

**OXFORD CAMBRIDGE AND RSA EXAMINATIONS  
AS GCE**

**F332/01**

**CHEMISTRY B (SALTERS)**

**Chemistry of Natural Resources**

**ADVANCE NOTICE**

**For issue on or after: 13 MARCH 2014**

**DURATION: 1 hour 45 minutes  
plus your additional time allowance**

**MODIFIED ENLARGED**

**READ INSTRUCTIONS OVERLEAF**

## **NOTES FOR GUIDANCE (CANDIDATES)**

- 1 This leaflet contains an article which is needed in preparation for a question in the externally assessed examination F332.**
- 2 You will need to read the article carefully and also have covered the learning outcomes for Unit F332 (*Chemistry of Natural Resources*). The examination paper will contain questions on the article. You will be expected to apply your knowledge and understanding of the work covered in Unit F332 to answer these questions. There are 20 marks available on the paper for these questions.**
- 3 You can seek advice from your teacher about the content of the article and you can discuss it with others in your class. You may also investigate the topic yourself using any resources available to you.**
- 4 For the examination on 3 JUNE 2014 you will be given a fresh copy of this article, together with a question paper. You will NOT be able to bring your copy of the article, or other materials, into the examination.**
- 5 You will not have time to read this article for the first time in the examination if you are to complete the examination paper within the specified time. However, you should refer to the article when answering the questions.**

**Any blank pages are indicated.**

## **INSTRUCTION TO EXAMS OFFICER/INVIGILATOR**

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# Chemistry of Wine

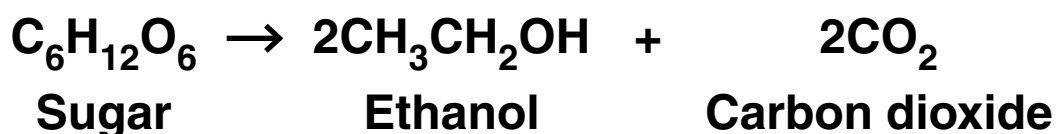
Article taken from Chemistry Review Magazine, published by Philip Allen, Volume 21, number 2, November 2011.

It is not known for sure when and where the alcoholic beverage we now know as wine was first produced, but it is generally agreed that it dates back to around 4000 BC, perhaps even as early as 6000 BC. References to wine are found in many ancient cultures, such as the biblical reference to Noah's planting of a vineyard and making wine, to references in Ancient Egyptian texts, and Dionysus, the Ancient Greek god of winemaking.

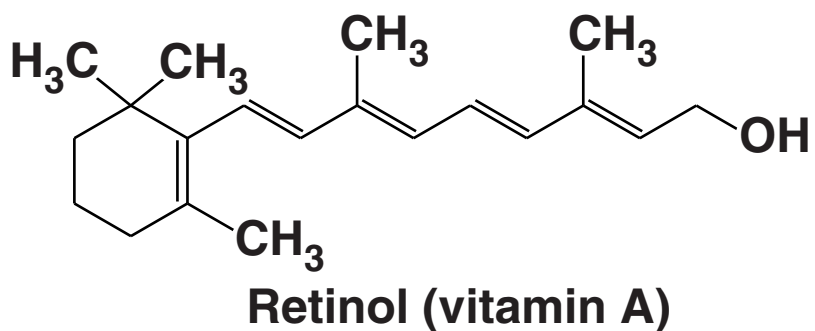
Wine has certainly played a significant role in religious ceremonies, which meant that monks were at one point largely responsible for the production of wine in Europe. Outside religious ceremonies, wine was mainly consumed by royalty and priests, whereas ale was the drink of the majority, which echoes the impression we still have today of a glass of wine being a more sophisticated drink than a pint of beer.

