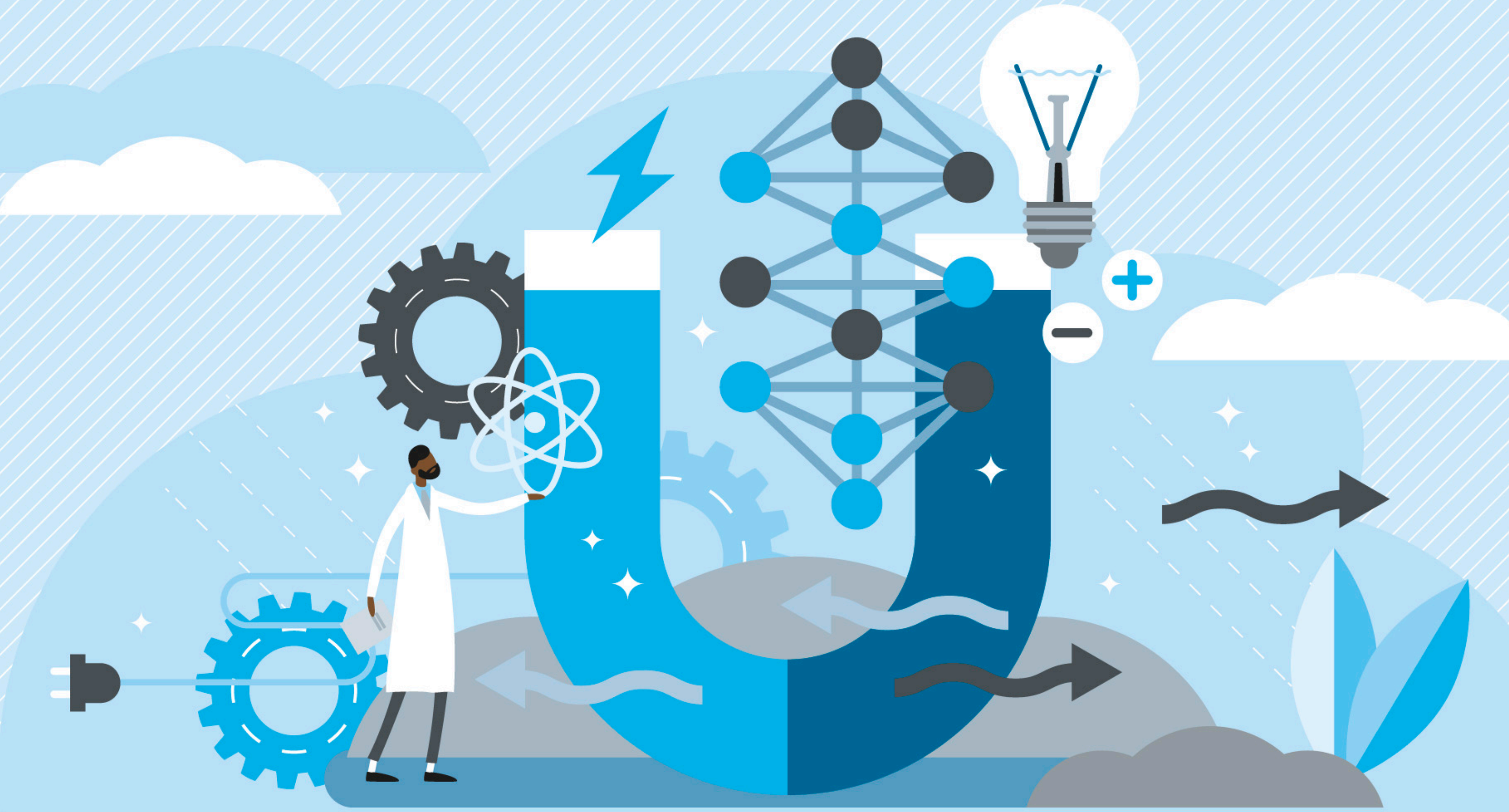
PARTICIPANT'S HANDOUT

2017 TERM 2 TRAINING WORKSHOP

PHYSICAL SCIENCES



GRADES 10-11

PILO

IMPROVING LEARNER PERFORMANCE

education
Department:
Education
PROVINCE OF KWAZULU-NATAL

Just-in-Time Training Workshop Term 2 2017

Participants' Manual

Physical Sciences

Stoichiometry Grade 10 & 11

Endorsed by:

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what I do matters

Grade 10-11 Content, Concepts and Skills

Grade 10 Content , concepts and skills extracted from CAPS pp 50-52	
Quantitative aspects of chemical change:	Learners should recognise that owing to the small size of the atoms, molecules and ions, properties of these species are often compared on a mole basis and that the Avogadro constant is a number which chemists commonly use in the comparison of physical and chemical properties. Stoichiometry is the study of quantitative composition of chemical substances and the qualitative changes that take place during chemical reactions.
Atomic mass and the MOLE CONCEPT;	•Describe the mole as the SI unit for amount of substance • Relate amount of substance to relative atomic mass • Describe the relationship between mole and Avogadro's number • Conceptualize the magnitude of Avogadro's number using appropriate analogies • Write out Avogadro's number with all the zeros to get a better concept of the amount • Define molar mass • Describe the relationship between molar mass and relative molecular mass and relative formula mass • Calculate the molar mass of a substance given its formula
Molecular and formula masses;	• Reason qualitatively and proportionally the relationship between number of moles, mass and molar mass • Calculate mass, molar mass and number of moles according to the relationship n= m/M • Determine the **empirical formula** for a given substance from percentage composition • Determine the number of moles of **water of crystallization** in salts like $AlCl_3 \cdot nH_2O$
Determining the composition of substances	• Determine **percent composition** of an element in a compound • Define and determine concentration as moles per volume
Amount of substance (mole), molar volume of gases, concentration of solutions.	• Calculate the number of moles of a salt with given mass • Definition of molar volume is stated as: 1 mole of gas occupies 22.4 dm3 at 00C (273 K) and 1 atmosphere (101.3 kPa) • Calculate the molar concentration of a solution
Basic stoichiometric calculations	• Do calculations based on concentration, mass, moles, molar mass and volume • Determine the theoretical yield of a product in a chemical reaction, when you start with a known mass of reactant
Grade 11 Content , concepts and skills extracted from CAPS pp 82-83	
Quantitative aspects of	The conservation of atoms in chemical reactions leads to the

