OCR
RECOGNISING ACHIEVEMENT

Tuesday 4 June 2013 – 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: 'Atmospheric Nitrogen'* (inserted)

Other materials required:
- Scientific calculator

Duration: 1 hour 45 minutes

Candidate forename		Candidate surname	

Centre number						Candidate number				

INSTRUCTIONS TO CANDIDATES

- The Inserts will be found in the centre of 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.

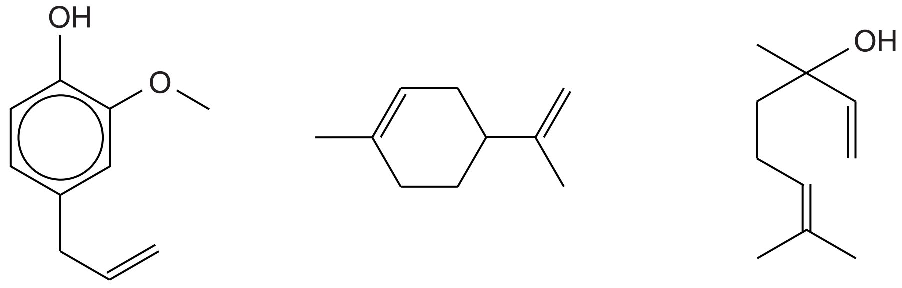
INFORMATION FOR CANDIDATES

- The number of marks is given in brackets **[ ]** at the end of each question or part question.
- 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 *'Atmospheric nitrogen'* 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**.
- This document consists of **20** pages. Any blank pages are indicated.

Turn over

Answer **all** the questions.

1 A car screen-wash product contains a mixture of eugenol, limonene and linalool.



eugenol **limonene** **linalool**

(a) **(i)** Name a functional group that is present in all three of these compounds.

.... **[1]**

(ii) Name a functional group that is present in eugenol but **not** in linalool (not the arene ring or the hydroxyl group).

.... **[1]**

(b) Limonene reacts with bromine.

(i) Draw the structure of the molecule that is produced from the reaction of a molecule of limonene with excess bromine.

[2]

(ii) Underline two words that describe the mechanism of the reaction between limonene and bromine.

addition **electrophilic** **nucleophilic** **radical** **substitution**

[2]

(iii) The impure liquid organic product of the reaction of limonene with bromine is dried after it has been prepared.

Name a drying agent that could be used.

.... **[1]**

(iv) Name the process that would be used to purify the liquid product.

.... **[1]**

(c) Limonene reacts with hydrogen.

Give the reagents and conditions for the reaction of limonene with hydrogen.

....

.... **[2]**

(d) Linalool contains an alcohol group.

(i) Classify the alcohol group in linalool as primary, secondary or tertiary.

.... **[1]**

(ii) Explain your answer to **(d)(i)**.

....

.... **[1]**

(iii) Linalool is heated with acidified potassium dichromate solution.

Describe and explain what you would **see**.

....

....

.... **[2]**

(e) When linalool vapour is passed over heated aluminium oxide at 300 °C, the linalool reacts to produce *Z*-ocimene.

linalool **Z-ocimene**

(i) Give the molecular formula of *Z*-ocimene.

.... **[2]**

(ii) The reaction producing *Z*-ocimene from linalool has an inorganic product.

Identify this product.

.... **[1]**

(iii) Underline the term below that describes the type of reaction that has occurred when *Z*-ocimene is produced from linalool.

addition **hydrolysis** **elimination** **substitution**

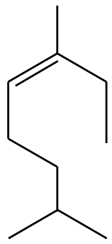
[1]

(iv) During the reaction that forms *Z*-ocimene from linalool, *E*-ocimene is also produced.

Draw a skeletal formula for a molecule of *E*-ocimene.

[1]

(f) *Z*-Ocimene reacts with hydrogen. One of the partially hydrogenated products of this reaction is shown below.

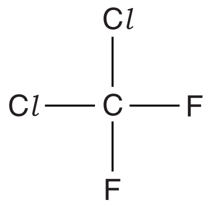


Give the systematic name of this compound.

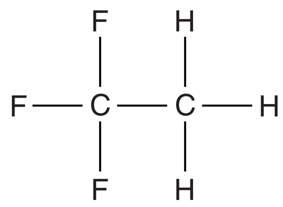
.... **[2]**

[Total: 21]

2 CFCs, such as CFC 12, were used as refrigerants. More recently, HFCs have taken over from CFCs because HFCs have much lower ozone depletion potentials. Examples of a CFC and an HFC are shown below.