## Turning grape juice into wine

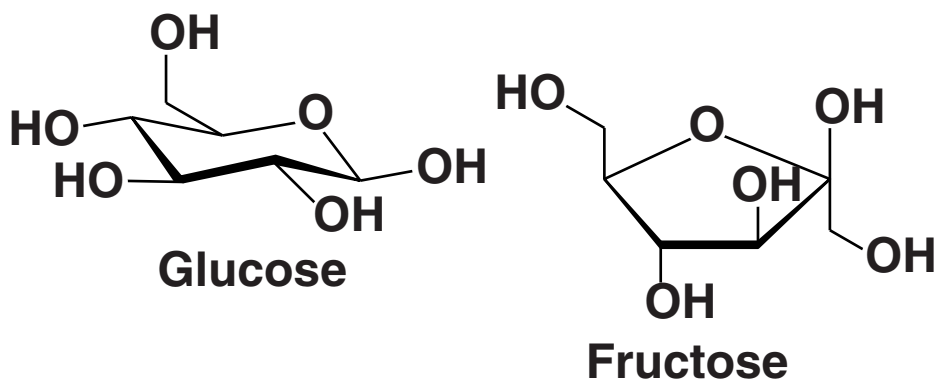
After harvesting, the grapes are crushed to release their juices. Like most fruit juices, the grape juice is a mixture of sugars and organic acids including vitamin C (Fig. 1). To change this into wine, yeast is used to convert the glucose and fructose sugars to ethanol in the fermentation process, which involves a series of biochemical pathways.



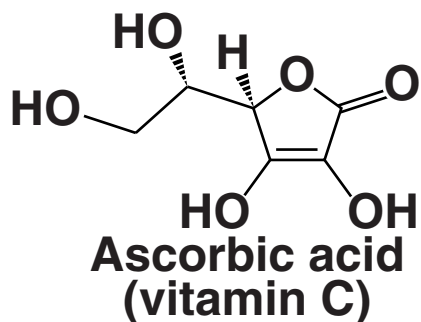
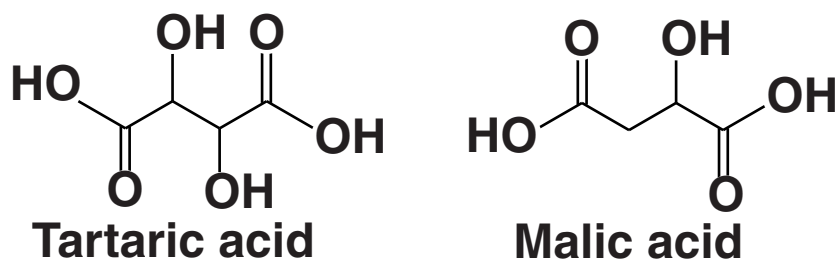
**Fig. 1: Some of the compounds found in grape juice**



### **Sugars**



### **Organic acids**



**For red wine the juice is left to ferment with the grape skins or stalks. White wine is made using just the juice. The fermentation can be carried out either by yeasts that naturally occur on the grapes (sometimes visible as a white 'dusting' on the grape's exterior) or using yeast that has been specifically cultured for use in wine fermentation.**

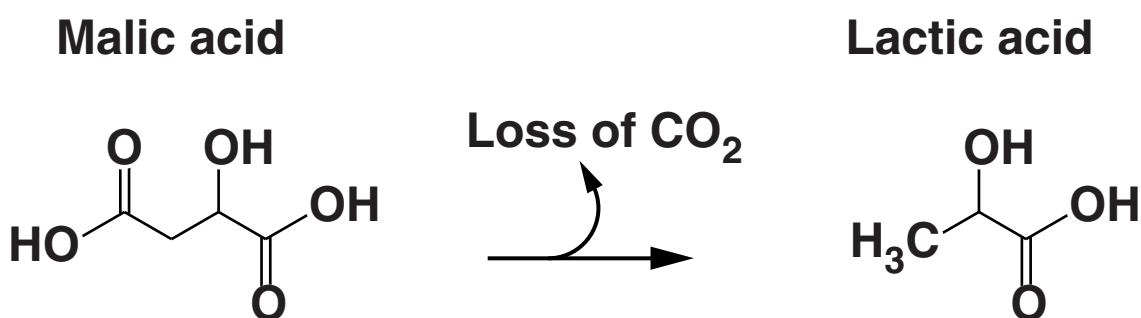
**The first stage of the fermentation process is carried out aerobically (in the presence of oxygen) and occurs relatively rapidly, typically over several days to a week. The yeast uses the nutrients within the grape juice to feed, grow and reproduce.**