chemical change	principle of conservation of matter and the ability to calculate the mass of products and reactants.
Molar volume of gases; concentration of solutions.	1 mole of gas occupies $22.4dm^3 at\ 0^0C\ (273K)$ and 1 atmosphere (101.3 kPa) • Interpret balanced reaction equations in terms of volume relationships for gases under the same conditions of temperature and pressure (volume of gases is directly proportional to the number of particles of the gases) • Calculate molar concentration of a solution
More complex Stoichiometric calculations	•Perform stoichiometric calculations using balanced equations that may include limiting reagents • Do stoichiometric calculation to determine the percent yield of a chemical reaction • Do calculations to determine empirical formula and molecular formula of compounds (revise empirical formula calculations done in grade 10) • Determine the percent $CaCO_3$ in an impure sample of sea shells (purity or percent composition)
Volume relationships in gaseous reactions.	• Do stoichiometric calculations with explosions as reactions during which a great many molecules are produced in the gas phase so that there is a massive increase in volume e.g. ammonium nitrate in mining or petrol in a car cylinder. $2NO_4NO_3 \rightarrow 2N_{2(g)} + 4H_2O_{(g)} + O_{2(g)}$ $2C_8H_{18} + 25O_2 \rightarrow 16CO_2 + 18H_2O$ •Give the reactions and use it in stoichiometric calculations • Do as application the functioning of airbags. Sodium azide reaction: $2NaN_{3(s)} \rightarrow 2Na_{(s)} + 3N_{2(g)}$ Reaction must be given when used in calculations

Contents

1 Introduction

How can teachers use their understanding of learner errors to approach teaching? This is the premise from which the development of this manual is derived. This manual is aimed at assisting teachers to pay attention to learners' mistakes and to learn from those mistakes. It envisaged that lessons learned from those mistakes, inform their teaching. The manual has been prepared for Grades 10-11 Stoichiometry and electricity circuits. The reliance on samples of learner mistakes to inform the development of the material could not be fully realised because of the limited time available at the time of its preparation and the non-availability of Grades 10-11 learner answer sheets with answers at that time.

The experience of the materials developer has been the major source of information on problems that learners have when answering stoichiometry questions.

Grade 12 examiners reports have also been used to highlight problematic arears with the understanding that problems in stoichiometry and electricity at Grade12 would have started at Grades 10 and 11. Another source of information on learner problems in stoichiometry, electricity and Physical Sciences as a whole has been the Research conducted by Lee and co-researchers. This research provides valuable information as per the extract below:

1. Prior knowledge:
- Specific knowledge: knowledge directly related to the problem.
- Non-specific but relevant knowledge: knowledge related to the subject area of the problem.

2. Linkage
- Concept relatedness: relatedness between concepts involved in problem solving.
- Idea association: linkage between the information retrieved from the existing knowledge structure and the external cues.

3. Problem recognition skill
- Problem translating skill: the capacity to comprehend, analyse, interpret and define a given problem.

Extract: *Tóth T. & Sebesteyén, A.* (2009), *p.* 9

Whilst knowing mistakes that learners make is crucial to informing teacher practice in class, it does not provide reasons behind those wrong answers. Teachers should make every effort to find out what led to those answers.

The findings of the research by Lee and his co-researchers provides answers to why learners make the mistakes we observe in class during science lessons. Learners fail to relate the present problem to the knowledge they have, they lack the understanding of scientific language, they lack analysing and interpretation skills, they lack maths skills, they fail to associate concepts to other concepts, to link ideas and they fail to apply skills that have been used in the past, to solve a problems of a similar nature in future. Focus should be aimed at helping learners acquire these skills, mainly association skills. Facilitating acquisition and assessing these skills at regular and short intervals is of vital importance to solving the problem of poor achievements in Maths and Science.

Knowing the different groups of problems learners have is of vital importance to the teacher. There are four groups of sources of learner errors which will be discussed in this manual. Lack of prior knowledge in the form of specific or non –specific but relevant knowledge is one of the sources of error which can be established from learner responses. The second source of error is the problem recognition skill, which entails lack of problem translating skill, no capacity to comprehend, analyse, interpret and define the given problem. The third source of learner error is lack of problem recognition skill and the final category is lack of association of concepts skills.

It is on the basis of the above that the approach adopted in this manual is more of looking at what causes learner mistakes than at what those mistakes are. Knowing causes of those mistakes is key to addressing them as teachers can be proactive in terms of addressing them.

2. Problems associated with language

This kind of problem is specific to a given topic. For learners to understand and be able to analyse and interpret questions, they need to know the language of Science. One of the factors which contribute to learners getting low marks in tests and exams is that learners do not understand the language of Maths and Science. This is not about English as a language per se but language needed to comprehend questions and language to use to answer given questions. It is worth noting that the language comes in three forms which are **spoken language, symbols and signs**.

The Law of constant composition states that for any chemical compound, all the samples of that compound will be made up of the same elements in the same proportion or ratio.

Understanding this law calls for the knowledge of Maths and Science, concepts which have nothing to do with knowing English as a language, but demands understanding peculiar to Maths and Science only.

