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

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

Centre number | | | | | |

Candidate number | | | | |

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# Mole calculations

Time allowed: 45 minutes

**Subject code** **0620**

# Chemistry

## Paper 4 (Extended)

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

Total marks

**/ 46**

### 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 6 questions worth 46 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.

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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.

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..... g
[4]

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**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]

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**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]

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**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]

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**(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]

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**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.

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

[Total: 9]

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**6** 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]

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**(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]

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