OXFORD CAMBRIDGE AND RSA EXAMINATIONS

AS GCE

F332/01/TEST

CHEMISTRY B (SALTERS)

Chemistry of Natural Resources

WEDNESDAY 16 JANUARY 2013: Morning

DURATION: 1 hour 45 minutes plus your additional time allowance

MODIFIED ENLARGED 24pt

Candidate forename		Candidate surname	

Centre number						Candidate number				

Candidates answer on the Question Paper.

OCR SUPPLIED MATERIALS:

Data Sheet for Chemistry B (Salters) **(inserted)**

Advance Notice: 'A hole in the sky' **(inserted)**

OTHER MATERIALS REQUIRED:

Scientific calculator

READ INSTRUCTIONS OVERLEAF

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INSTRUCTIONS TO CANDIDATES

- **The Inserts will be found in the centre of this document.**
- **Write your name, centre number and candidate number on the first page. Please write clearly and in capital letters.**
- **Use black ink. HB pencil may be used for graphs and diagrams only.**
- **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.**
- **Answer ALL the questions.**

INFORMATION FOR CANDIDATES

- **The number of marks is given in brackets [ ] at the end of each question or part question.**
-  **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 *'A hole in the sky'* 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.**
- **The total number of marks for this paper is 100.**

Answer ALL the questions.

1 Many seashells contain calcium carbonate. The carbonate ions, CO_3^{2-}, come from atmospheric carbon dioxide that dissolves in the sea water.

(a) (i) Name TWO industrial processes that are major sources of atmospheric carbon dioxide.

_____

_____ **[2]**

(ii) Companies use various methods for the disposal of the carbon dioxide they produce to prevent its release straight into the atmosphere.

Suggest TWO methods that they could use for disposal of carbon dioxide.

_____

_____

_____ **[2]**

(b) Carbon dioxide is a gas at room temperature. Silicon dioxide, another Group 4 oxide, is a solid with a high melting point.

Explain this difference in melting point in terms of bonding and structure.

_____

_____

_____

_____

_____

_____

_____ **[3]**

(c) Carbon dioxide acts as a greenhouse gas because it can absorb infrared radiation.

(i) Describe what happens to carbon dioxide molecules when they absorb the infrared radiation.

_____

_____ **[1]**

(ii) The changes that happen after the process in (c)(i) result in the warming of the troposphere.

Describe these changes and explain how they warm the troposphere.

_____

_____

_____

_____ **[2]**

(d) In an air sample that was analysed, carbon dioxide was found to be present at a concentration by volume of 395 parts per million.

Calculate the percentage of carbon dioxide in the sample.

% carbon dioxide = _____

[1]

(e) When carbon dioxide dissolves in water, the following reactions occur.

$$CO_2(g) \rightleftharpoons CO_2(aq)$$

EQUATION 1.1

$$CO_2(aq) + H_2O(l) \rightleftharpoons H^+(aq) + HCO_3^-(aq)$$

EQUATION 1.2

$$HCO_3^-(aq) \rightleftharpoons H^+(aq) + CO_3^{2-}(aq)$$

EQUATION 1.3

(i) Give the systematic name of the HCO_3^- ion.

_____ **[1]**

(ii) The reaction in EQUATION 1.3 can reach a state of dynamic equilibrium.

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

_____

_____

_____

_____ **[2]**

(iii) Suggest why the balance of $CO_2(g)$ in the atmosphere and $CO_2(aq)$ in the oceans cannot be regarded as a dynamic equilibrium.

_____

_____

_____ **[1]**

$$CO_2(g) \rightleftharpoons CO_2(aq)$$

EQUATION 1.1

$$CO_2(aq) + H_2O(l) \rightleftharpoons H^+(aq) + HCO_3^-(aq)$$

EQUATION 1.2

$$HCO_3^-(aq) \rightleftharpoons H^+(aq) + CO_3^{2-}(aq)$$

EQUATION 1.3

(iv) The concentration of hydrogen ions in a sample of sea water is increased.

