

**Investigation A: “How much sugar is in an alcopop?”**

Requirements (per group)

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| --- | --- |
| **Chemicals** | **Apparatus** |
| 1 bottle of sucrose | 1 accurate balance |
| Bottles of alcopops e.g. Bacardi Breezers | 1x 500ml standard flask |
| Deionised water | 8 x 50ml standard flasks† |
|  1 bottle of ethanol (100ml) | 25 ml pipette |
|  | Pipette fillers |
|  | Pipettes available to measure 35ml (or use a burette) |

**Teaching notes**

**Background**

This has a similar approach to that on investigation 1. This investigation uses the fact that sugar solutions are more dense than water and so the density can be used to calculate the sugar content of the drink. Wine, beer and cider makers use this method to follow the progress of their fermentations and to calculate the amount of alcohol. The solution starts off dense due to the sugar and the density gradually drops and the sugar is converted to less dense alcohol.

**Experiment**

1. If possible, it would be easier to make sure that the class is using alcopops of the same alcohol concentration. That way a larger volume of, say, 5% ethanol in water can be made up in advance for them to use for making their sucrose solution – it also means that it is possible to pool results for the reference curve.
2. † It is OK to just use the 1 flask if need be. As long as the initial mass of the flask is taken when dry and that is the figure that is subtracted from the final masses of the solutions, the results will still be valid.
3. It is impossible to pipette a liquid accurately if it is fizzing. To de-gas a sample. Put it in a flask and stir or shake. (Or shake it in a bottle releasing the pressure by undoing the cap from time to time).
4. For calculating the density of the alcopop samples, you can just use an ordinary flask or beaker. The volume is measured accurately with the pipette so just weigh the container, add the 25cm3 of alcopop, re-weigh and subtract the first reading.
5. It is important that pupils make **accurate** measurements to help construct a good calibration graph. Pupils could plot their results using an Excel spreadsheet so that they can quickly check their graph and re-do any standard solutions which produce results which lie outside the best fit line. If time is available, pupils could be encouraged to repeat their experiments.

Measurements really do need to be made **very carefully**. A difference of 1 drop is about 0.02g and this can give a difference in the final alcohol percentage of about 0.2% - which considering we are mainly looking at a range of 5 – 10 sugar is quite significant.

The collation of the calibration readings from the whole class (or at least a few groups) should allow the construction of a more accurate calibration curve.

For this technique to work, the drink must not contain lots of other compounds which could significantly affect the density of the drink. In trials, Bacardi breezers produced fairly accurate results, but slightly more viscous drinks (such as Blue WKD) did not produce accurate results.

Some brands state the sugar content on the ingredients label. Again, it would seem sensible to “hide” this from pupils to give them a greater sense of satisfaction as they solve the problem.

The method used has been adapted from a technique used to determine the sugar content of soft drinks: <http://ares.unimet.edu.ve/quimica/fbqi01/Labqui/p1122.pdf>

**Investigation B: Do all white wines contain the same % alcohol?**

Requirements (per group)

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| **Chemicals** | **Apparatus** |
| 1 bottle of ethanol (200 cm3) | 6 x 100 cm3 volumetric flasks† |
|  | 1x 50 cm3 volumetric flask |
| Deionised/distilled water | Accurate balance (at least 2dp) |
| 1 bottle of 2M NaOH (aq) (250 cm3) | Graduated pipettes to allow measurement of 8-20 cm3 (Alternatively, use a burette) |
| 2 bottles of white wine | Pipette fillers |
| 1 jar of boiling chips | 50 cm3 or 25cm3 pipette |
|  | 100cm3 RB flask with quickfit attachments to perform a distillation (include thermometer) |
|  | 1 heating mantle |

**Teaching notes**

**Background**

Ethanol has a lower density than that of water. (0.79g/cm3). As a result, the higher the concentration of ethanol in a mixture of ethanol and water, the lower its density will be. This experiment uses standard mixtures of ethanol and water to create a density reference curve and then pupils distil samples of wine to extract the alcohol, calculate its density and use their graph to convert this figure into a % alcohol reading.

