A Guide to Quantitative Aspects of Chemical Change

Teaching Approach

In this topic it is possible for weaker learners to get lost along the way when doing calculations based on equations. It is therefore imperative that you formulate a systematic method for answering problems of this nature. The worked examples clearly show how to do this. Learners are often unwilling to deal with problems of this calibre and therefore fail to commit to a systematic method when not being supervised. But it is in their best interests to do so, and this should be encouraged by the educator wherever possible.

One other way to use this series could be to get learners to complete the questions and activities as homework or else group work. In this way there is a structure which could help to motivate them into attempting questions in this topic.
Video Summaries

Some videos have a ‘PAUSE’ moment, at which point the teacher or learner can choose to pause the video and try to answer the question posed or calculate the answer to the problem under discussion. Once the video starts again, the answer to the question or the right answer to the calculation is given.

Mindset suggests a number of ways to use the video lessons. These include:

- Watch or show a lesson as an introduction to a lesson
- Watch or show a lesson after a lesson, as a summary or as a way of adding in some interesting real-life applications or practical aspects
- Design a worksheet or set of questions about one video lesson. Then ask learners to watch a video related to the lesson and to complete the worksheet or questions, either in groups or individually
- Worksheets and questions based on video lessons can be used as short assessments or exercises
- Ask learners to watch a particular video lesson for homework (in the school library or on the website, depending on how the material is available) as preparation for the next day’s lesson; if desired, learners can be given specific questions to answer in preparation for the next day’s lesson

1. Mole Revision

   This lesson revises the mole concept and the use of the equation: \( n = \frac{m}{M} \).

2. Moles and Gases

   This lesson shows the use of the equation \( n = \frac{m}{M} \) in order to do mole calculations involving gases.

3. Moles and Solutions

   This lesson shows the use of equation \( n = \frac{m}{M} \) in order to do mole calculations involving solutions.

4. Moles: Chemical Reactions

   This lesson shows the use of the mole ratio in balanced chemical equations to calculate an unknown quantity, such as mass or volume, of one of the substances in the equation.

5. Applying Mole Relationships

   This lesson is an application lesson of the previous lesson in which the material learnt is taken into the laboratory and demonstrated practically.

6. Titrations

   This lesson looks at the use of mole ratios in the context of titrations. A titration is demonstrated as well as the calculations involved.
7. Limiting Reagents
   This lesson uses mole ratios and balanced equations to determine which reactant is the limiting reagent and which reactant is the substance in excess in a balanced equation.

8. Explosions and Airbags
   This lesson uses mole ratios and balanced equations and looks at an application of these:
   - In explosives
   - In a car’s engine
   - In airbags