Activity 1

Aim	1. To allow the participants to have practice with using different forms of science language 2. To allow participants an opportunity to reflect on their knowledge of science concepts 3. To impress upon the participants the need for them to ensure that learners have a good understanding of the meaning attached to science concepts.
Duration	10 minutes
Method	Individual work
Resources	CAPS document, any relevant textbook, calculators and this manual.

a) Given the balanced chemical equation $3H_{2(g)} + N_{2(g)} \rightarrow 2NH_{3(g)}$, explain the meaning of the given chemical equation.

Answer.

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b) Write down a balanced chemical equation for the decomposition of Hydrogen Peroxide to form hydrogen and oxygen gases.

Answer

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Physical and Chemical Changes

One of the problems learners have is to tell the difference between physical and chemical changes.

c) Given the following reactions, classify them as either physical or chemical by making a tick in the relevant column.

Reaction	Physical	Chemical
A burning candle		
An silver metal rod turning red when heated		
Water changing to steam when heated		
Decomposition of water to form hydrogen and oxygen gases		
Burning of wood		

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d) Give the meaning of the following concepts:

(i) Stoichiometry

Answer

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ii) Empirical Formula

Answer

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iii) Molecular formula

Answer

3. Problems associated with understanding and use of the mole concept.

3.1 Understanding the mole concept.

Understanding the mole concept is key to the dealing with stoichiometry problems Learners need to know everything about the mole and be able to use their knowledge of ratio and proportion to solve problems involving mole calculations. Activity 2 assesses understanding of the mole concept

Activity 2

Aim	To facilitate understanding of the meaning attached to the mole concept.
Duration	1o minutes
Method	Group work
Resources	CAPS document, any relevant textbook, calculators and this manual.

3.1.1 What are three defining features of a mole of a substance?

Answer.

3.1.2 How many moles of atoms are there in 3 moles of ammonia molecules? Explain how you arrived at your answer.

Answer.

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3.1.3 How many moles of protons are there in 3 moles of ammonia molecules? Explain how you arrived at your answer.

Answer.

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3.1.4 How many moles of electrons are there in 2 moles of water molecules? Explain how you arrived at your answer.

Answer.

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3.2 Using the mole concept in calculations based on chemical equations.

Steps to follow when doing calculations based on chemical equations:

a. Make sure that the equation is balanced.
b. Write the mole ratio for the substances using the balanced equation
c. Calculate the number of moles of the substance for which you have been given information
d. Use the mole ratio to calculate the number of moles of the substance you want to find
e. Use the number of moles of the substance to find what is required, which can be a mass or volume.

Activity 3

Aim	To allow the participants practice on the use of moles to calculate amounts of reactants and products in chemical reactions.
Duration	10 minutes
Method	Individual work
Resources	CAPS document, any relevant textbook, calculators and this manual.

Oxygen reacts with sulphur dioxide to form sulphur trioxide as per the following chemical equation:

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

Calculate the volume of oxygen required to react with $350\ dm^3$ of sulphur dioxide to form sulphur trioxide at standard temperature and pressure (STP).

Answer.

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3.3 Understanding and using the RICE table

Activity 4

Aim	To allow the show participants one way of using the RICE table in teaching stoichiometry calculations.
Duration	15 minutes
Method	Individual work
Resources	CAPS document, any relevant textbook, calculators and this manual.

Given the RICE table below and the balanced chemical equation for the formation of sulphur trioxide from sulphur dioxide and oxygen, answer the questions below:

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

Balanced equation	$2SO_{2(g)}$	$+$	$O_{2(g)}$	$\rightarrow$	$2SO_{3(g)}$
R	2		1		2
I	A		B		C
C	D		E		F
E	G		H		I

a) What does each letter in the word RICE represent?
b) What does each letter from (A to I) in the table represent?
c) If the reaction started with 10 moles of sulphur dioxide molecules s reacting with 7 moles of oxygen molecules, how many moles of product molecules formed will the letter I represent?

d) What will be the total number of moles of gas molecules present at the end of the reaction?

(a)	*Answers*
R	
I	
C	
E	
(b)	Answers.
A	
B	
C	
D	
E	
F	
G	
H	
I	
	Answers.
c)	
(d)	

3.4 Calculating concentrations of solutions

The concentration of a solution tells us the strength of a solution in terms of the number of moles in a given volume. The unit of concentration is $mol. dm^{-3}$.

If concentration is given in cm^3, the volume has to be divided by 1000 to convert to dm^3 because $1\ dm^3 = 1000cm^3 = 1l.$

$c = \frac{n}{V}$
$c = concentration (mol. dm^3)$
$n = nunber\ of\ moles\ (mol)$
$V = volume\ of\ gas\ (dm^3)$

If given the mass of a compound you have to convert it to volume using the equation:
$n = \frac{m}{M}$
$n = nunber\ of\ moles\ (mol)$
$m = mass\ (g)$
$M = molar\ mass (g. mol^{-1})$

Example 1

Calculate the concentration of a solution if 4g of sodium hydroxide (NaOH) s dissolved in enough water to make a solution with a volume of 200cm^3.

Answer.

$M(_{NaOH}) = 23 + 16 + 1 = 40g \cdot mol^{-1}$

$$n = \frac{m}{M}$$

$$n = \frac{4}{40}$$
$$n = 0{,}1mol$$

$$V = \frac{200}{1000}$$
$$V = 0{,}2\ dm^3$$

$$c = \frac{n}{V}$$
$$c = \frac{0{,}1}{0{,}2}$$
$$c = 0{,}5mol. dm^{-3}$$

4. Problems associated with maths in stoichiometry exercises

Closely related to the issue of language is the issue of Maths. Language used in Maths and computational skills needed have a major impact on learner performance in Science. Teachers need to spend a lot of time teaching maths skills during science lessons. Ratio and proportion are key to the successful understanding and performance in stoichiometry.