Using EQUATION 1.3, describe and explain what would happen, if anything, to the concentration of carbonate ions.

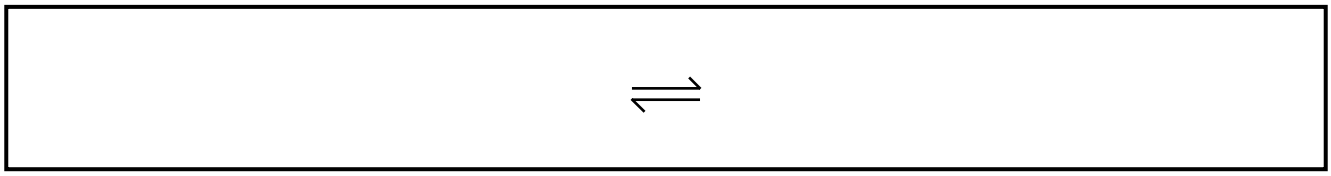
_____

_____

_____

_____ **[2]**

(v) **Give the overall equation for the reaction of gaseous carbon dioxide with water that produces CO_3^{2-} ions.**



[1]

(f) Mineral water often contains dissolved carbon dioxide. The water also contains a range of dissolved ionic compounds.

A student analyses a sample of mineral water to check the amount of dissolved sulfate ions, SO_4^{2-}, it contains.

(i) The student adds barium chloride solution to the water to precipitate out the sulfate ions as barium sulfate. The student collects, dries and weighs the precipitate.

Write the IONIC equation for the precipitation of barium sulfate.

Include state symbols.

→

[2]

(ii) From the results, the student calculates that the mineral water contains sulfate ions at a concentration of 7.4×10^{-5} mol dm^{-3}. The student looks at the label on the bottle and finds that the concentration is quoted in g dm^{-3}.

Calculate the concentration of sulfate ions in the water in g dm^{-3}.

Give your answer to TWO significant figures.

concentration of sulfate ions = _____ g dm^{-3}

[3]

(iii) Suggest why the presence of CO_3^{2-} ions in the mineral water might lead to the student obtaining a higher value for the sulfate ion concentration than is given on the label on the bottle.

_____

_____

_____ **[1]**

[TOTAL: 24]

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2 Leafcutter ants are responsible for producing some of the halogenoalkanes that are released into the Earth's atmosphere. The ants have been found to be responsible for producing large quantities of chloromethane and bromomethane.

(a) Why does chloromethane not photodissociate in the troposphere?

_____

_____

_____ **[1]**

HALOGENOALKANE	ESTIMATED GLOBAL EMISSIONS / TONNES PER YEAR	ATMOSPHERIC LIFETIME / YEARS
Chloromethane, CH_3Cl	800	1.3
Bromomethane, CH_3Br	500	0.7

(b) If a bromomethane molecule reaches the stratosphere, UV radiation breaks the C–Br bond in the molecule, forming bromine atoms.

(i) The C–Br bond has an enthalpy of +290 kJ mol^{-1}.

Calculate the minimum energy (in Joules) needed to break a SINGLE C–Br bond.

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

minimum energy = _____ J
[2]

(ii) Calculate the frequency of radiation that is needed to break a SINGLE C–Br bond.

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

frequency = _____ Hz

[2]

(c) Chloromethane and bromomethane are both gases at room temperature whilst water is a liquid.

(i) Name BOTH types of intermolecular bond that can form between molecules of chloromethane.

_____

_____ **[2]**

(ii) Water molecules are held together by hydrogen bonds.

Draw a diagram to show how TWO water molecules can be linked by a hydrogen bond.

Include relevant lone pairs and partial charges in your diagram.

[4]

(iii) Hydrogen bonds only form when hydrogen atoms are bonded to atoms of certain elements.

Name these elements.

_____

_____ **[1]**

(d) The following table gives values for the boiling points of bromomethane, chloromethane and water:

	BOILING POINT/K
BROMOMETHANE	277
CHLOROMETHANE	249
WATER	373

Use ideas about intermolecular bonds to explain:

(i) why chloromethane has a lower boiling point than water;

_____

_____ **[1]**

(ii) why bromomethane has a higher boiling point than chloromethane.