9. Percentage Composition and the Empirical Formula
   Lesson 9 discusses how to calculate percentage purity of substances by using the empirical formula.
<table>
<thead>
<tr>
<th>Resource Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Mole Revision</td>
</tr>
<tr>
<td><a href="http://www.slideshare.net/robertgist/mole-calculations-aeg3">http://www.slideshare.net/robertgist/mole-calculations-aeg3</a></td>
</tr>
<tr>
<td>2. Moles and Gases</td>
</tr>
<tr>
<td><a href="http://www.docbrown.info/page04/4_73calcs09mvg.htm">http://www.docbrown.info/page04/4_73calcs09mvg.htm</a></td>
</tr>
<tr>
<td><a href="http://www.bbc.co.uk/bitesize/higher/chemistry/calculations_1/mole/revision/4/">http://www.bbc.co.uk/bitesize/higher/chemistry/calculations_1/mole/revision/4/</a></td>
</tr>
<tr>
<td>3. Moles and Solutions</td>
</tr>
<tr>
<td><a href="http://www.youtube.com/watch?v=w1a5BNlTXOA">http://www.youtube.com/watch?v=w1a5BNlTXOA</a></td>
</tr>
<tr>
<td>4. Moles: Chemical Reactions</td>
</tr>
<tr>
<td><a href="http://www.youtube.com/watch?v=p_vh_uiZ2QI">http://www.youtube.com/watch?v=p_vh_uiZ2QI</a></td>
</tr>
<tr>
<td>5. Applying Mole Relationships</td>
</tr>
<tr>
<td>Application of previous lesson, so no additional material to list.</td>
</tr>
<tr>
<td>6. Titrations</td>
</tr>
<tr>
<td><a href="http://www.youtube.com/watch?v=q8jdCWC10vQ">http://www.youtube.com/watch?v=q8jdCWC10vQ</a></td>
</tr>
<tr>
<td><a href="http://www.bbc.co.uk/schools/gcsebitesize/science/triple_ocr_gateway/how_much/titrations/revision/1/">http://www.bbc.co.uk/schools/gcsebitesize/science/triple_ocr_gateway/how_much/titrations/revision/1/</a></td>
</tr>
<tr>
<td>7. Limiting Reagents</td>
</tr>
<tr>
<td><a href="http://www.youtube.com/watch?v=4OeKFsVRmfQ">http://www.youtube.com/watch?v=4OeKFsVRmfQ</a></td>
</tr>
<tr>
<td><a href="http://www.youtube.com/watch?v=qLUJdF_18LA">http://www.youtube.com/watch?v=qLUJdF_18LA</a></td>
</tr>
<tr>
<td>--------------------------</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>
Task

Question 1
How many moles are there in 65 g of NaOH?

Question 2
Calculate the volume that 8 g of oxygen gas occupies at standard temperature and pressure.

Question 3
What is the mass of 56 dm$^3$ of nitrogen gas at standard temperature and pressure?

Question 4
45 g of NaOH is dissolved in water and made up to a volume of 250 cm$^3$. Calculate the concentration of the solution.

Question 5
What mass of HCl would have to be placed in a beaker and made up to a volume of 375 cm$^3$ if the concentration is to be 0,2 mol.dm$^{-3}$?

Question 6
If 10 g of sodium hydroxide is reacted with hydrochloric acid, calculate the mass of sodium chloride formed.
NaOH(s) + HCl(aq) → NaCl(aq) + H$_2$O(l)

Question 7
Calculate the volume of oxygen obtained when 29,4 g of potassium chlorate is heated.
KClO$_3$(s) → KCl(s) + O$_2$(g)

Question 8
Calculate the volume of sulfur dioxide required to produce 85 dm$^3$ of sulfur trioxide.
SO$_2$(g) + O$_2$(g) → SO$_3$(g)

Question 9
Calculate the mass of oxygen required to react completely with 2 g of magnesium.
Mg(s) + O$_2$(g) → MgO(s)

Question 10
What is the volume of hydrogen gas released when 7 g of zinc reacts with hydrochloric acid?
Zn(s) + HCl(aq) → ZnCl$_2$(aq) + H$_2$(g)

Question 11
What mass of sulfur would have to be burnt in order to produce 2,24 x 10$^3$ dm$^3$ of sulfur dioxide?
S(s) + O$_2$(g) → SO$_2$(g)
**Question 12**
What volume of hydrogen chloride gas is formed when 170 dm$^3$ of hydrogen combines with chlorine?

\[ \text{H}_2(\text{g}) + \text{Cl}_2(\text{g}) \rightarrow \text{HCl}(\text{g}) \]

**Question 13**
36 cm$^3$ of nitric acid of concentration 0,2 mol.dm$^{-3}$ is to be neutralised by potassium hydroxide. What mass of potassium hydroxide is needed to neutralise the sample of nitric acid?

\[ \text{HNO}_3(\text{aq}) + \text{KOH}(\text{aq}) \rightarrow \text{KNO}_3(\text{aq}) + \text{H}_2\text{O}(\text{l}) \]

**Question 14**
60 cm$^3$ of sodium carbonate solution with a concentration of 0,15 mol.dm$^{-3}$ is reacted with excess calcium chloride solution. A white precipitate, calcium carbonate is produced. Calculate the mass of the precipitate formed.