4.1 Teaching ratio and proportionality.

Learners often struggle with calculations involving these two concepts because they do not have understanding of what they mean. To assist with the understanding of these concepts, learners need to be reminded indirectly how they use the two concepts in their daily lives.

An example of the **fictitious recipe** for baking scones can be used as an example.

To make 12 scones you need the following:

- 3 glasses of milk
- 4 cups of flour
- 2 teaspoons of sugar
- 1 pocket baking powder.
- 6 eggs

To facilitate the understanding of ratio learners have to be asked the following questions:

a) If 8 cups of flour have been used, how many eggs would have been used?
    a. 12 eggs
b) If 36 scones have been baked how many glasses of milk would have been used?
    a. 9 glasses
c) How many eggs do you need to bake 60 scones?
    a. 30 eggs

If learners give correct answers to these questions, then they know the concept ratio. Learners need to tell how they arrived at their answers. This discussion will ultimately lead to the definition and meaning of ratio. A balanced chemical reaction equation works the same way as a baking recipe.

To facilitate the understanding of proportion learners have to be asked the following questions:

d) How many eggs do you need to bake 24 scones?
e) How many eggs do you need to bake 36 scones?
f) How many eggs do you need to bake 60 scones?

If learners give correct answers to these questions, then they know the concept proportionality. The learners then need to tell how they arrived at their answers. This discussion will ultimately lead to the definition and meaning of proportionality.

This exercise can then be followed by calculations involving reactants and products in chemical reaction equations.

4.2 Finding the limiting reactant through the ideal ratio.

The same mock baking scenario which has been used above can be used to teach the concept of the limiting reactant.

The question asked could be, If I have 15 glasses of milk, 12 cups of flour, 4 pockets of baking powder, 7 teaspoons of sugar and 36 eggs:

a) How many scones can I bake?
b) How much of each ingredient will be left?

Answer to this question will lead learners to understand that the number of scones that can be baked is limited to a maximum number by the availability of ingredients. One of the ingredients will get finished first. What leads to that ingredient getting finished is the initial amount of that ingredient available and the rate at which it is used as per the baking recipe. That understanding will then assist in finding the limiting reactant in any given chemical reaction with a balanced chemical equation.

When a chemical reaction takes place, the reaction comes to an end when one of the reactants has been finished. At this point the maximum amount of product will have been formed. What determines when a given reactant will be finished is the starting amount of that reactant and the rate at which it is being used up during a chemical reaction. Given the chemical reaction equation $N_{2(g)} + 3H_{2(g)} \rightarrow 2NH_{3(g)}$ the rate at which hydrogen gas is used up is three times that of nitrogen in the formation of ammonia gas. The same applies to nitrogen. The starting amount of nitrogen and the rate at which nitrogen is being used up will determine whether or not it is finished before hydrogen.

Example

Question: Ammonia (NH_3) is produced when nitrogen gas (N_2) is combined with hydrogen gas (H_2) by the reaction $N_{2(g)} + 3\ H_{2(g)} \rightarrow 2\ NH_{3(g)}$

50 grams of nitrogen gas and 10 grams of hydrogen gas are reacted together to form ammonia. Which of the two gasses will run out first? (Which gas is the limiting reactant?)

Answer: The reaction shows us that for every mole of N_2 consumed, 3 moles of H_2 is also consumed. We need 3 moles of hydrogen gas for every mole of nitrogen gas. The first thing we need to find out is the number of moles of each gas is on hand.

N_2 **Gas:** How many moles of nitrogen gas is 50 grams? One mole of nitrogen is 14.007 grams, so one mole of N_2 will weigh 28.014 grams.

$$\frac{1 \text{ mole } N_2}{28.014 \text{ g}} = \frac{x \text{ moles } N_2}{50 \text{ g}}$$

$$x \text{ moles } N_2 = \frac{50 \text{ g}}{28.014 \text{ g}}$$

x moles N_2 = 1.78

H_2 **Gas:** How many moles of hydrogen gas is 10 grams? One mole of hydrogen is 1.008 grams so one mole of H2 is 2.016 grams.

$$\frac{1 \text{ mole } H_2}{2.016 \text{ g}} = \frac{x \text{ moles } H_2}{10 \text{ g}}$$

$$x \text{ moles } H_2 = \frac{10 \text{ g}}{2.016 \text{ g}}$$

x moles H_2 = 4.96

Now we know the number moles of each reactant, we can use the ratio from the chemical equation to compare the amounts. The ratio between hydrogen gas and nitrogen gas should be:

$$\frac{3 \text{ mole } H_2}{1 \text{ mole } N_2}$$

If we divide our moles of H_2 into moles of N_2, our value will tell us which reactant will come up short. Any value greater than the above ratio means the top reactant is in excess to the lower number. A value less than the ratio means the top reactant is the limiting reactant. The key is to keep the same reactant on top as the step above.

$$\frac{4.96}{1.78}$$

2.79

Since our value is less than the ideal ratio, the top reactant is the limiting reactant. In our case, the top reactant is the hydrogen.

Answer: Hydrogen gas is the limiting reactant.