CFC 12



HFC 143a

(a) What does *CFC* stand for?

.... **[1]**

(b) Give another large scale use for CFCs during the last century, other than as refrigerants.

.... **[1]**

(c) CFC 12 was made from tetrachloromethane, CCl_4, by reacting it with hydrogen fluoride.

(i) The reaction requires the use of a catalyst.

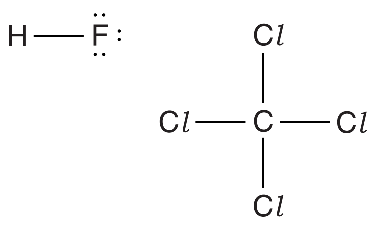
Explain how a catalyst increases the rate of a chemical reaction.

....

....

.... **[2]**

(ii) Add relevant partial charges and 'curly arrows' to the diagram to show the attack of one hydrogen fluoride molecule on tetrachloromethane and the resulting electron pair movement in the tetrachloromethane molecule.



[3]

(d) CFCs cause ozone depletion because their C–C*l* bonds break in the stratosphere when UV radiation is absorbed. The chlorine radicals that are produced catalyse the breakdown of ozone.

(i) Name the **type** of bond breaking process that occurs to form chlorine radicals from CFC molecules.

.... **[1]**

(ii) The bond enthalpy of the C–F bond is +467 kJ mol^{-1}.

Calculate the minimum energy (in Joules) needed to break a **single** C–F bond.

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

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

(iii) Calculate the frequency of radiation that is needed to break a single C–F bond.

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

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

frequency = ... Hz **[3]**

(iv) Explain why C–F bonds are much less likely than C–C*l* bonds to be broken in the stratosphere.

....

....

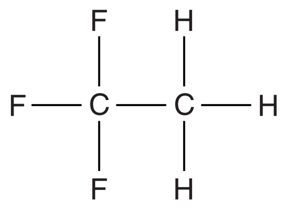
.... **[2]**

(v) In the 1980s, scientists researching the levels of ozone in the atmosphere discarded some of the data because they thought it was incorrect.

Explain why they thought the values were incorrect.

....

.... **[1]**



HFC 143a

(e) Give the systematic name for HFC 143a.

.... **[2]**

(f) HFC 143a is also a powerful greenhouse gas.

Explain how the 'greenhouse effect' enables energy from the Sun to be transferred to heat energy that warms the Earth's atmosphere.

In your answer you should include:

- what happens to the radiation from the Sun that enters the Earth's troposphere;
- what happens to a molecule of HFC 143a and how this results in the warming of the troposphere.

....

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....

....

.... **[5]**

(g) Give the evidence for the relationship between the increased concentration of greenhouse gases in the atmosphere and global warming.

....

.... **[1]**

[Total: 24]

3 Chlorine is manufactured by the electrolysis of sodium chloride solution. There are several different types of cell that can be used, including diaphragm and membrane cells.

A membrane cell with oxygen-depolarised cathodes, ODC, is a new development that is being trialled. The ODC cell differs from the others in that it does not produce hydrogen at the cathode.

The table below compares the three different types of cell.

		Diaphragm	**Membrane**	**Membrane with ODC**
Operating voltage (V)		2.9–3.5	3.0–3.6	Approx. 2
Relative energy consumption per tonne Cl_2	Electrolysis	2.7	2.6	1.8*
	Evaporation	0.6	0.2	0.2
	Total	3.3	2.8	2.0*
CO_2 emissions (tonnes per tonne Cl_2)		1.7	1.5	1.0

* estimated values

(a) Suggest **two** reasons why the new ODC cell is being classed as green technology when compared to the other types of cell.

....

....

.... **[2]**

(b) In all these cells, chlorine is produced at one electrode.

(i) Write the half-equation for the production of chlorine at this electrode in any of these cells.

$\rightarrow$

[2]

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

.... **[1]**

(iii) Give **two** large scale uses for the chlorine that is formed.

....

....

.... **[2]**

(iv) If an accident occurred causing a release of chlorine, people dealing with the incident would wear breathing apparatus.

Explain why this would be necessary.

....