\[ \text{Na}_2\text{CO}_3(\text{aq}) + \text{CaCl}_2(\text{aq}) \rightarrow \text{NaCl}(\text{aq}) + \text{CaCO}_3(\text{s}) \]

**Question 15**
40 cm$^3$ of sulfuric acid with a concentration of 0,4 mol.dm$^{-3}$ is neutralised with a sodium hydroxide solution of concentration 0,25 mol.dm$^{-3}$. What volume of sodium hydroxide solution was used in the neutralisation reaction?

\[ \text{H}_2\text{SO}_4(\text{aq}) + \text{NaOH}(\text{aq}) \rightarrow \text{Na}_2\text{SO}_4(\text{aq}) + \text{H}_2\text{O}(\text{l}) \]

**Question 16**
16.1 Calculate which of the two substances is in excess, if 52 g of Zn and 50 g of HCl are reacted together.

\[ \text{Zn}(\text{s}) + \text{HCl}(\text{aq}) \rightarrow \text{ZnCl}_2(\text{aq}) + \text{H}_2(\text{g}) \]

16.2 What mass of this substance is in excess?

**Question 17**
16.3 Calculate which of the two substances is in excess, if 20 g of NO and 15 g of O$_2$ are reacted together.

\[ \text{NO}(\text{g}) + \text{O}_2(\text{g}) \rightarrow \text{NO}_2(\text{g}) \]

16.4 What mass of this substance is in excess?

**Question 18**
18.1 Calculate which of the two substances is in excess, if 20 g of NH$_3$ and 40 g of O$_2$ are reacted together.

\[ \text{NH}_3(\text{g}) + \text{O}_2(\text{g}) \rightarrow \text{HNO}_3(\text{g}) + \text{H}_2\text{O}(\text{g}) \]

18.2 What mass of this substance is in excess?

**Question 19**
12,5 kg of ammonium nitrate is packaged and made into a bomb. What is the total volume of gas at STP released when the bomb detonates?

\[ 2\text{NH}_4\text{NO}_3(\text{s}) \rightarrow 2\text{N}_2(\text{g}) + 4\text{H}_2\text{O}(\text{g}) + \text{O}_2(\text{g}) \]
**Question 20**

Each stroke of a car’s piston introduces 7 g of petrol into the piston shaft. The petrol combusts and produces carbon dioxide and water vapour. Calculate the volume of gases at STP produced in each piston per stroke of the engine.

\[2C_8H_{18} + 25 O_2 \rightarrow 16CO_2(g) + 18H_2O(g)\]

petrol

**Question 21**

The volume of an aeroplane’s emergency escape chute is 1680 dm³ when inflated. Calculate the mass of sodium azide that would have to be packed into the chute so that it can inflate in an emergency.

\[2NaN_3(s) \rightarrow 2Na(s) + 3N_2(g)\]

**Question 22**

Calculate the empirical formula of each of the compounds which have the following percentage compositions:

- 22.1 31.8% K, 29% Cl, 39.2% O
- 22.2 30.4% N, 69.6% O
- 22.3 53% Al, 47% O
- 22.4 43.4% Na, 11.3% C, 45.3% O

**Question 23**

4 g of an impure sample of NaOH is reacted with sulfuric acid. 5 g of Na₂SO₄ is produced. Calculate the percentage purity of the sample of NaOH.

\[2NaOH(aq) + H_2SO_4(aq) \rightarrow Na_2SO_4(aq) + H_2O(l)\]
Task Answers

Question 1

\[ n = \frac{m}{M} \]
\[ = \frac{65}{40.01} \]
\[ = 1.62 \text{ mol} \]

Question 2

Oxygen gas = \( \text{O}_2 \)
\[ n = \frac{m}{M} \]
\[ = \frac{8}{32} \]
\[ = 0.25 \text{ mol} \]
\[ V = n \times V_o \]
\[ = 0.25 \times 22.4 \]
\[ = 5.6 \text{ dm}^3 \]