**During this time about three quarters of the fermentation within the wine will have taken place. The secondary fermentation phase is carried out under anaerobic conditions (ie in the absence of oxygen), and being much slower, can last for several weeks. By minimising the oxygen supply, cell replication of the yeast cells is made unfavourable, effectively forcing the remaining sugars within the liquid to be used for anaerobic respiration to produce ethanol.**

# Fine-tuning the flavour

With some wines, another process is often needed to obtain the desired flavours. Malolactic acid fermentation mainly involves the conversion of malic acid into the less acidic tasting lactic acid (Fig. 2). Malic acid is the more acidic out of the two, and is the main acid that provides the flavour in green apples, whereas lactic acid is the main acid in fermented dairy products such as yogurt. With wines such as Rieslings this process would take away their characteristic flavour, so is prevented from occurring. It has been proposed that the malolactic fermentation process also increases the amount of volatile molecules within wine. Before this process many of the aroma compounds, such as terpenes, are bound to sugars, effectively ‘anchoring’ them to the solution and preventing them forming a vapour above the surface of the wine. The malolactic fermenting bacteria produce glycosidase enzymes that cleave the sugar-binding bonds, enabling the molecules to be more volatile. Wines that have undergone malolactic fermentation typically have a more buttery taste (such as aged Chardonnays), which is primarily due to increased levels of butanedione (diacetyl). Chemical reactions can also be detrimental to the flavour of wine, and can even make it undrinkable (Box 1).

Fig. 2: Conversion of malic acid to lactic acid



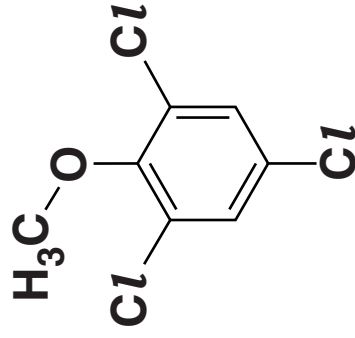
## **Box 1: Corked wine**

**Occasionally a bottle of wine, no matter how expensive, is said to be undrinkable because of it being 'corked'. Corked wine is recognisable by its mouldy, damp smell and taste, which is mainly due to the compound 2,4,6-trichloroanisole (TCA), but also 2-methoxyphenol, geosmin, 2-methylisoborneol, oct-1-en-3-ol and oct-1-en-3-one (Structural formula of compounds on page 8).**

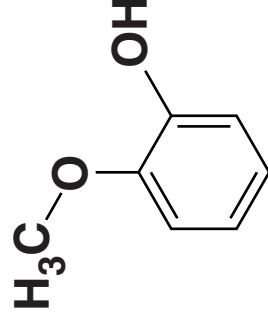
**The generation of TCA in the cork of the wine is thought to have several possible sources. Chlorophenol compounds can be taken up by the cork tree from pesticides or can result from chemical treatments used to sterilise the wine corks before use. It is also hypothesised that it may be the result of compounds the tree itself has evolved to produce in order to protect itself from fungal attack. Microorganisms can then convert these chlorophenol compounds to TCA, which can be tasted at incredibly low levels in wine. In white wines, TCA needs only to be present at about two parts per trillion for the bottle to be ruined, while in red wine it is about five parts per trillion.**

