*3176628830*

# Tuesday 3 June 2014 – Afternoon

## AS GCE CHEMISTRY B (SALTERS)

**F332/01/TEST** Chemistry of Natural Resources

Candidates answer on the Question Paper.

**OCR supplied materials:**
- *Data Sheet for Chemistry B (Salters)* (inserted)
- *Advance Notice: 'Chemistry of Wine'* (inserted)

**Other materials required:**
- Scientific calculator

**Duration:** 1 hour 45 minutes

*F33201TEST*

| Candidate forename | | Candidate surname | |
|---|---|---|---|

| Centre number | | | | | | Candidate number | | | | |
|---|---|---|---|---|---|---|---|---|---|---|

**INSTRUCTIONS TO CANDIDATES**

- The Inserts will be found inside this document.
- Write your name, centre number and candidate number in the boxes above. Please write clearly and in capital letters.
- Use black ink. HB pencil may be used for graphs and diagrams only.
- Answer **all** the questions.
- Read each question carefully. Make sure you know what you have to do before starting your answer.
- Write your answer to each question in the space provided. If additional space is required, you should use the lined pages at the end of this booklet. The question number(s) must be clearly shown.
- Do **not** write in the bar codes.

**INFORMATION FOR CANDIDATES**

- The number of marks is given in brackets **[ ]** at the end of each question or part question.
- The total number of marks for this paper is **100**.
- Where you see this icon you will be awarded marks for the quality of written communication in your answer.
  This means for example you should:
  - ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear;
  - organise information clearly and coherently, using specialist vocabulary when appropriate.
- You may use a scientific calculator.
- The insert *'Chemistry of Wine'* is provided for use with Question 5.
- A copy of the *Data Sheet for Chemistry B (Salters)* is provided as an insert with this question paper.
- You are advised to show all the steps in any calculations.
- This document consists of **20** pages. Any blank pages are indicated.

Answer **all** the questions.

**1** Iodine can be extracted from the ash of burnt seaweed. The ash is washed with water. The remaining solid is heated with manganese(IV) oxide and concentrated sulfuric acid, forming iodine.

$$2I^- + MnO_2 + 4H^+ \rightarrow Mn^{2+} + 2H_2O + I_2$$ **equation 1.1**

**(a)** Complete the table below to show the oxidation states for manganese and iodine in the reaction shown in **equation 1.1**.

| Element | Initial oxidation state | Final oxidation state |
|---|---|---|
| Mn | | |
| I | | |

**[2]**

**(b)** Write the half-equation for the conversion of iodide ions to iodine.

| → |
|---|

**[1]**

**(c)** **Name** the reducing agent in the reaction in **equation 1.1**.

Explain your answer in terms of oxidation states.

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**(d)** Describe the appearance and physical state of iodine at room temperature.

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**(e)** Give **one** use for compounds of the iodine that is produced.

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**(f)** A student extracts iodine from seaweed ash. The student suspects that the water which has been used to wash the ash contains a mixture of salts, including sodium chloride.

The student tests this water to see if it contains chloride ions.

**(i)** What reagent would the student need to add to the water?

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**(ii)** Give the result of the test for chloride ions and name the compound formed.

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**(iii)** Suggest why the student might not get the expected test result.

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**(g)** Iodine and chlorine are both members of the halogen group.

**(i)** Write the electron configuration for a chlorine atom in terms of s and p sub-shells.

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**(ii)** Write the electron configuration for the highest energy sub-shell for an iodine atom.

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**(iii)** Chlorine is more readily reduced than iodine.

Explain what is meant by *reduction* in terms of electrons.

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**(h)** The student collected 0.92 g of impure iodine, $I_2$, and decided to determine its purity.