Question 3

Nitrogen gas = \( \text{N}_2 \)
\[ n = \frac{V}{V_o} \]
\[ = \frac{56}{22.4} \]
\[ = 2.5 \text{ mol} \]
\[ m = n \times M \]
\[ = 2.5 \times 28 \]
\[ = 70 \text{ g} \]
Question 4

\[ n = \frac{m}{M} = \frac{45}{40.01} = 1.125 \text{ mol} \]

\[ c = \frac{n}{V} = \frac{1.125}{0.25} = 4.5 \text{ mol.dm}^{-3} \]

Question 5

\[ n = cV = 0.2 \times 0.375 = 0.075 \text{ mol} \]

\[ m = nM = 0.075 \times 36.46 = 2.73 \text{ g} \]

Question 6

\[ m = 10 \text{ g} \]

<table>
<thead>
<tr>
<th>Balanced equation</th>
<th>NaOH</th>
<th>+ HCl</th>
<th>→ NaCl</th>
<th>+ H₂O</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mole ratio</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>
| Calculations      | \[ n = \frac{m}{M} = \frac{10}{40.01} = 0.25 \text{ mol} \]

\[ m = n \times M = 0.25 \times 58.45 = 14.61 \text{ g} \]

Question 7

\[ m = 29.4 \text{ g} \]

<table>
<thead>
<tr>
<th>Balanced equation</th>
<th>2KClO₃</th>
<th>→ 2KCl</th>
<th>+ 3O₂</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mole ratio</td>
<td>2</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

\[ V = ? \]
### Question 8

<table>
<thead>
<tr>
<th>Balanced equation</th>
<th>2SO₂</th>
<th>+</th>
<th>O₂</th>
<th>→</th>
<th>2SO₃</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mole ratio</td>
<td>2</td>
<td>1</td>
<td></td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>Calculations</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>n = \frac{m}{M}</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>= \frac{29.4}{122.55}</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>= 0.24 mol</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\[ V = n \times V_o \]

\[ = 0.24 \times 22.4 \]

\[ = 8.06 \text{ dm}^3 \]

### Question 9

<table>
<thead>
<tr>
<th>Balanced equation</th>
<th>2Mg</th>
<th>+</th>
<th>O₂</th>
<th>→</th>
<th>2MgO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mole ratio</td>
<td>2</td>
<td>1</td>
<td></td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>Calculations</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>n = \frac{m}{M}</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>= \frac{24.3}{65.4}</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>= 0.36 mol</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\[ V = \frac{V_o}{n} \]

\[ = \frac{85}{22.4} \]

\[ = 3.79 \text{ mol} \]

### Question 10

<table>
<thead>
<tr>
<th>Balanced equation</th>
<th>Zn</th>
<th>+</th>
<th>2HCl</th>
<th>→</th>
<th>ZnCl₂</th>
<th>+</th>
<th>H₂</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mole ratio</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td></td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Calculations</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>n = \frac{m}{M}</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>= \frac{7}{65.4}</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>= 0.11 mol</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\[ V = n \times V_o \]

\[ = 0.11 \times 22.4 \]

\[ = 2.40 \text{ dm}^3 \]
### Question 11

$$m = ?$$  
$$V = 2.24 \times 10^3 \text{ dm}^3$$

<table>
<thead>
<tr>
<th>Balanced equation</th>
<th>S + O$_2$ $\rightarrow$ SO$_2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mole ratio</td>
<td>1 + 1 $\rightarrow$ 1</td>
</tr>
<tr>
<td>Calculations</td>
<td>$n = 100 \text{ mol}$</td>
</tr>
<tr>
<td></td>
<td>$m = n \times M$</td>
</tr>
<tr>
<td></td>
<td>$= 100 \times 32.1$</td>
</tr>
<tr>
<td></td>
<td>$= 3210 \text{ g}$</td>
</tr>
</tbody>
</table>

$$n = \frac{V}{V_o}$$  
$$= \frac{2.24 \times 10^3}{22.4}$$  
$$= 100 \text{ mol}$$