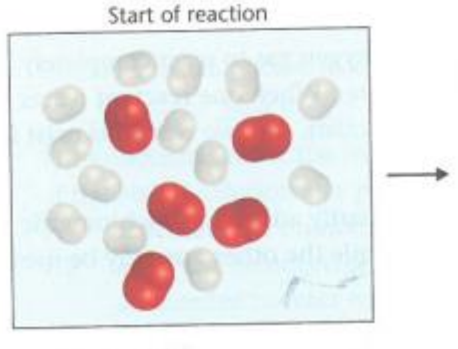
It doesn't matter which reactant you put on top when you do this type of problem as long as you keep it the same throughout the calculations. If we had put nitrogen gas on top instead of hydrogen the ratio would have worked out the same way. The ideal ratio would have been $\frac{1}{3} = 0{,}33$ and the calculated ratio would have been $\frac{1{,}78}{4{,}96} = 0{,}359$,the value would have been greater than the ideal ratio so the bottom reactant in the ratio would be the limiting reactant. In this case, it is the hydrogen gas.

ACTIVITY 5

Aim	To allow the participants to have practice on the use of models to teach chemical reactions. To allow participants an opportunity of practicing doing ratio and proportion calculations
Duration	10 minutes
Method	Individual work
Resources	CAPS document, any relevant textbook, calculators and this manual.

The diagram below represent the reaction between hydrogen gas and oxygen gas to produce steam: $2H_{2(g)} + O_{2(g)} \rightarrow 2H_2O_{(g)}$.The diagram on the left shows all the hydrogen and oxygen molecules whereas the diagram on the right shows only one molecule of steam produced.

End of reation



Look at the container at the start of the reaction and answer the following questions:

a. Write down the number of hydrogen molecules and the number of oxygen molecules?
b. How many steam molecules can be made from the number of hydrogen molecules available?
c. Use diagrams to represent **ALL** steam molecules can be made from the number of oxygen molecules available. *Use end of reaction box above.*
d. Which is the limiting reactant? Explain your answer.

	Answers
a)	
b)	
c)	*Use end of reaction box above.*
d)	

Now look at the container at the end of the reaction and answer the questions below: Only one molecule of steam has been shown, other molecules have been hidden for participants to figure out their numbers.

e) Apart from steam molecules will there be other types of molecules?
f) How many gas molecules are in the container at the end of the reaction?
g) Are there any oxygen molecules at the end of the reaction? Give a reason for your answer.

	Answers
e)	
f)	
g)	

Activity 6

Aim	To assist teachers to address the problem of understanding ratio and proportion. Some questions in activity 4 above also involve application of ratio and proportion apart from knowledge of atomic structure and mole concept.
Duration	10 minutes
Method	Individual work
Resources	CAPS document, any relevant textbook, calculators and this manual.

Ammonia is used as a fertiliser or to make fertilisers. Ammonia is prepared industrially from nitrogen gas and hydrogen gas according to the equation $N_{2(g)} + 3H_{2(g)} \rightarrow 2NH_{3(g)}$. In one such reaction 50g of nitrogen and 15g of hydrogen are mixed and reacted to give ammonia. Calculate the mass of ammonia produced after completion of the reaction.

Answer

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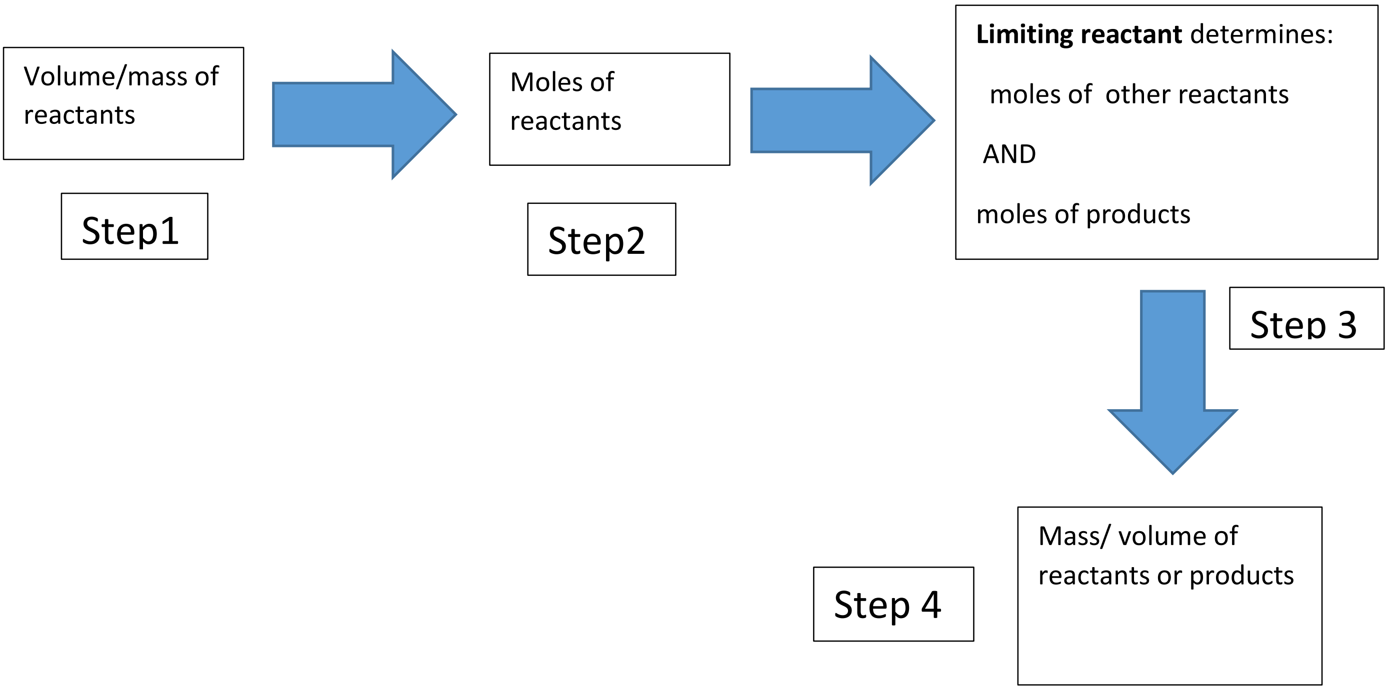
5. Problems associated with analysis and interpretation of questions

Assistance with problem analysis and interpretation of questions has been provided through the use of flow diagrams. The material has been designed to allow teachers to teach learners to break problems into small chunks which deal with one aspect and easy to understand. Idea association has to be provided by explanation on how those small chunks are related and how they lead to the solution of the problem. This has been done in the form of flow diagrams comprising different stages of problem solution. Three different activities have been provided to address problems requiring problem interpretation and analysis skills.