The student dissolved the impure iodine in potassium iodide solution. This iodine solution was then titrated with sodium thiosulfate solution. The equation for the reaction is shown below.

$$I_2(aq) + 2S_2O_3^{2-}(aq) \rightarrow S_4O_6^{2-}(aq) + 2I^-(aq)$$ **equation 1.2**

**(i)** The titration required 28.40 $cm^3$ of 0.200 mol $dm^{-3}$ sodium thiosulfate solution.

Calculate the number of moles of thiosulfate ions, $S_2O_3^{2-}$, used.

moles thiosulfate = ................................................ mol **[1]**

**(ii)** Give the number of moles of iodine, $I_2$, in the iodine solution.

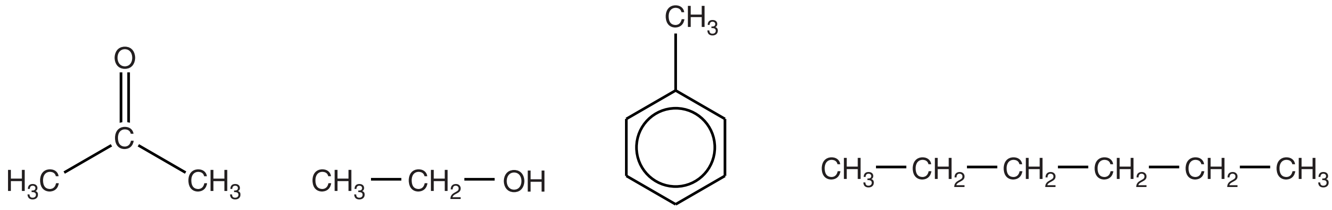
moles iodine = ................................................ mol **[1]**

**(iii)** Calculate the percentage purity of the iodine.

purity of iodine = .................................................. % **[2]**

**[Total: 19]**

**2** The structures of some common organic solvents are shown below.



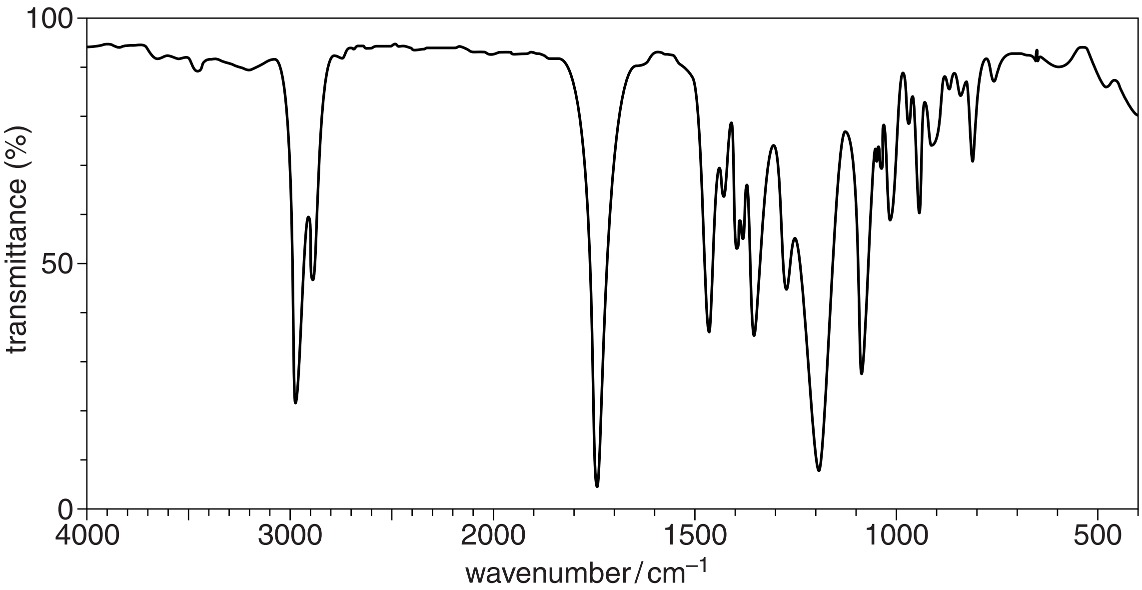

**propanone** **ethanol** **methylbenzene** **hexane**

**(a)** Propanone can be made by the oxidation of an alcohol.

**(i)** **Name** the alcohol from which propanone can be made.

.................................................................................................................................... **[1]**

**(ii)** A student carries out the oxidation of **ethanol**, which can form two different oxidation products. The infrared spectrum of the compound the student obtained is given below.




Use the spectrum to identify the compound formed.

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**(iii)** Explain how the spectrum in **(ii)** shows that no ethanol remains.

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**(b)** Ethanol can be made from ethene in an industrial process.

Give the reagents and conditions required for this reaction.

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**(c)** Propanone dissolves in ethanol and methylbenzene dissolves in hexane.