**Experiment**

1. It is quite acceptable to use IMS (Industrial Methylated Spirit) rather than pure ethanol for the reference samples. The main other constituent apart from ethanol is methanol and the densities of the two are very close.
2. † It is OK to just use the 1 flask if need be. As long as the initial mass of the flask is taken when dry and that is the figure that is subtracted from the final masses of the solutions, the results will still be valid.
3. The protocol suggests collecting about 25 cm3 of distillate and diluting up to 50 cm3. This should ensure that all the ethanol has come over. By this stage, the thermometer should be reading 100°C (though variations in air pressure will have an effect on this)
4. Prior to distillation, pupils should add a small amount of 2M NaOH to ensure any volatile acids do not distil over with the ethanol. To be accurate, pupils may wish to carry out a trial titration to see how much NaOH they should add to just neutralise the wine. (The figure used in the industry is pH8.2). We have found that 2.5 cm3 each time has been fine. If in doubt, add a little extra rather than too little.
5. It is important that pupils make **accurate** measurements to help construct a good calibration graph. Pupils could plot their results using an Excel spreadsheet so that they can quickly check their graph and re-do any standard solutions which produce results which lie outside the best fit line. If time is available, pupils could be encouraged to repeat their experiments.

Measurements really do need to be made **very carefully**. A difference of 1 drop is about 0.02g and this can give a difference in the final alcohol percentage of about 0.25% - which considering we are mainly looking at a range of 12 – 14 alcohol v/v is quite significant.

The collation of the calibration readings from the whole class (or at least a few groups) should allow the construction of a more accurate calibration curve.

1. If the white wine is fizzy, pupils will have to de-gas the sample as it will be difficult to measure an accurate volume using a pipette. Simply swirling a sample of the wine in an open conical flask will do this. (Of shaking in a bottle, releasing the lid from time to time).
2. The density of the wine cannot be used directly as it contains many other substances which affect the density. The point of the distillation technique is to ensure that the sample made from the wine is really just ethanol and water.\* To achieve this, two procedures are performed;
	1. the wine is made alkaline. This ensures that any volatile acids in the wine have reacted-to produce non-volatile salts- to prevent them carrying over during distillation and affecting the density.
	2. the wine is distilled. This ensures that only ethanol and water are present in the solution produced.

\* A quick smell of the distillate will suggest to pupils that this is not so – particularly in comparison with the ethanol/water samples they made up for the reference graph. Wine is an immensely complex mixture with hundreds of different components. The distillation does not give pure ethanol but it does make sure that the amount of most other components is minimised. In fact, if you look at the densities for the various other alcohols and esters that are present (all of them in small quantities) the figures are pretty close to that of ethanol so it can be ignored.

1. Most wines have the % ethanol displayed. You may wish to “hide” this from pupils so that they gain a greater sense of satisfaction from working out the value.

The following A-level chemistry website provides lots of useful Q&A for both pupils and teachers

<http://www.chemistry-react.org/go/search/SearchResults.html?action=SearchActions&action_search=search&search_scope=1&search_query=wine>

**Investigation C: “How does the SO2 concentration of wine compare with cider?”**

**Investigation D: “Do white wines from different countries have different concentrations of SO2 ?”**

**Investigation E: “How does the concentration of SO2 in a dry white wine compare with that in a sweet white wine?”**

**The same methods used in all three of these investigations.**

Requirements (per group)