_____

_____

_____

_____

_____ **[2]**

(e) Most of the chloromethane and bromomethane molecules that enter the troposphere are removed by reaction with hydroxyl radicals.

Draw a '*dot-and-cross*' diagram for the hydroxyl, OH, radical.

Show outer shell electrons only.

[1]

(f) The chloromethane and bromomethane that dissolve in the oceans are hydrolysed by the water, releasing HC*l* or HBr.

(i) Write the equation for this hydrolysis of chloromethane.

→

[1]

(ii) Name the organic compound that forms in the reaction in (f)(i).

_____ **[1]**

(iii) **Underline TWO of the following words to describe the hydrolysis reaction in (f)(i).**

ADDITION

ELECTROPHILIC

ELIMINATION

NUCLEOPHILIC

RADICAL

SUBSTITUTION

[2]

(g) The rates of hydrolysis of chloromethane and bromomethane may depend on either of the factors shown below:

the polarity of the carbon–halogen bond

the strength of the carbon–halogen bond.

(i) State which bond, C–C*l* or C–Br, is more polar and explain why.

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

_____

_____

_____ **[1]**

(ii) Suggest which bond, C–C*l* or C–Br, is stronger and explain why.

_____

_____

_____ [1]

(iii) Under the same reaction conditions, the hydrolysis of bromomethane occurs more rapidly than the hydrolysis of chloromethane.

Explain why this observation indicates that bond strength contributes more than bond polarity to the rate of hydrolysis.

_____

_____

_____

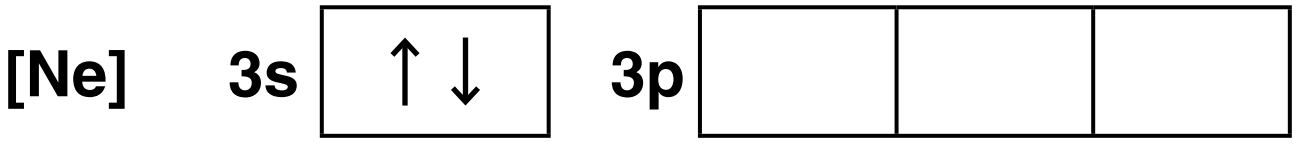
_____ [1]

[TOTAL: 23]

3 Wine labels often show that the wine contains sulfites, because sulfur dioxide gas has been added as a preservative. Strict legal limits have been placed on the amount of SO_2 that can be added to wine, because above a certain value the sulfur dioxide affects the taste of the wine.

(a) Sulfur dioxide can be made industrially by burning sulfur in air.

(i) Complete this diagram to show the arrangement of electrons in a sulfur atom.



[1]

(ii) Industries producing sulfur dioxide have to make sure they do NOT allow the sulfur dioxide to escape into the atmosphere.

Name a type of pollution caused by sulfur dioxide in the atmosphere.

_____ [1]

(b) The concentration of sulfur dioxide in a sample of white wine can be found by titrating the wine with a solution of iodine.

The equation for the reaction between sulfur dioxide and iodine is shown below.

$$SO_2(aq) + I_2(aq) + 2H_2O(l) \rightarrow SO_4^{2-}(aq) + 2I^-(aq) + 4H^+(aq)$$

EQUATION 3.1

(i) Give the oxidation states of the iodine and sulfur before and after the reaction.

Oxidation state of sulfur in:

SO_2 _____

SO_4^{2-} _____

Oxidation state of iodine in:

I_2 _____

I^- _____ [3]

(ii) Give the reducing agent in the reaction shown in EQUATION 3.1.

Explain your answer in terms of oxidation states.

reducing agent: _____

explanation: _____

_____ [2]

(iii) Give the colour and physical state of the iodine that would be used to make the iodine solution.

