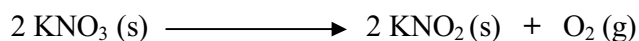
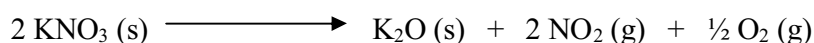


Which Is the Correct Equation?**Aim**

To design an experiment to measure a volume of gas that will show which of the two equations given is more likely to be the correct volume.

Experiment Equations (s)**Equation 1:**

Moles of Gas = 1

Equation 2:Moles of Gas = $2 \frac{1}{2}$ **Risk assessment/ Safety.**

Safety while working in the chemistry lab is must if I want to achieve accurate and reliable results in conjunction with not harming my self or other chemists around me.

Some of the precautions I will undertake:

- Wearing safety goggles at all times, this ensures that no chemicals make contact with my eyes.
- Wearing a laboratory coat to ensure that there are no spillages onto my clothing.
- Using a bench mat to avoid spillages onto my work bench.

- **Nitrogen dioxide² (gas)** - Highly toxic by inhalation, can be fatal. Severe respiratory irritant. Gloves must be worn and syringes that contain the gas must be dismantled in the fume cupboard while wearing a face mask.
- **Potassium nitrate** - inhalation causes irritation to the respiratory tract. Can be avoided by carrying out potentially hazardous steps of the method in a fume cupboard, wearing a face mask and/or taking care not to raise any dust of potassium nitrate. Wear gloves to avoid spilling potassium nitrate¹ skin, causes irritation.
- **Oxygen (O₂)** - not a hazard.
- Clamp test tube on stand and wait for it to cool before touching to avoid being burnt.
- Glass can melt and in doing so a hole may be melted into the test tube. To minimise the chances of this happening, while heating the test tube, move the flame to different places of the test tube (making sure it is kept far enough from the rubber bung), this stops only one part being heated.
- Dispose waste in waste beakers, in the fume cupboard.
- Wash hands when finished.

Apparatus and Chemicals

Method

1. Assemble the apparatus (refer to *Figure 1*) without the addition of potassium nitrate and check for faults and/or leaks.

A quick and simple way to check if the syringe is faulty is to draw a convenient volume of air into the syringe, e.g. 50 cm³ (before connecting it to the test tube).

Push and pull the plunger in a gentle manner. It should feel springy and return near to the position it started in.

2. Dismantle the apparatus and stand the tube in a dry 100 cm³ beaker on a top-pan balance. Set the reading to 0.00 using tare (T).
3. Weight as accurately as possible, the calculated mass (this will be calculated and shown later in the write-up) into the test tube (which is standing inside the beaker). Potassium nitrate can cause irritation to the respiratory tract; therefore, care should be taken as to avoid raising dust.
4. Spread potassium nitrate out at the bottom of the test tube. This will increase the surface area and therefore increase the reaction rate.
5. Assemble the apparatus again, remembering to clamp the test tube horizontally (close to its open end). Make sure the plunger is at zero or, take an initial reading and subtract from the final volume.
6. Heat the potassium nitrate gently at first (air hole of the Bunsen burner is about half open). Heat strongly towards the end of the reaction, this makes sure all of the reactant has reacted.
7. Stop heating the potassium nitrate when the decomposition has finished. This will be clear as the plunger will have stopped moving as no more gas is being produced.
8. After waiting for around five minutes for the syringe cool before taking the reading.
9. Repeat the experiment 9 more times. Replicating the experiment makes the results reproducible and highlight anomalies, therefore increasing the reliability of the experiment.
10. Wash hands when finished.

Ensuring accuracy

- To minimise transfer loss of potassium nitrate, stand test tube in beaker when weighing out on balance and put potassium nitrate in test tube.. This will ensure there is no need to transfer from potassium nitrate from different containers unnecessarily.
- Replicating the experiment makes the results reproducible and highlight anomalies, therefore increasing the reliability of the experiment.
-

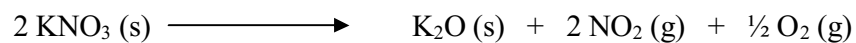
Calculations

I have decided to aim for 80cm^3 of gas to be produced. I have chosen this volume because it is a number that will give a more reliable result. Since the capacity of the syringe is 100cm^3 , anything less than 100cm^3 would not give a reliable result. However, using the appropriate mass of potassium to produce a volume of gas more than $80/85\text{cm}^3$ would carry a risk of expanding to greater volume of the syringes capacity (due to heating). Furthermore, the balance has an error so there is again the chance of overfilling the syringe.