Name the strongest type of intermolecular bond formed between:

- propanone and ethanol
- methylbenzene and hexane.

Explain how the intermolecular bonds you have named are produced.

*In your answer, you should make it clear how the properties of the molecules you have described result in an intermolecular bond being formed.*

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**(d)** Another common solvent, ethyl ethanoate, can be made by reacting ethanol with ethanoic acid, as shown in the equation below.

$$CH_3CH_2OH + CH_3COOH \rightleftharpoons CH_3COOCH_2CH_3 + H_2O$$ **equation 2.1**

**(i)** The reaction in **equation 2.1** is allowed to reach dynamic equilibrium.

Explain what is meant by the term *dynamic equilibrium*.

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**(ii)** Some ethanoic acid is added to the equilibrium mixture. The mixture is allowed to reach equilibrium again.

Describe the effect on the amount of ethyl ethanoate formed.

Use le Chatelier's principle to explain this effect.

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**[Total: 18]**

**3** The halogenoalkanes $CBr_4$, $CF_3Cl$ and $CBrClF_2$ have been used in fire extinguishers.

**(a)** $CF_3Cl$ is a chlorofluorocarbon.

**(i)** Give the systematic name for $CF_3Cl$.

............................................................................................................................................ **[1]**

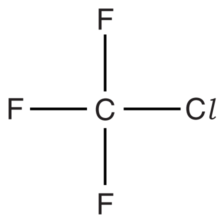
**(ii)** Draw a 3D diagram to show the shape of a $CF_3Cl$ molecule.

Include the bond angle.

**[2]**

**(iii)** The molecules of $CF_3Cl$, contain polar bonds.

Mark **all** the partial charges on the atoms in the diagram of the $CF_3Cl$ molecule shown below.




**[1]**

**(iv)** Explain why the molecule $CF_3Cl$ has the partial charges you have shown in **(iii)**.

*In your answer, you should use appropriate technical terms, spelled correctly.*

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**(v)** Explain whether or not the molecule of $CF_3Cl$ is polar.

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**(b)** When a different halogenoalkane, $CBrClF_2$, is exposed to high temperatures in a fire, one of the bonds in the molecule breaks.

Suggest which bond is most likely to break.

.................................................................................................................................. **[1]**

**(c)** When $CBr_4$ vapour gets into the Earth's atmosphere, a C–Br bond can be broken by UV radiation from the Sun.

**(i)** Name the **type** of bond breaking that occurs.

Explain what happens during this process.

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**(ii)** The minimum frequency of radiation needed to break one C–Br bond is $7.14 \times 10^{14}$ Hz.

Calculate the minimum energy, in J, required to break one C–Br bond.

Planck constant, $h = 6.63 \times 10^{-34}\,J\,Hz^{-1}$

minimum energy = ...................................................... J **[2]**

**(iii)** Calculate the bond enthalpy of the C–Br bond, in $kJ\,mol^{-1}$.

Give your answer to **three** significant figures.

Avogadro constant, $N_A = 6.02 \times 10^{23}\,mol^{-1}$

bond enthalpy = + ............................................ $kJ\,mol^{-1}$ **[3]**

**(d)** The production of $CBrClF_2$ has been banned in most countries since 1994 because it contributes to ozone depletion.

Describe the theoretical work and research that led to the discovery of ozone depletion in the stratosphere and why the evidence was originally overlooked.

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**(e)** Some halogenoalkanes also contribute to global warming.

**(i)** Explain how an increase in the concentration of a greenhouse gas leads to an enhanced greenhouse effect.

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**(ii)** Describe the evidence for the relationship between the increased concentration of greenhouse gases and global warming.

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**[Total: 22]**

4 Natural processes in the air can control some types of atmospheric pollutants, such as carbon monoxide and ozone. Although carbon monoxide emissions increased in the twentieth century, the percentage of carbon monoxide in the troposphere has remained almost constant.

**(a)** The increased use of cars in the twentieth century is one reason for the increase in carbon monoxide emissions.

Explain the origin of these carbon monoxide emissions.

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**(b)** Give **two** reasons why carbon monoxide is classed as a polluting gas.

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**(c)** The reaction of carbon monoxide with hydroxyl radicals helps control atmospheric carbon monoxide concentrations. Hydroxyl radicals form by the breakdown of water molecules.