_____ [1]

(c) A sample of white wine is analysed for its sulfur dioxide content by titrating it with an aqueous solution of iodine.

$$SO_2(aq) + I_2(aq) + 2H_2O(l) \rightarrow SO_4^{2-}(aq) + 2I^-(aq) + 4H^+(aq)$$

EQUATION 3.1

(i) Name a suitable piece of equipment for adding the aqueous iodine solution to the wine.

_____ [1]

(ii) 15.80 cm^3 of 0.0100 mol dm^{-3} aqueous I_2 solution is needed to react with 50.00 cm^3 of the wine.

Calculate the number of moles of iodine, I_2, used in the titration.

moles I_2 = _____ mol
[1]

(iii) Use your answer to (ii) and EQUATION 3.1 to write down the number of moles of sulfur dioxide in the 50.00 cm^3 of wine.

moles
sulfur dioxide = _____ mol
[1]

(iv) What is the concentration of sulfur dioxide in the wine in $mol\,dm^{-3}$?

concentration =

_____ $mol\,dm^{-3}$ [1]

(v) In Britain, the maximum amount of sulfur dioxide that can be added to white wine is $3.28 \times 10^{-3}\,mol\,dm^{-3}$. Above this limit, the taste of the wine is affected.

A concentration of less than $1.56 \times 10^{-4}\,mol\,dm^{-3}$ is insufficient to preserve the wine.

Use this information to comment on your answer to (iv).

_____

_____ [1]

(d) The concentration of sulfur dioxide in wine can also be found by converting the sulfur dioxide to sulfuric acid. The sulfuric acid is then titrated with sodium hydroxide solution.

How would you know when the end-point of the titration of sulfuric acid with sodium hydroxide has been reached?

_____

_____ **[1]**

[TOTAL: 14]

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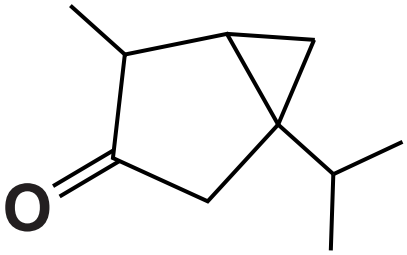
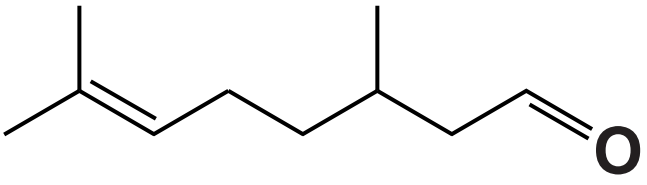
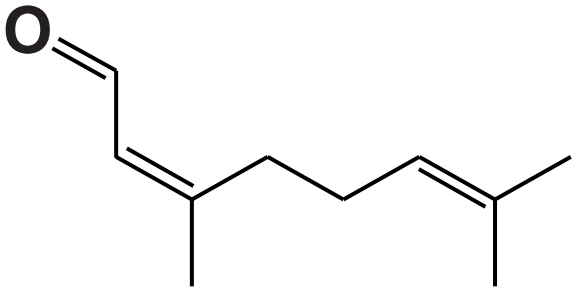
4 Absinthe was a popular alcoholic drink in the nineteenth century. It contained a mixture of organic compounds, including thujone, citronellal, neral and linalool. It was claimed that absinthe caused hallucinations because of the thujone it contained.



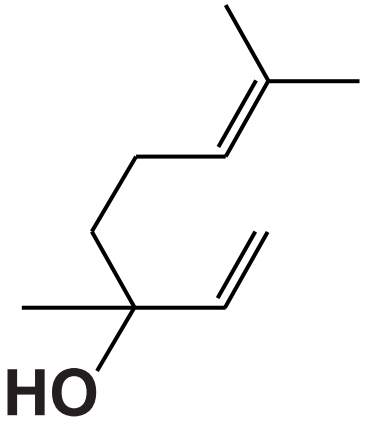
THUJONE



CITRONELLAL



NERAL



LINALOOL

(a) (i) Name a functional group that is present in thujone but NOT in neral.