### Box 1: Corked wine (Structural formula)

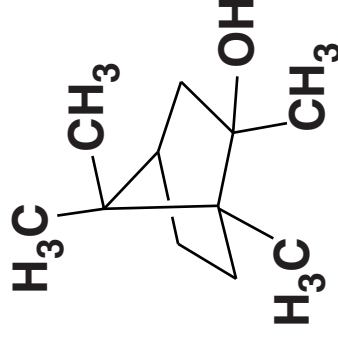
2,4,6-trichloroanisole



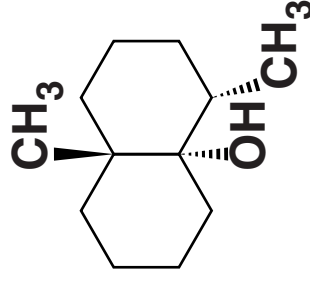
2-methoxyphenol



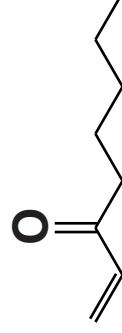
2-methylisoborneol



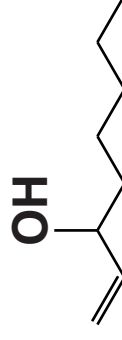
Geosmin



Oct-1-en-3-one



Oct-1-en-3-ol



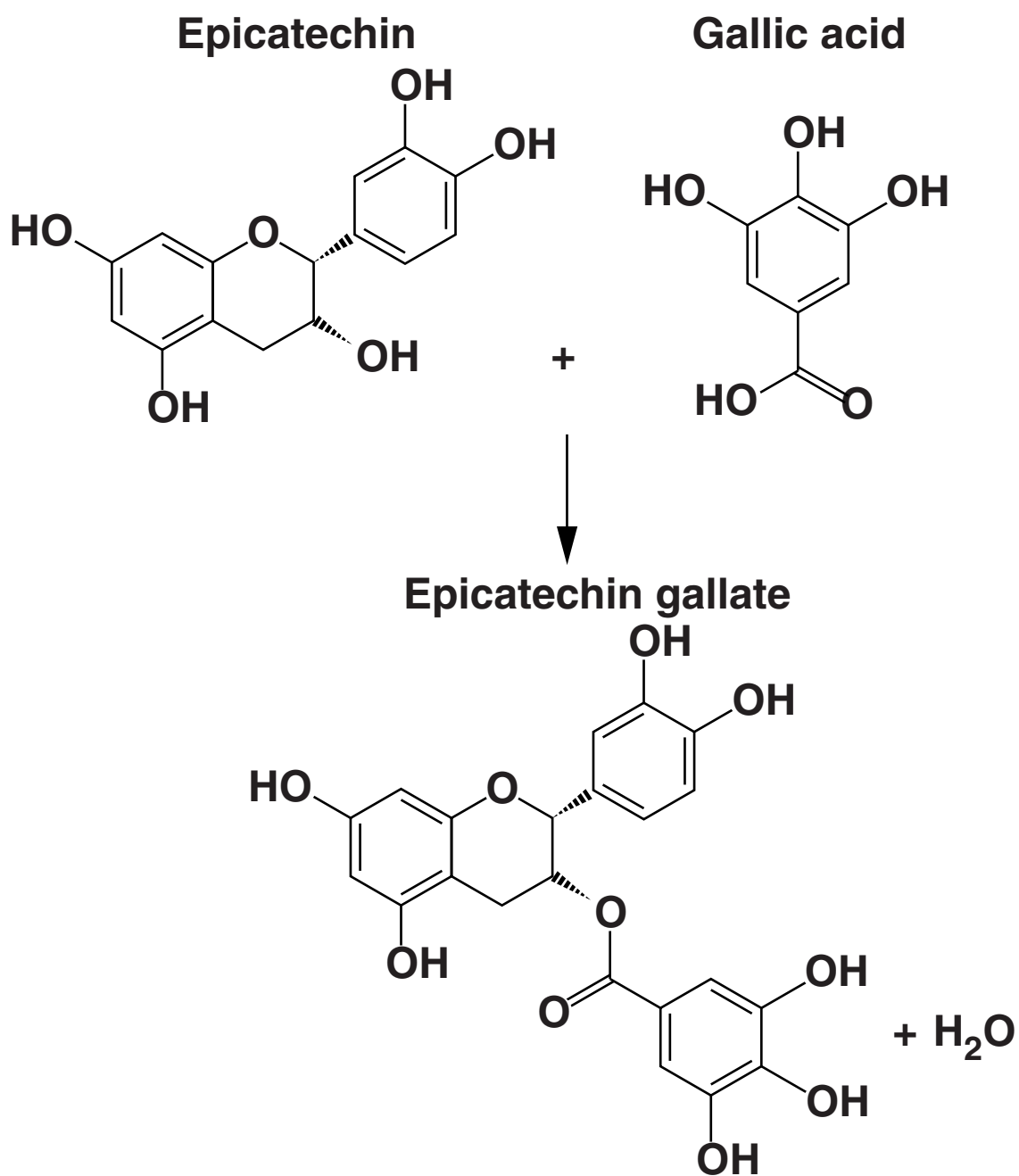
## **A cocktail of compounds**

**Wine contains an enormous number of different compounds, including several types of flavanoid-type polyphenols, whose basic structure consists of two fused six-membered carbon rings bonded to another six-membered ring.**

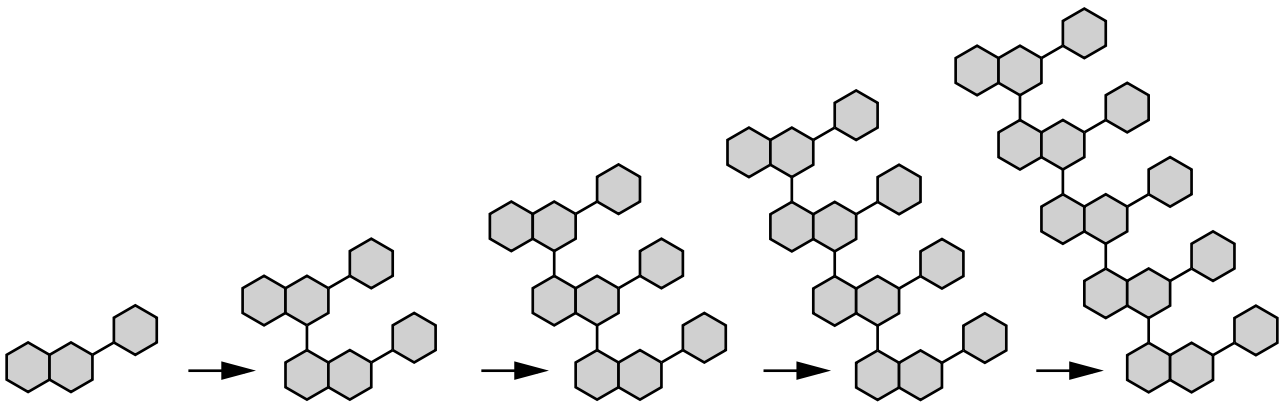
**There are several types of polyphenolic compounds found within wine, such as flavanols and anthocyanins. Flavanols, also known as catechins, found in wine are predominantly in the form of esters, which they form with gallic acid (Fig. 3). This is the most abundant type of polyphenolic compound found in wine and grapes, occurring within the fruit's skin and seeds. They are also found in tea.**

**Flavanols have a tendency to partially polymerise to form proanthocyanidins or fully polymerise to form condensed tannins. Polymerisation of flavanols has the effect of reducing their bitter flavour, but has little effect on their astringent (sharp) taste. With wines that have been aged over many years, the tannin polymers can continue to increase in size (Fig. 4) until they are no longer able to remain in solution, giving rise to the precipitate that is sometimes observed in aged wines.**

**Fig. 3: Ester formation between epicatechin and gallic acid**



**Fig. 4: Polymerisation of flavanols to form condensed tannins, which is catalysed by the low pH of the wine**





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