5.1 Use of flow diagrams in teaching stoichiometry

To find the volume of a gas at the end of the reaction using the amounts of gases at the beginning of the reaction.



Consider the reaction for the formation of ammonia from hydrogen and nitrogen gases:

$N_2 + 3\ H_2 \rightarrow 2\ NH_3$

If 60 litres of nitrogen were added to 150 litres of hydrogen at STP:

a) How many litres of nitrogen will be used in the reaction
b) How many litres of hydrogen will be used in the reaction
c) What will be the volume of ammonia produced
d) What will be the volume of gas in the container after completion of the reaction?

Solution

Step 1 $V(N_2) = 60l$

$V(H_2) = 150l$

Step 2 $n(N_2) = \frac{60}{22,4}$

$= 2,68$

$n(H_2) = \frac{150}{22,4}$

$= 6,70$

Step 3

$1mole\ N_2 reacts\ with\ 3\ moles\ H_2$

$2{,}23\ moles\ N_2 reacts\ with\ \frac{2{,}68\times 3}{1}\ moles\ H_2 = 8{,}04mol\ H_2$ but there is only 6, 70 moles of H_2 available hence H_2 a limiting reactant.

$number\ of\ moles\ of\ H_2 = \frac{1}{3} \times 6{,}7 = 2{,}23mol\ H_2$ and (2, 68 -2,23) = 0,45 moles of H_2 will remain unreacted.

Number of moles of ammonia formed:

$$6{,}70\ moles\ H_2\ produces\ \frac{6{,}70 \times 2}{3}\ moles\ NH_3 = 4{,}47mol\ NH_3$$

Step 4

Volume of nitrogen remaining

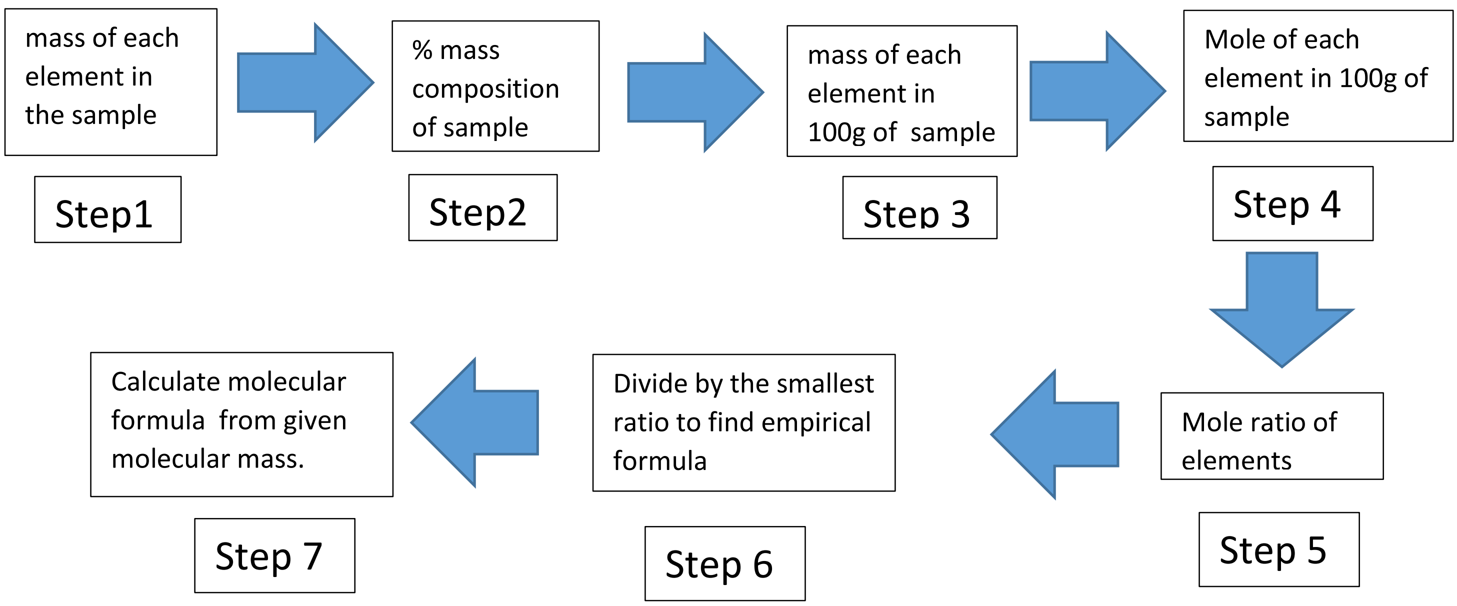
$$n = \frac{V}{V_0}$$
$$0{,}45 = \frac{V}{22{,}4}$$
$$V = 10{,}08l$$

Volume of ammonia produced:

$$n = \frac{V}{V_0}$$
$$4{,}47 = \frac{V}{22{,}4}$$
$$V = 100{,}13l$$

Total volume at the end=100, 13 +10, 08 =110, 21 litres.