### Question 12

$$V = 170 \text{ dm}^3$$  
$$V = ?$$

<table>
<thead>
<tr>
<th>Balanced equation</th>
<th>H$_2$ + Cl$_2$ $\rightarrow$ 2HCl</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mole ratio</td>
<td>1 + 1 $\rightarrow$ 2</td>
</tr>
<tr>
<td>Calculations</td>
<td>$n = \frac{V}{V_o}$</td>
</tr>
<tr>
<td></td>
<td>$= \frac{170}{22.4}$</td>
</tr>
<tr>
<td></td>
<td>$= 7.59 \text{ mol}$</td>
</tr>
</tbody>
</table>

$$n = \frac{7.59 \times 2}{1} = 15.18 \text{ mol}$$  
$$V = n \times V_o$$  
$$= 15.18 \times 22.4$$  
$$= 340 \text{ dm}^3$$

### Question 13

$$c = 0.2 \text{ mol.dm}^{-3}$$  
$$V = 36 \text{ cm}^3$$  
$$m = ?$$

<table>
<thead>
<tr>
<th>Balanced equation</th>
<th>HNO$_3$ + KOH $\rightarrow$ KNO$_3$ + H$_2$O</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mole ratio</td>
<td>1 + 1 $\rightarrow$ 1 + 1</td>
</tr>
<tr>
<td>Calculations</td>
<td>$n = c \times V$</td>
</tr>
<tr>
<td></td>
<td>$= 0.2 \times 0.036$</td>
</tr>
<tr>
<td></td>
<td>$= 0.007 \text{ mol}$</td>
</tr>
</tbody>
</table>

$$n = 0.007 \text{ mol}$$  
$$m = n \times M$$  
$$= 0.007 \times 56.11$$  
$$= 0.40 \text{ g}$$

### Question 14

$$c = 0.15 \text{ mol.dm}^{-3}$$  
$$V = 60 \text{ cm}^3$$  
$$m = ?$$

<table>
<thead>
<tr>
<th>Balanced equation</th>
<th>Na$_2$CO$_3$ + CaCl$_2$ $\rightarrow$ 2NaCl + CaCO$_3$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mole ratio</td>
<td>1 + 1 $\rightarrow$ 2 + 1</td>
</tr>
</tbody>
</table>
Calculations

\[ n = c \times V \]
\[ = 0.15 \times 0.06 \]
\[ = 0.009 \text{ mol} \]

\[ m = n \times M \]
\[ = 0.009 \times 100.1 \]
\[ = 0.90 \text{ g} \]

**Question 15**

\[ c = 0.4 \text{ mol.dm}^{-3} \]
\[ V = 40 \text{ cm}^3 \]
\[ c = 0.25 \text{ mol.dm}^{-3} \]
\[ V = ? \]

\[ \text{Balanced equation} \quad \text{H}_2\text{SO}_4 + 2\text{NaOH} \rightarrow \text{Na}_2\text{SO}_4 + 2\text{H}_2\text{O} \]

<table>
<thead>
<tr>
<th>Mole ratio</th>
<th>1</th>
<th>2</th>
<th>1</th>
<th>1</th>
</tr>
</thead>
</table>
| Calculations | \[ n = c \times V \]
\[ = 0.4 \times 0.04 \]
\[ = 0.016 \text{ mol} \]
\[ V = \frac{n}{c} \]
\[ = \frac{0.032}{0.25} \]
\[ = 0.128 \text{ dm}^3 \]

**Question 16**

**16.1**

\[ m = 52 \text{ g} \]
\[ m = 50 \text{ g} \]

\[ \text{Balanced equation} \quad \text{Zn} + 2\text{HCl} \rightarrow \text{ZnCl}_2 + \text{H}_2 \]