**Equation 4.1** represents the reaction of carbon monoxide with hydroxyl radicals to produce carbon dioxide.

$$CO + OH \rightarrow CO_2 + H$$ **equation 4.1**

**(i)** Explain what is meant by the term *radical*.

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**(ii)** Classify the reaction represented by **equation 4.1** as initiation, propagation or termination.

Explain your choice.

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$$CO + OH \rightarrow CO_2 + H$$ **equation 4.1**

**(iii)** Suggest why OH radicals are not produced in the **troposphere** by the action of sunlight on water molecules.

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**(iv)** The reaction represented by **equation 4.1** has a low activation enthalpy.

Suggest why the reaction represented by **equation 4.1** still occurs slowly in the atmosphere.

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**(d)** The reaction represented by **equation 4.1** produces carbon dioxide, which is a gas at room temperature. Silicon dioxide, another Group 4 oxide, is a solid at room temperature.

Explain this difference in physical state in terms of bonding and structure.

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**(e)** Scientists monitor the composition of the Earth's atmosphere. They have found that the concentration of carbon dioxide in dry, unpolluted tropospheric air has increased from 300 ppm in 1900 to around 380 ppm today.

**(i)** Calculate the percentage **increase** in carbon dioxide in the air between 1900 and the present day. Take the present day value to be 380 ppm.

increase in carbon dioxide concentration = .................................................... % **[1]**

**(ii)** A sample of air is analysed and found to contain $1.20 \times 10^{-5}$% carbon monoxide by volume.

How much more abundant is carbon dioxide than carbon monoxide in this sample of air? Take the value for carbon dioxide to be 380 ppm.

carbon dioxide concentration = ...................................... times more **[2]**

**(f)** Tropospheric ozone is a pollutant, but the presence of ozone in the stratosphere is important to humans.

**(i)** Give one problem caused by **tropospheric** ozone and one benefit to humans of **stratospheric** ozone.

problem caused by tropospheric ozone ..............................................................................

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benefit of stratospheric ozone ..........................................................................................

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**[2]**

**(ii)** Describe **one natural** process that causes ozone to be **broken down** in the stratosphere.

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**(iii)** Describe **one natural** process that causes ozone to be **formed** from $O_2$ in the stratosphere.

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**[Total: 21]**

**5** This question is based on the Advance Notice article '***Chemistry of Wine***' which is provided as an insert to this paper.

**(a)** During wine production, ethanol forms from sugars in grape juice. If the wine is left open to the air, the ethanol reacts with oxygen and the taste of the wine becomes sharp and acidic.

Suggest the name of the organic compound that gives the wine this sharp taste.

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**(b)** **Box 1** in the article shows the structures of molecules that can make wine undrinkable because it is 'corked'.

**(i)** Give the molecular formula of oct-1-en-3-one.

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**(ii)** Name the **two** functional groups in oct-1-en-3-one.

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**(iii)** Draw a circle around the term from the list below which describes the type of reaction that occurs when oct-1-en-3-ol is converted to oct-1-en-3-one.

**addition** **dehydration** **redox** **substitution**

**[1]**

**(iv)** Name a functional group, other than arene, that is in molecules of both 2,4,6-trichloroanisole and 2-methoxyphenol.

............................................................................................................................. **[1]**

**(c)** **Fig. 1** in the article shows some of the organic compounds found in grape juice.

**(i)** Retinol can exhibit *E*/*Z* isomerism. One part of the molecule responsible for this isomerism is the structure around the C=C nearest to the OH group.

One isomer is shown in **Fig. 1**.

Draw the skeletal formula of the other isomer caused by this C=C bond.

**[2]**

**(ii)** Retinol reacts with bromine at room temperature and pressure.

Describe the colour change when retinol reacts with liquid bromine.

........................................................................................................................ **[1]**

**(iii)** Write the equation for the reaction of retinol with excess bromine.

Represent retinol by its molecular formula, $C_{20}H_{30}O$.

$$\rightarrow$$

**[2]**

**(iv)** **Fig. 1** in the article shows some of the compounds found in grape juice.

Give **two** compounds in **Fig. 1** that contain a **primary** alcohol group.

........................................................................................................................

........................................................................................................................ **[2]**

**(d)** During the manufacture of wines, chemical processes often take place that improve their flavour. The article refers to **two** such processes.