5.2 Flow diagram to determine the molecular formula from percentage by mass composition of a sample.



Activity 7

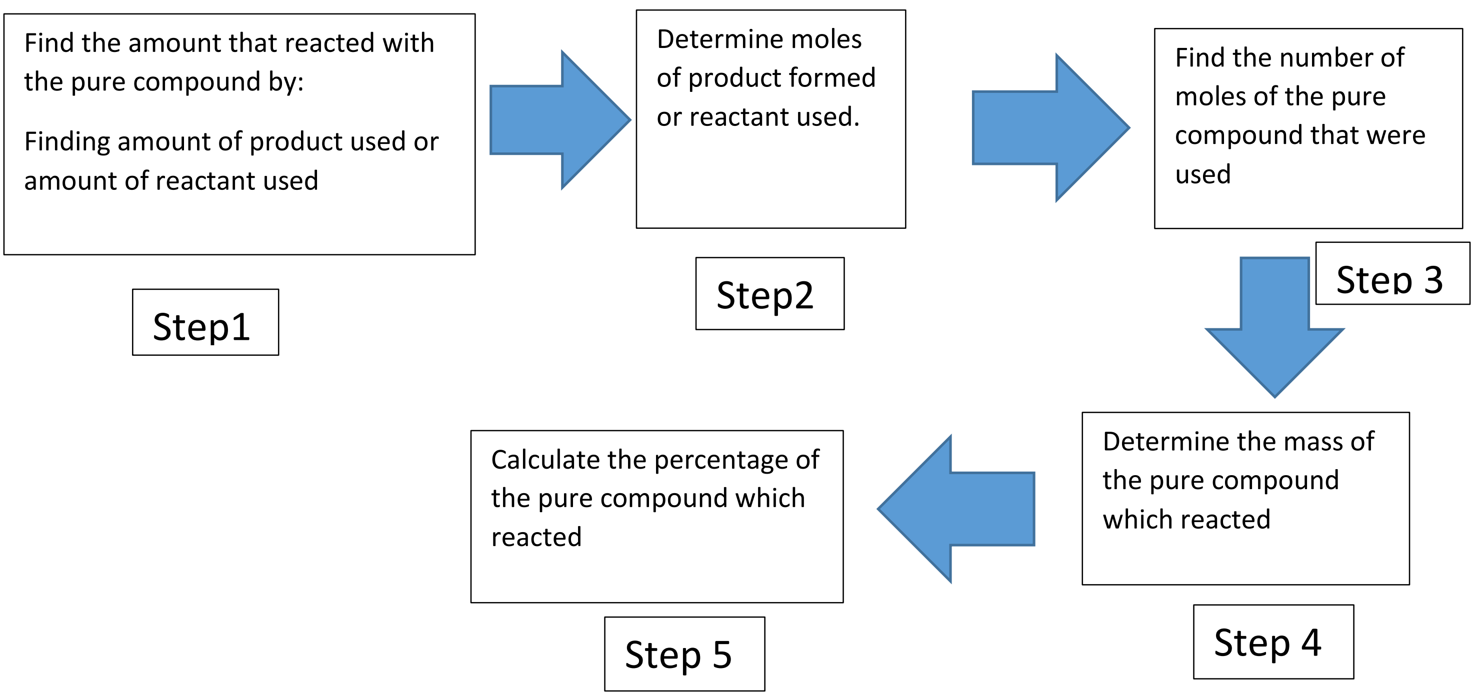
Aim	To allow participants practice on using percentage composition to determine the empirical and molecular formulae of a compound.
Duration	20 minutes
Method	Individual work
Resources	CAPS document, any relevant textbook, calculators and this manual.

A 25g sample of a compound with a molar as of $142g \cdot mol^{-1}$ is analysed. The sample contains 8,0925g sodium, 5,6425g sulphur and 11,2650g oxygen. Determine:

a) the empirical formula
b) the molecular formula of the compound.

Answer

5.3 Flow diagram for determination of percentage composition of a compound.



5.4 Determination of percentage $CaCO_3$ in an impure sample of sea shells.

Activity 8

Aim	To allow the participants to have practice on determination of percentage purity of a compound
Duration	20 minutes
Method	Individual work
Resources	CAPS document, any relevant textbook, calculators and this manual.

Suppose a sample of sea shells has a mass of 4, 5 g. The sample is heated at 100^0C and it decomposes into carbon dioxide and quicklime, calcium oxide according to the equation $CaCO_{3(s)} \overset{\Delta}{\rightarrow} CO_{2(g)} + CaO_{(s)}$. The carbon dioxide is collected while the sample is heated until no more gas is formed. When the mass of the carbon dioxide collected is measured, it is found to be 0,65g. Calculate the percentage $CaCO_3$ in the sample.

Answer

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6. Problems associated with association of concepts

There are questions that learners do not even attempt, where a learner would say I do not know where to start. The problem of those learners is inability to relate concepts to one another. There is no link between the given information and the required answer.

Example.

Consider the reaction for the formation of ammonia from hydrogen and nitrogen gases:

$N_{2(g)} + 3\ H_{2(g)} \rightarrow 2\ NH_{3(g)}$

If 60 litres of nitrogen were added to 150 litres of hydrogen at STP, **how much ammonia in grams will be formed?**

If a learner does not know where to start when answering this question, it is because there is no link between the two masses that have been given and the amount of ammonia that will be formed.