<table>
<thead>
<tr>
<th>Mole ratio</th>
<th>1</th>
<th>2</th>
<th>1</th>
<th>1</th>
</tr>
</thead>
</table>
| Calculations | \[ n = \frac{m}{M} \]
\[ = \frac{52}{65.4} \]
\[ = 0.80 \text{ mol} \]
\[ n = \frac{m}{M} \]
\[ = \frac{50}{36.46} \]
\[ = 1.37 \text{ mol} \]

\[ \text{Mole ratio} \quad \text{Zn} : \text{HCl} = 1 : 2 \]

Not enough \text{HCl} to react fully with the \text{Zn}.

\[ n(\text{Zn}) = 1.37 \div 2 = 0.69 \text{ mols} \]
\[ m = n \times M = 0.69 \times 65.4 = 44.84 \text{ g} \]
\[ \text{mass in excess} = 52 - 44.84 = 7.16 \text{ g} \]
### Question 17

#### 17.1

<table>
<thead>
<tr>
<th>Balanced equation</th>
<th>2NO</th>
<th>+</th>
<th>O₂</th>
<th>→</th>
<th>2NO₂</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mole ratio</td>
<td>2</td>
<td></td>
<td>1</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>Calculations</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
|                   | \( n = \frac{m}{M} \) | \( n = \frac{m}{M} \) | \( n = \frac{m}{M} \) | \( n = \frac{m}{M} \) |  \
|                   | \( \frac{20}{30} \) | \( \frac{15}{32} \) | \( \frac{0,67}{0,33} \) | \( \frac{0,47}{0,33} \) |  \
|                   | 0,67 | 0,47 | \( \text{Mole ratio} \ 2 : 1 \) |  \
|                   |     |   | 0,67 | 0,33 |  \

Therefore O₂ is in excess.

#### 17.2

\[ n(O₂) = 0,47 - 0,33 = 0,14 \text{ mols} \]
\[ m = n \times M = 0,14 \times 32 = 4,48 \text{ g} \]

### Question 18

#### 16.1

<table>
<thead>
<tr>
<th>Balanced equation</th>
<th>NH₃</th>
<th>+</th>
<th>2O₂</th>
<th>→</th>
<th>HNO₃</th>
<th>+</th>
<th>H₂O</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mole ratio</td>
<td>1</td>
<td>2</td>
<td></td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Calculations</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
|                   | \( n = \frac{m}{M} \) | \( n = \frac{m}{M} \) | \( n = \frac{m}{M} \) | \( n = \frac{m}{M} \) |  \
|                   | \( \frac{20}{17,03} \) | \( \frac{40}{32} \) | \( \frac{1,17}{2,34} \) | \( \frac{1,25}{2,34} \) |  \
|                   | 1,17 | 1,25 | \( \text{Mole ratio} \ 1 : 2 \) | \( \text{Mole ratio} \ 1,17 : 2,34 \) |  \

Therefore NH₃ is in excess.

#### 16.2

\[ n(NH₃) \text{ used} = 1,25 \div 2 = 0,63 \text{ mols} \]
\[ n(NH₃) \text{ left over} = 1,17 - 0,63 = 0,55 \text{ mols} \]
\[ m = n \times M = 0,55 \times 17,03 = 9,28 \text{ g} \]
**Question 19**

\[
\begin{array}{|c|c|c|c|}
\hline
\text{Balanced} & \text{Mole ratio} & \text{Calculations} & \text{Result} \\
\text{equation} & & & \\
\text{2 NH}_4\text{NO}_3 & 2 & n = \frac{m}{M} & n = \frac{156,17}{2} \\
& & = \frac{12500}{80,04} & = 156,17 \text{ mol} \\
& & = 156,17 \text{ mol} & \\
& & V = n \times V_o & V = 3498,21 \text{ dm}^3 \\
\hline
\end{array}
\]