_____ **[1]**

(ii) Name a functional group that is present in all these compounds EXCEPT thujone.

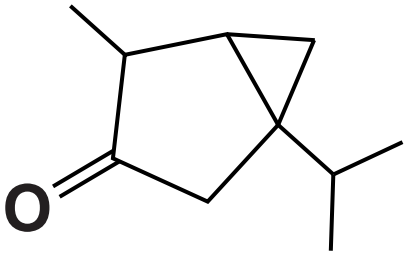
_____ [1]

(b) The aldehyde group in citronellal can be oxidised by acidified dichromate(VI).

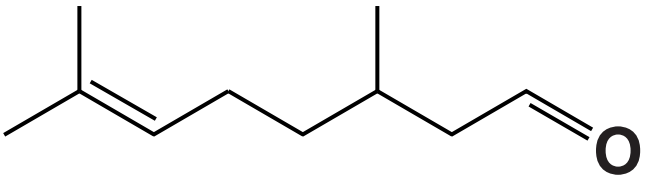
(i) Draw the full structural formula of the functional group that forms and name this functional group.

name of functional group:

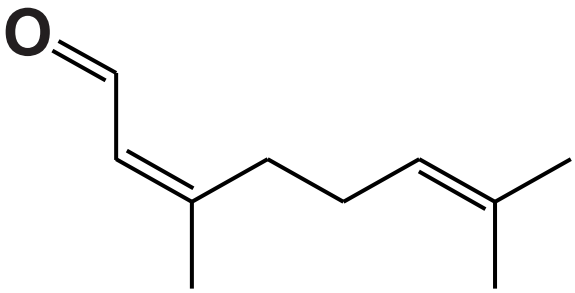
_____ [2]



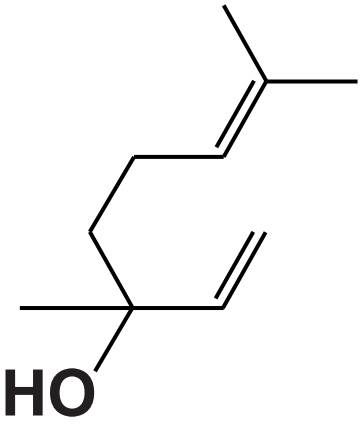
THUJONE



CITRONELLAL



NERAL



LINALOOL

(ii) Put a tick in the table for each of the other compounds in absinthe that would be oxidised by acidified dichromate(VI).

	LINALOOL	NERAL	THUJONE
WILL BE OXIDISED			

[1]

(c) Neral has *E*/*Z* isomers, but linalool does not.

(i) The diagram of neral shown on page 42 is the *Z* isomer. Draw a diagram of the *E* isomer of neral.

[1]

(ii) Explain why neral has *E*/*Z* isomers.

_____

_____

_____

_____ **[2]**

(d) Citronellal molecules can take part in an addition polymerisation reaction.

Underline the compound from the list that CANNOT form an addition polymer.

LINALOOL

NERAL

THUJONE **[1]**

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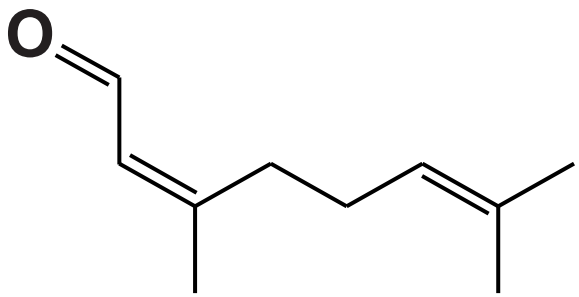


NERAL

(e) Neral reacts with H_2O.

(i) Give the reaction conditions that would be needed for the reaction of neral with H_2O, using a phosphoric acid catalyst.