.... **[2]**

(c) **Equations 3.1** and **3.2** show the processes that occur in an ODC cell at one electrode.

$$O_2 + 4e^- \rightarrow 2O^{2-}$$ **equation 3.1**

$$2O^{2-} + 2H_2O \rightarrow 4OH^-$$ **equation 3.2**

Write the overall half-equation for the reaction at this electrode.

$$\rightarrow$$

[1]

(d) **Equation 3.3** represents the overall reaction that occurs in the membrane electrolysis cell. All three products have uses in industry.

$$2NaCl(aq) + 2H_2O(l) \rightarrow H_2(g) + Cl_2(g) + 2NaOH(aq)$$ **equation 3.3**

(i) Calculate the volume of chlorine gas (in dm^3) that would be produced from 200 kg of dissolved sodium chloride.

Assume that 1 mole of gas occupies 24 dm^3 under the conditions of the experiment.

volume = ... dm^3 **[3]**

(ii) Give the atom economy for the reaction shown in **equation 3.3**.

.... **[1]**

(e) Sodium chloride can be produced in the laboratory by burning sodium in chlorine.

(i) In the reaction between sodium and chlorine, each sodium atom forms a sodium ion.

Write an equation representing the first ionisation enthalpy of sodium.

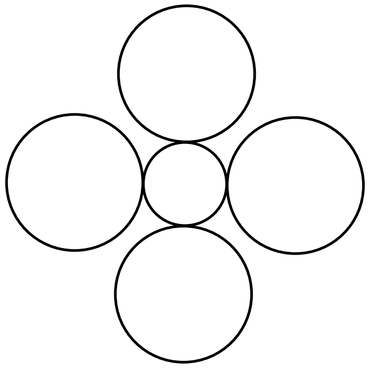
Include state symbols.

$\rightarrow$

[2]

(ii) The diagram below shows part of a layer of the sodium chloride lattice.

Label each type of particle and complete the diagram by drawing in enough particles to show the structure of the **layer** clearly.



[3]

[Total: 19]

4 Large quantities of propene, $CH_3CH{=}CH_2$, are manufactured every year. Most of this propene is used to make poly(propene), which is used to cover electrical wires.

(a) Draw the structure of **one** repeat unit of poly(propene).

[1]

(b) Suggest a property of poly(propene) that makes it suitable for the covering of electrical wires.

....

.... **[1]**

(c) Poly(propene) is an example of a thermoplastic polymer.

Explain what is meant by the term *thermoplastic*.

....

.... **[1]**

(d) Propene reacts with water, forming propan-1-ol as one of the products.

Propan-1-ol has a higher boiling point than propene.

Explain this difference in boiling points in terms of intermolecular bonding.

In this question, you should make it clear how the points you make are linked to one another.

....

....

....

....

....

....

....

....

.... **[5]**

(e) A chemical company decided to make propan-1-ol from propene. The equation for the reaction is shown below.

$$CH_3CH{=}CH_2(g) + H_2O(g) \rightleftharpoons CH_3CH_2CH_2OH(g) \quad \Delta H = -37\ kJ\ mol^{-1}$$ **equation 4.1**

Describe and explain the effect, if any, on the equilibrium **yield** of propan-1-ol in each of these cases:

(i) increasing the temperature,

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

....

....

....

.... **[2]**

(ii) increasing the pressure.

....

....

.... **[2]**

(f) **(i)** The temperature of the reaction mixture is increased.

Explain why the rate of the forward reaction in **equation 4.1** increases.

....

....

....

.... **[3]**

(ii) What happens to the rate of the reverse reaction in **equation 4.1** when the temperature is increased?

....

.... **[1]**

[Total: 16]

5 This question is based on the Advance Notice article '***Atmospheric Nitrogen: Out of Thin Air***' that is provided as an insert to this paper.

(a) Explain what is meant by the term *radical*. Give an example of a radical from the article, other than the hydroxyl radical.

explanation: ....

....

example: ....

.... **[2]**

(b) One nitrogen-containing compound found in the atmosphere is N_2O, see Fig. 2 in the article.

(i) Draw a '*dot-and-cross*' diagram to represent the bonding in a molecule of N_2O.

Show outer electrons only.

[2]

(ii) Using your answer in **(i)**, describe and explain the shape of an N_2O molecule.

....

....

....

.... **[3]**

(c) Nitrogen is also present in the atmosphere in NH_4^+ and NO_2^-.

(i) The conversion of NH_4^+ to NO_2^- is classified as oxidation.

Calculate the oxidation states for the nitrogen in NH_4^+ and NO_2^-. Use these oxidation states to explain why this conversion is classified as oxidation.

oxidation state of N in NH_4^+ ....

oxidation state of N in NO_2^- ....

explanation: ....

....

.... **[3]**

(ii) Give the systematic name for NO_2^-.

.... **[1]**

(d) Some of the ammonia in the atmosphere comes from the decomposition of urea.