\[
\begin{array}{|c|c|c|c|}
\hline
\text{Balanced} & \text{Mole ratio} & \text{Calculations} & \text{Result} \\
\text{equation} & & & \\
\text{2N}_2 & 2 & n = \frac{m}{M} & n = \frac{156,17}{4} \\
& & = \frac{12500}{80,04} & = 312,34 \text{ mol} \\
& & = 312,34 \text{ mol} & \\
& & V = n \times V_o & V = 6996,42 \text{ dm}^3 \\
\hline
\end{array}
\]

\[
\begin{array}{|c|c|c|c|}
\hline
\text{Balanced} & \text{Mole ratio} & \text{Calculations} & \text{Result} \\
\text{equation} & & & \\
\text{O}_2 & 1 & n = \frac{m}{M} & n = \frac{156,17}{2} \\
& & = \frac{12500}{80,04} & = 78,09 \text{ mol} \\
& & = 78,09 \text{ mol} & \\
& & V = n \times V_o & V = 1749,22 \text{ dm}^3 \\
\hline
\end{array}
\]

\[
V_{\text{Total}} = 3498,21 + 6996,42 + 1749,22 = 12243,85 \text{ dm}^3
\]

**Question 20**

\[
\begin{array}{|c|c|c|c|}
\hline
\text{Balanced} & \text{Mole ratio} & \text{Calculations} & \text{Result} \\
\text{equation} & & & \\
\text{2C}_8\text{H}_{18} & 2 & n = \frac{m}{M} & n = \frac{7}{114,18} \\
& & = \frac{7}{114,18} & = 0,06 \text{ mol} \\
& & = 0,06 \text{ mol} & \\
& & V = n \times V_o & V = 10,99 \text{ dm}^3 \\
\hline
\end{array}
\]

\[
\begin{array}{|c|c|c|c|}
\hline
\text{Balanced} & \text{Mole ratio} & \text{Calculations} & \text{Result} \\
\text{equation} & & & \\
\text{25O}_2 & 25 & n = \frac{m}{M} & n = \frac{0,06}{2} \\
& & = \frac{0,06}{2} & = 0,49 \text{ mol} \\
& & = 0,49 \text{ mol} & \\
& & V = n \times V_o & V = 12,36 \text{ dm}^3 \\
\hline
\end{array}
\]

\[
\begin{array}{|c|c|c|c|}
\hline
\text{Balanced} & \text{Mole ratio} & \text{Calculations} & \text{Result} \\
\text{equation} & & & \\
\text{16CO}_2(g) & 16 & n = \frac{m}{M} & n = \frac{0,06}{2} \\
& & = \frac{0,06}{2} & = 0,55 \text{ mol} \\
& & = 0,55 \text{ mol} & \\
& & V = n \times V_o & V = 12,36 \text{ dm}^3 \\
\hline
\end{array}
\]

\[
V_{\text{Total}} = 10,99 + 12,36 = 23,35 \text{ dm}^3
\]

**Question 21**

\[
\begin{array}{|c|c|c|c|}
\hline
\text{Balanced} & \text{Mole ratio} & \text{Calculations} & \text{Result} \\
\text{equation} & & & \\
\text{2NaN}_3 & 2 & n = \frac{m}{M} & n = \frac{75}{3} \\
& & = \frac{75}{3} & = 50 \text{ mol} \\
& & = 50 \text{ mol} & \\
& & V = n \times V_o & V = 1680 \text{ dm}^3 \\
\hline
\end{array}
\]

\[
\begin{array}{|c|c|c|c|}
\hline
\text{Balanced} & \text{Mole ratio} & \text{Calculations} & \text{Result} \\
\text{equation} & & & \\
\text{2Na} & 2 & n = \frac{m}{M} & n = \frac{1680}{22,4} \\
& & = \frac{1680}{22,4} & = 75 \text{ mol} \\
& & = 75 \text{ mol} & \\
& & V = n \times V_o & V = 1680 \text{ dm}^3 \\
\hline
\end{array}
\]
Question 22