Describe, for each process, the reaction that occurs.

Comment on how the taste of the wine is affected.

*In your answer, you should link the change in taste of the wine to the chemical process involved.*

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**[Total: 20]**

**END OF QUESTION PAPER**

## ADDITIONAL ANSWER SPACE

If additional answer space is required, you should use the following lined page(s). The question number(s) must be clearly shown in the margins.

**PLEASE DO NOT WRITE ON THIS PAGE**

# For issue on or after: 13 March 2014

## AS GCE CHEMISTRY B (SALTERS)

**F332/01** Chemistry of Natural Resources

**ADVANCE NOTICE**

**Duration:** 1 hour 45 minutes

*3176786286*

**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.

This document consists of **8** pages. 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.

$$C_6H_{12}O_6 \rightarrow 2CH_3CH_2OH + 2CO_2$$

**Sugar** **Ethanol** **Carbon dioxide**

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.

*Yeast can be seen as a white 'dusting' on a grape's exterior*

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.

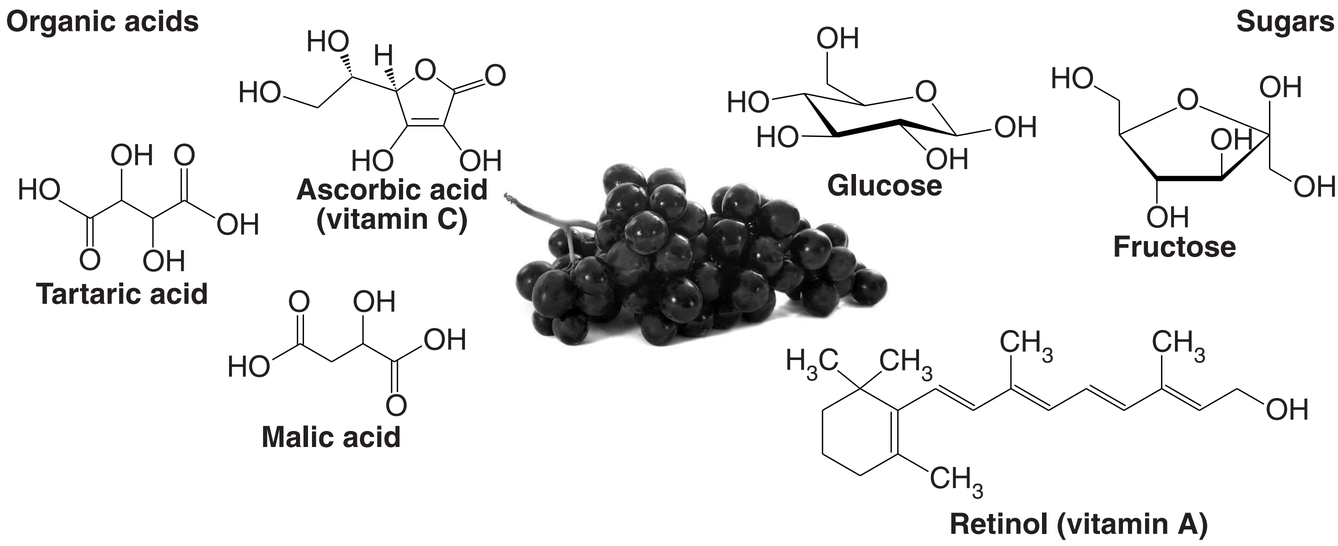



**Fig. 1:** Some of the compounds found in grape juice

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).

## 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.

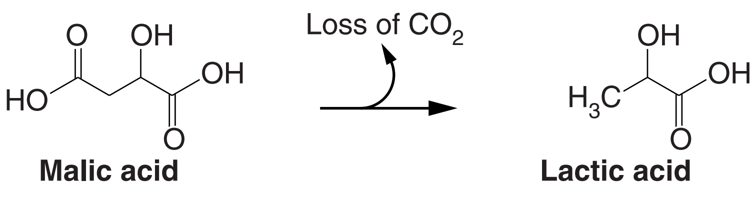
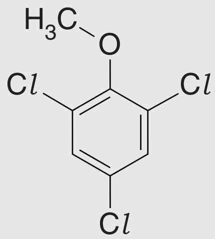



**Fig. 2:** Conversion of malic acid to lactic acid

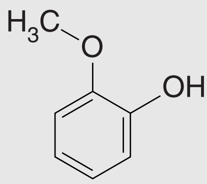
**Box 1: Corked wine**

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.