For a learner to answer this question there are a lot of associations that must be made. The learner need to know the relationship between the given mass of hydrogen and number of moles of hydrogen. The link between the given mass of hydrogen and the number of moles of hydrogen in the molecular mass of hydrogen molecule. The molecular mass of hydrogen is linked to atomic masses of hydrogen atoms which need to be found from the periodic table. The link between the mass of nitrogen atoms and number of moles of nitrogen is the same as that referred to earlier about hydrogen. Once both number of moles of hydrogen and nitrogen have been calculated the next link is the ratio of the number of moles of the reactants. This ratio and will enable one to identify the limiting reactant and do calculations of the number of moles of ammonia produced using ratio and proportionality, and finally the amount of ammonia produced,

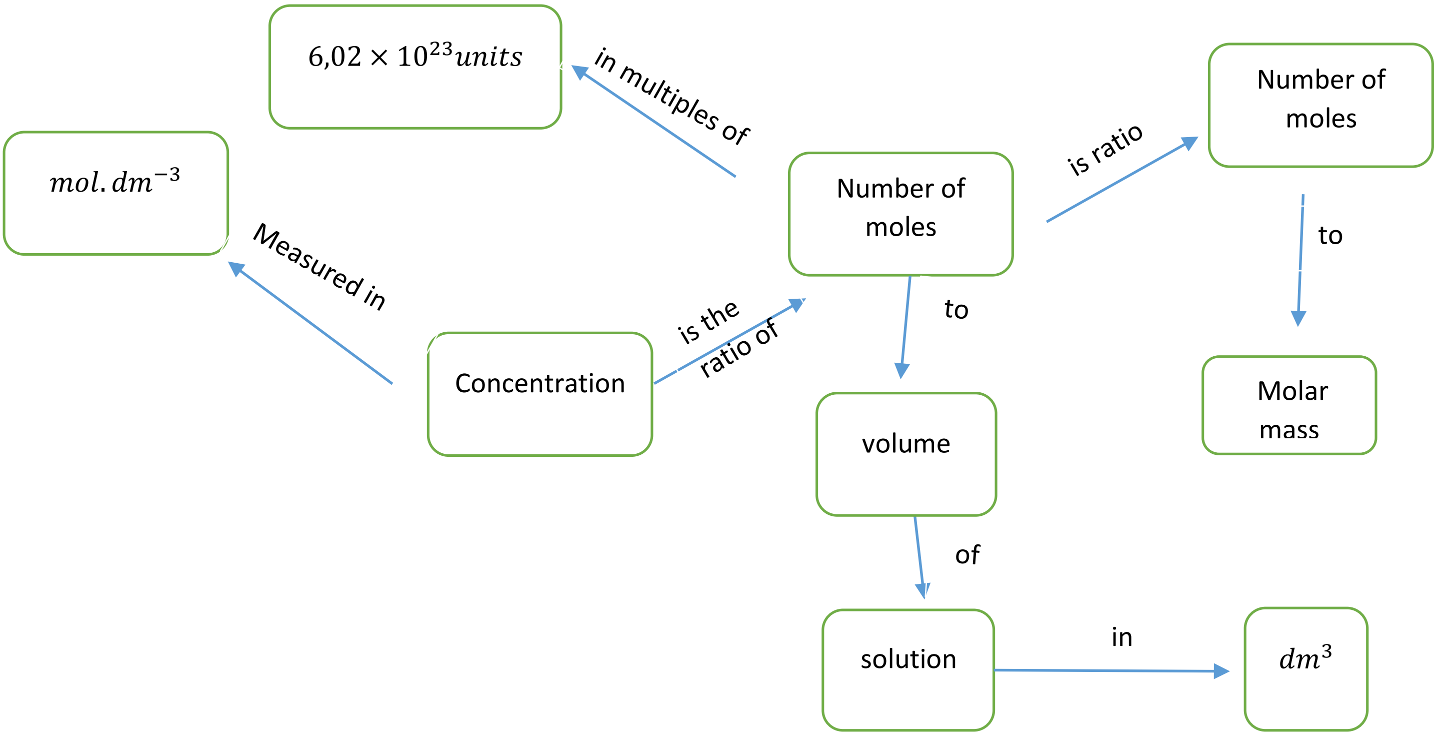
A learner who has the problem of not knowing where to start might be assisted by breaking the question into parts as follows:

a) How many moles of nitrogen are there in 60 litres of nitrogen?
b) How many litres of hydrogen are there in 150 litres of hydrogen?
c) Using the mole ratio in the chemical equation and the answers in (a) and (b) above how many moles of ammonia will be formed and finally
d) How much ammonia will be formed?

Failure to notice or to understand the relationship among concepts can be approached using concept maps in teaching. Concept maps show the link between concepts and can be used to assess understanding or to inform teaching.

7. Use of concept maps in teaching to facilitate association of concepts.

Learners have to be given exercises to design concept maps or maps with gaps where they have to fill missing information.



8. Concluding Remarks

The approach to focus teachers' attention on learner errors for purposes of informing their practice in class is the way to go. Learner responses to verbal questions are an ideal source of information about learner errors. Teachers are in the best position to know the thinking behind those errors if they allow learners to give reasons behind their answers Reminding teachers to pay attention to learners' wrong answers should be part and parcel of the workshop focus.

The source of errors have been categorised in this manual. Lack of prior knowledge directly related to the problem and lack of knowledge related to the problem is one of the source of errors. Teachers should be able to detect lack of prior knowledge and engage learners in gap filling exercises. Teachers tend to focus on finishing the syllabus at the expense of ensuring that gaps are filled. Extra classes and vacation classes can assist in providing extra time for extra tuition.

The second source of learner errors that has been identified is lack of association of concepts. Concepts in science are related. Learners' involvement in designing their own concept maps and flow diagrams should be encouraged for them to get used to relating concepts to each other. When learners get new information, they should be in a position to relate it to existing knowledge.

The lack of problem recognition skill as a source of error is the third category learners should be assisted with. It begins with what has been given, then what is required to be proved followed by a systematic proof. What is key to problem solving is how to sift the relevant information to be used from the pool of knowledge possessed. Learners need short regular assessments with regular feedback for them to master the problem solving skills.

Given learner responses with incorrect answers, teachers should be in position to know what is lacking in the learners' knowledge structure and provide appropriate remedial intervention.

9. References

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