The first thing that will need to be calculated is how many grams of potassium nitrate I will need. To find this I will use the equation:

$$\text{Moles} = \text{volume of gas} \div 24000 \text{ cm}^3$$

I will substitute this formula into equation 2 as it produces the most gas (this is because there is a risk of overfilling the syringe if I use equation 1, but the more accurate equation is 2):



Moles:	2	1	2	$\frac{1}{2}$
--------	---	---	---	---------------

Step 1

Work out the number of moles of gas:

$$= 80 \div 24000 \text{ cm}^3$$

$$= 3.33 \times 10^{-3}$$

Step 2

Work out the ratio of potassium nitrate to combined gases:

$$= 2:2^{1/2}$$

$$= 4:5$$

÷ by smallest number (the number of moles in KNO_3)

$$= 1:1\frac{1}{4}$$

Step 3

By applying the simplest ratio (above), I can calculate how many moles of potassium nitrate I should weigh out:

If 1: 1¼

Therefore using the ratio, number of moles of potassium nitrate

$$= 3.33 \times 10^{-3} \times 4/5$$

$$= 2.67 \times 10^{-3}$$

Step 4

Knowing the amount of moles of potassium nitrate I need to weigh out will enable me to find the mass using the equation:

$$\text{Mass(g)} = \text{no. moles} \times A_r \text{ or } M_r$$

$$\text{Therefore mass of KNO}_3 = 2.67 \times 10^{-3} \times (39.1 + 14 + (16 \times 3))$$

$$\text{Mass of KNO}_3 = 0.27\text{g}$$

Weighing

Weighing out the potassium nitrate will involve the use of a balance. This will be done using a balance that shows mass (g) to two decimal places; 2dp balance.

A 2dp balance has an uncertainty of $\pm 0.02\text{g}$.

We can use this number and the mass of potassium nitrate to find the percentage error, using the equation:

$$\begin{aligned} \% \text{ Error} &= (\text{uncertainty} \div \text{mass (g) weighed out}) \times 100. \\ &= (0.02 \div 0.27) \times 100 \\ &= 7.41 \% \end{aligned}$$

The percentage error is too high and is therefore compromising the accuracy of the experiment. Therefore, balance giving a mass to 3 decimal places can be used as it has an uncertainty of 0.002g .

$$\begin{aligned} \% \text{Error} &= (0.002 \div 0.27) \times 100. \\ &= 0.74 \% \end{aligned}$$

This would give a more reliable result; however, we do not have access to 3dp balances in our school chemistry labs.

Is it possible to tell which equation is ‘correct’?

Total % Error for **equation 2** = % Error of syringe $((1 \div 80) \times 100)$ + % Error of 2dp balance (7.40)

*It is one 1 divided by 80 as that the scale of the syringe can have an error of ± 1 .

$$= 1.25 + 7.41 = 8.66\%$$

8.66% of $80\text{cm}^3 = 6.92$ therefore, the ranges of values for **equation 2** are:

If the volume of gas lies somewhat between this range, then equation 2 is correct.

$$76.5 \rightarrow 80 \rightarrow 83.5\text{cm}^3$$

For equation 1, to work out the total error, I will first need to know the volume of gas

I will be trying to collect. This can be calculated using both the equations:

$$\text{Moles} = \text{Mass (g)} \div A_r \text{ or } M_r$$

And...

$$\text{Mass (g)} = \text{Moles} \times 24000\text{cm}^3$$

Step 1

I know that I need to weigh out 0.27g for two moles of potassium nitrate.

For equation 1, potassium nitrate has a 2:1 mole ratio to the volume of gas produced (oxygen).

Firstly I will need to convert the 0.27g of potassium nitrate into a molar value;

$$\begin{aligned} \text{Moles} &= 0.27\text{g} \div (39.1 + 14 + (16 \times 3)) = 0.27\text{g} \div 101.1 \\ &= 2.67 \times 10^{-3} \end{aligned}$$

Step 2

However the molar value calculated is for two moles (2:1 ratio of potassium nitrate to oxygen). Therefore, to convert it into a value of one mole, I will divide by two.

$$\begin{aligned} &2.67 \times 10^{-3} \div 2 \\ &= 1.335 \times 10^{-3} \text{ mol} \end{aligned}$$

Step 3

Since I know the number of moles of the oxygen gas, I can substitute this value into the equation **Mass (g) = Moles x 24000cm³**.

$$= (1.335 \times 10^{-3}) \times 24000\text{cm}^3$$

$$= 32.0\text{cm}^3$$

Therefore, total % Error for **equation 1** = % Error of syringe ((1÷32.0) x 100) + % Error of 2dp balance (7.40)

$$= 3.1 + 7.40 = 10.5\%$$

10.5% of 32.0cm³ = 3.37 therefore, the ranges of values for **equation 1** are:

$$30.3 \rightarrow 32.0 \rightarrow 33.7\text{cm}^3$$

If the volume of gas produced lies somewhat between this range, then equation 1 is correct.

So, I know that by considering apparatus error it can be possible to distinguish which equation is 'correct'. However, there may be others that are not quantifiable. For example, if 55cm³ was the result you would not be able to tell which equation was correct.

.....

Figure 1³

References

1. <http://www.jtbaker.com/msds/englishhtml/P5950.htm>
2. http://physchem.ox.ac.uk/msds/Nl/nitrogen_dioxide.html
3. The Bench Chemists Guide, pg 22- Hills Road Sixth Form College, chemistry department.

.....