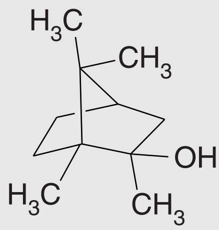
The generation of TCA in the cork of the wine is thought to have several possible sources. Chlorophenol compounds can be taken up by the cork tree from pesticides or can result from chemical treatments used to sterilise the wine corks before use. It is also hypothesised that it may be the result of compounds 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.



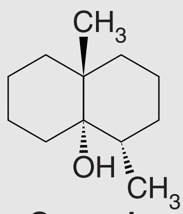

**2,4,6-trichloroanisole**



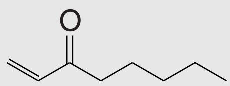

**2-methoxyphenol**



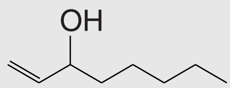

**2-methylisoborneol**




**Geosmin**




**Oct-1-en-3-one**




**Oct-1-en-3-ol**

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.

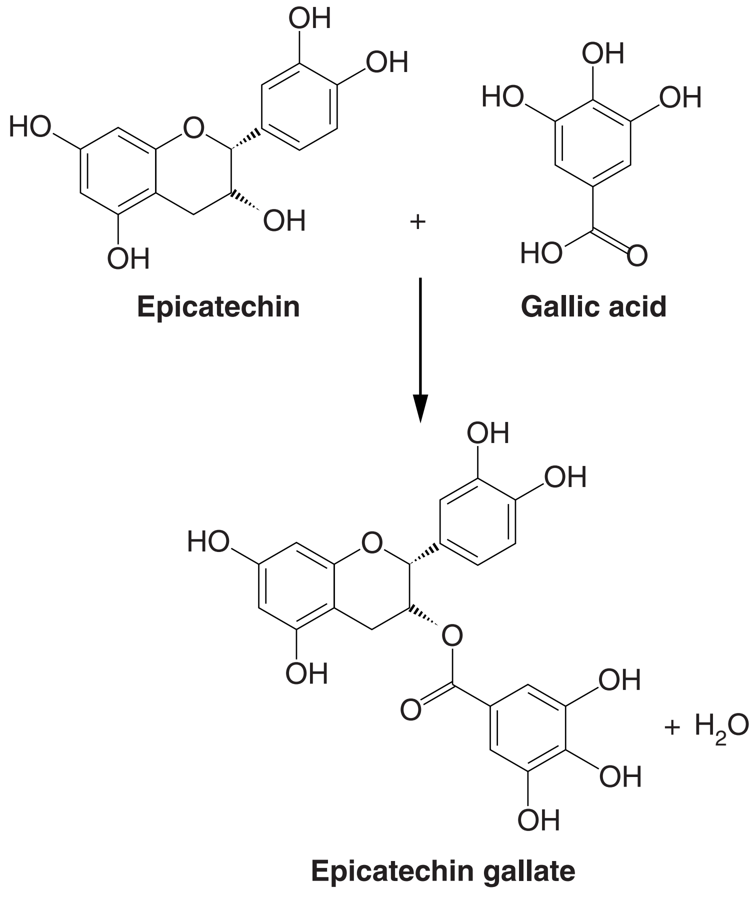



**Fig. 3:** Ester formation between epicatechin and gallic acid

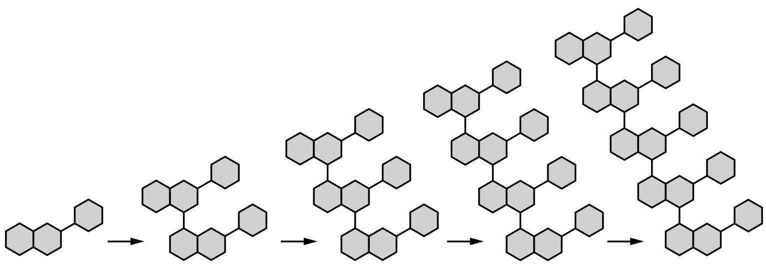


**Fig. 4:** Polymerisation of flavanols to form condensed tannins, which is catalysed by the low pH of the wine

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