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| --- | --- |
| **Chemicals** | **Apparatus** |
| white wine/cider | 2 x 25cm3 pipettes |
| 1 bottle of starch solution (1%) | 2x250 cm3 conical flask |
| Deionised water | White tiles |
|  2 moll-1 sulphuric acid (aq) (250 cm3) | 2x burettes and stands |
| 1 moll-1 sodium hydroxide (aq) (250 cm3) | Pipette fillers |
| 1 bottle of standard iodine (aq) 0.001 moll-1(500 cm3) |  |
| 1 bottle of standard iodine (aq) 0.005 moll-1(500 cm3) |  |
| 1 bottle of dilute sodium thiosulphate for spills |  |

**Teaching notes**

**Background**

Sulphur dioxide is used as a preservative in wine making. Chemists refer to two types of sulphur dioxide:

(i) free - e.g. SO2, H2SO3, HSO3- and SO32-

(ii) combined- joined to aldehydes, ketones and phenolic derivatives.

We also use the term total SO2. Total = free + combined

The bound SO2 doesn’t have antimicrobial activity, but the free does. Hence, it’s important that winemakers are able to analyse their wine and assess the concentration of these compounds.

The SO2 content is determined via the following redox titration using starch as indicator:

SO2 (aq) + I2(aq) + 2H2O (l) 🡪 4H+ (aq) + SO42- (aq) + 2I- (aq)

If a standard iodine solution is added to a sample of wine, the iodine will react with the SO2.

When all of the SO2 has reacted, the iodine will react with the starch to give a blue-black colour. This is the end-point.

The concentration of SO2 can be calculated since 1 mole of iodine reacts with 1 mole of SO2.

Most countries express this concentration in ppm which is the same as mgl-1.

If a pupil calculates moles of SO2 as 0.00025 moles for 50ml of wine

* Mass SO2 = moles x formula mass = 0.00025 x 64 = 0.016g

i.e. 0.016g per 50ml of wine

* Per 1000ml of wine = 0.016 x (1000/50) = 0.32 g
* 0.32g = 0.32 x1000 = 320mg

So, the concentration is 320 mg l-1 = 320 ppm

Different countries have set different limits for the SO2 concentration. Generally, the limits are between 200 and 400 ppm.

### Maximum permitted levels of SO2 in mg/l

| **Type of wine** | **EU law** |
| --- | --- |
| **Red** | 160 |
| **White / rose** | 210 |
| **Sweet** | 400 |

**Experiment**

1. The titration is quite straightforward but the end point can be hard to see. To help with this;
	1. Use a more concentrated starch solution. We have found that a 5% solution gives a clearer end point.
	2. Have a ‘reference sample’ in a flask next to the one you are titrating. This should contain
		1. Your 25 cm3 aliquot of wine,
		2. 5 cm3 of 2M H2SO4 and
		3. roughly the amount of iodine solution equal to your titre.

This will give you a sample of the colour just before the change to compare. If your sample is still this colour – or returns to it quickly – then reaction is not complete.

1. Calculation

The calculation is fairly straightforward – here is a table showing the steps – for 2 readings (27.9cm3 for the free SO2 and 15.9cm3 for the total SO2.

|  |  |  |  |
| --- | --- | --- | --- |
|   | Free SO2 | Total SO2 |   |
| Titre | 27.9 | 15.9 |  |
| Mols | 0.0000279 | 0.0000795 | *= Titre x [I2]/1000 (0.001 for free and 0.005 for total)* |
| Mols/l | 0.001116 | 0.00318 | *= No of mols (above) x 1000/aliquot (25cm3 in this case)* |
| g/l | 0.069192 | 0.19716 | *= Mols/l x RMM SO2 (64)* |
| ppm | 69.192 | 197.16 | *1ppm = 1mg per l* |

Useful additional reading

1. <http://www.morethanorganic.com/sulphur-in-the-bottle>

2. <http://aurora.wells.edu/~agodert/Classes/Chm324LabDocs/Lab4%20-%20Free%20and%20total%20SO2.pdf>

3. <http://www.chemistry-react.org/go/search/SearchResults.html?action=SearchActions&action_search=search&search_scope=1&search_query=wine>