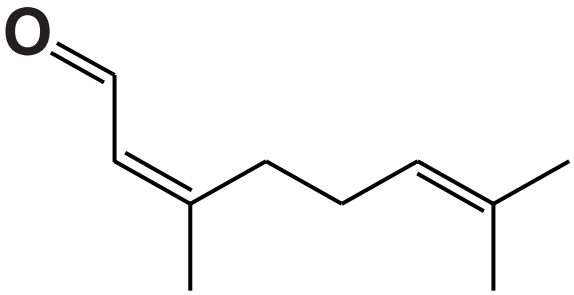
_____

_____ [1]

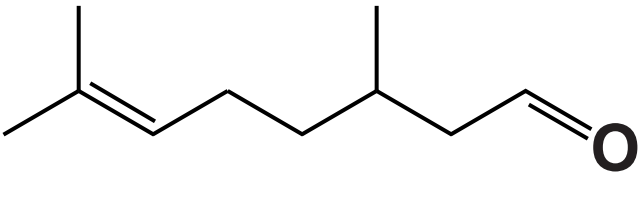
(ii) **Four organic products could form from the COMPLETE reaction of neral with H_2O. Assume that the aldehyde group does not react.**

Draw the structures of the FOUR isomeric products that could form.

[4]



NERAL



CITRONELLAL

(f) Neral and citronellal both react with bromine. A student adds bromine water drop by drop to 1 cm^3 of neral in a test-tube. The tube is shaken after each addition. The addition of bromine water is continued until no further change occurs.

In a second experiment, the student repeats the process with an equal amount of citronellal.

Describe and explain the SIMILARITIES and DIFFERENCES the student would observe in the two experiments.

In your answer, you should make it clear how the structures of the molecules being reacted with bromine link to the similarities and differences you have described.

[5]

[Total: 19]

5 This question is based on the Advance Notice article 'A HOLE IN THE SKY' that is provided as an insert to this paper.

(a) Catalytic cycles include reactions that are classified as propagation reactions.

Explain what is meant by a *propagation reaction*.

Give the number of a reaction from the article that is an example of a propagation reaction.

propagation reaction _____

_____

reaction number _____

[2]

(b) FIG. 1 in the article shows a '*dot-and-cross*' diagram that could be used to represent the bonding in a molecule of ozone.

(i) In an ozone molecule, BOTH bonds have a length of 0.128 nm.

Explain why the bond length values in ozone suggest that the diagram in FIG. 1 of the article does NOT represent the actual bonding for an ozone molecule.

_____

_____

_____

_____ **[2]**

(ii) **Explain why the diagram in FIG. 1 indicates that the ozone molecule is V-shaped.**

_____

_____

_____

_____ **[2]**

(c) REACTIONS 1 and 2 in the article result in the formation of ozone in the atmosphere.

(i) **Explain why REACTION 1 occurs at a faster rate at a higher altitude.**

_____

_____

_____

_____ **[2]**

(ii) REACTION 2, like most gaseous reactions, gets faster as the pressure increases.

Explain, in terms of the collision theory, why increased pressure increases the rate of a gaseous reaction.

_____

_____

_____

_____ **[2]**

(iii) **FIG. 2 in the article shows the variation of ozone concentration with altitude in the Earth's atmosphere.**

Explain why the ozone concentration is highest at an altitude of around 25 km.

_____

_____

_____

_____ **[1]**

(d) The article tells us that the ozone in the stratosphere is beneficial because it prevents some of the UV light from the Sun from reaching the Earth's surface.

Explain why this is considered to be beneficial to humans.

_____

_____

_____ **[2]**

QUESTION 5 CONTINUES ON PAGE 56

(e) Ozone is totally removed from the atmosphere at 20 km altitude over the South Pole in the polar spring.

Explain this. Include in your answer:

a description of the reactions by which chlorine radicals are produced from ClO radicals at 20 km altitude

an explanation of why these chlorine radicals are NOT removed by termination reactions at 20 km altitude in the polar spring

an explanation of how all the ozone is removed by chlorine radicals at 20 km altitude in the polar spring.

In your answer you should make it clear how the points you make link together.

[7]

[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.

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