The only products are calcium chloride and a colourless gas.

**(i)** What must be done to calcium chlorate(V) to make it thermally decompose?

..... [1]

**(ii)** Write a chemical equation for the thermal decomposition of calcium chlorate(V).

..... [2]

STEM | Exam Builder

**(c)** Chloric(V) acid, $HClO_3$, is a strong acid. It can be made from calcium chlorate(V).

**(i)** What colour is methyl orange indicator in chloric(V) acid?

..... [1]

**(ii)** Define the term *acid* in terms of proton transfer.

..... [1]

**(iii)** Complete the chemical equation to show $HClO_3$ behaving as an acid in water.

$$HClO_3 + H_2O \rightarrow \text{.....} + \text{.....}$$

[1]

[Total: 13]

STEM | Exam Builder

STEM | Exam Builder