22.1 K: \( n = \frac{m}{M} = \frac{31.8}{39.1} = 0.81 \text{ mols} \div 0.81 = 1 \)

Cl: \( n = \frac{m}{M} = \frac{29}{35.45} = 0.82 \text{ mols} \div 0.81 = 1 \)

O: \( n = \frac{m}{M} = \frac{39.2}{16} = 2.45 \text{ mols} \div 0.81 = 3 \)

Empirical formula = KClO₃

22.2 N: \( n = \frac{m}{M} = \frac{30.4}{14} = 2.17 \text{ mols} \div 2.17 = 1 \)

O: \( n = \frac{m}{M} = \frac{69.6}{16} = 4.35 \text{ mols} \div 2.17 = 2 \)

Empirical formula = NO₂

22.3 Al: \( n = \frac{m}{M} = \frac{53}{27} = 1.96 \text{ mols} \div 1.96 = 1 \times 2 = 2 \)

O: \( n = \frac{m}{M} = \frac{47}{16} = 2.94 \text{ mols} \div 1.96 = 1.5 \times 2 = 3 \)

Empirical formula = Al₂O₃

22.4 Na: \( n = \frac{m}{M} = \frac{43.4}{23} = 1.89 \text{ mols} \div 0.94 = 2 \)

C: \( n = \frac{m}{M} = \frac{11.3}{12} = 0.94 \text{ mols} \div 0.94 = 1 \)

O: \( n = \frac{m}{M} = \frac{45.3}{16} = 2.83 \text{ mols} \div 0.94 = 3 \)

Empirical formula = Na₂CO₃

Question 23

\( m = ? \) \hspace{2cm} \( m = 5 \text{ g} \)

<table>
<thead>
<tr>
<th>Balanced equation</th>
<th>2NaOH</th>
<th>+</th>
<th>H₂SO₄</th>
<th>→</th>
<th>Na₂SO₄</th>
<th>+</th>
<th>2H₂O</th>
<th>Mole ratio</th>
<th>Calculations</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2</td>
<td>( n = 0.035 \times 2 = 0.07 \text{ mol} )</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>( m = n \times M )</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>( = 0.07 \times 40.01 )</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2</td>
<td>( = 2.82 \text{ g} )</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2</td>
<td>( n = \frac{m}{M} )</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>142</td>
<td>( = \frac{5}{142} )</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.035 mol</td>
<td>( = 0.035 \text{ mol} )</td>
</tr>
</tbody>
</table>

\% purity = \( \frac{2.82}{4} \times 100 = 70.44\% \)
Acknowledgements
Mindset Learn Executive Head
Dylan Busa
Content Manager Classroom Resources
Jenny Lamont
Content Coordinator Classroom Resources
Helen Robertson
Content Administrator
Agness Munthali
Content Developer
Christine McLaren
Content Reviewers
Ross Moore
Duncan Chiriga

Produced for Mindset Learn by Traffic
Facilities Coordinator
Cezanne Scheepers
Production Manager
Belinda Renney
Director
Aliette Gibbs
Editor
Talent Maphisa
Presenter
Banji Longwe
Studio Crew
Abram Tjale
James Tselapedi
Wilson Mthembu
Graphics
Wayne Sanderson

Credits
http://upload.wikimedia.org/wikipedia/commons/3/3d/Avogadro_Amedeo.jpg
http://upload.wikimedia.org/wikipedia/commons/thumb/a/ac/Seitenairbag_Porsche.jpg/220px-Seitenairbag_Porsche.jpg
http://upload.wikimedia.org/wikipedia/commons/thumb/e/e4/Motorradairbag.JPG/800px-Motorradairbag.JPG
http://upload.wikimedia.org/wikipedia/commons/2/20/Airbag_SEAT_Ibiza.jpg

This resource is licensed under an Attribution-Share Alike 2.5 South Africa licence. When using this resource please attribute Mindset as indicated at http://www.mindset.co.za/creativecommons