(i) Write an equation for the decomposition of urea, in the presence of water, to form ammonia and carbon dioxide.

$$\rightarrow$$

[1]

(ii) The concentration of ammonia in a sample of air is found to be 0.0010 ppm.

The concentration of nitrogen in the same sample is 78%.

How much more abundant is nitrogen than ammonia in this sample of air?

answer = ... times more abundant **[2]**

Question 5 continues on page 16

(e) Nitrous oxide, N_2O, is an important greenhouse gas.

Describe ways in which nitrous oxide is put into the atmosphere and ways in which it is removed from the atmosphere.

Include **one** chemical equation in your answer.

In your answer, you should make a clear link between the process you have described and the equation for the reaction.

.... **[6]**

[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

OCR
RECOGNISING ACHIEVEMENT

For issue on or after: 13 March 2013

AS GCE CHEMISTRY B (SALTERS)

F332/01 Chemistry of Natural Resources

ADVANCE NOTICE

Duration: 1 hour 45 minutes

F314890613

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 **4 June 2013** 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 **4** pages. Any blank pages are indicated.

INSTRUCTION TO EXAMS OFFICER / INVIGILATOR

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Atmospheric Nitrogen: Out of Thin Air

Adapted from an article in Chemistry Review Magazine, Volume 20, Number 2, November 2010 by Tim Harrison and Dudley Shallcross. Published by Philip Allan Updates.

Molecular nitrogen, N_2, is an inert gas (Fig. 1) and makes up nearly 80% of the Earth's atmosphere. It is only in the upper atmosphere (altitudes higher than 100 km) that this gas becomes more reactive, where significant levels of very short wavelength radiation can be found (80–100 nm) that can break the bonds between nitrogen atoms through photolysis.

$$N \equiv N$$

Fig. 1: Structure of molecular nitrogen

Due to its great stability, nitrogen gas accounts for 99.9999% of atmospheric nitrogen, with nitrous oxide (N_2O, see Fig. 2) representing around 99% of the remainder. Therefore you would imagine that the global atmospheric nitrogen cycle is well understood.

$$N \equiv N \rightarrow O$$

Fig. 2: Structure of nitrous oxide (dinitrogen oxide)

However, despite their small and highly variable sources, there are other nitrogen containing species (Fig. 3), which are present in the atmosphere at trace levels, playing a disproportionately large role in determining atmospheric composition. Ammonia (NH_3), for example, is the only alkaline gas in the atmosphere and is important in the neutralisation of acidic aerosols.

NO_2 Nitrogen dioxide	HNO_3 Nitric acid	NO Nitric oxide
NH_3 Ammonia	$(NH_4^+)_2\ SO_4^{2-}$ Ammonium sulfate	

Fig. 3: Formulae of some other nitrogen containing compounds

Nitrogen oxides, NO and NO_2, play a vital role in the production and destruction of low altitude (tropospheric) smog, and so affect the radiative budget (the balance of incoming and outgoing radiation) of the Earth and the oxidising capacity of the atmosphere.

Ammonia has a short lifetime in the atmosphere of approximately 10 days and is removed predominantly by both **wet and dry deposition** processes, with some additional loss via reaction with $HO^\bullet$ radicals. The main sources arise from biological activity, such as the decomposition of urea ($(NH_2)_2CO$) in animal urine by enzymes, the decomposition of excrement and the release from soils and the ocean following mineralisation of organic material. Anthropogenic (man-made) sources centre around its use in fertilisers and as a by-product of waste production. Since deposition processes dominate its loss and sources are diverse, levels of ammonia are highly variable, ranging from 0.1 to 10 ppbv (parts per billion by volume) over continental regions. Ammonia forms ammonium sulfate aerosols that, when deposited, cause a decrease in soil pH, leading to a decline in plant growth.

$$2NH_4^+ + 3O_2 \rightarrow 2NO_2^- + 2H_2O + 4H^+$$

In the atmosphere, NO and NO_2 (collectively known as NO_x) are tightly coupled during sunlit hours and rapidly interconvert with one another in the presence of ozone (see Box 1):

$$NO + O_3 \rightarrow NO_2 + O_2$$

$$NO_2 \rightarrow NO + O$$

$$O + O_2 \rightarrow O_3$$

Box 1: Ozone

Ozone, O_3, is a molecule containing three oxygen atoms with a similar shape to a water molecule. It has an important role in the stratosphere, where it absorbs incoming UV radiation from the Sun and prevents it from reaching the Earth's surface.

New cars are equipped with catalytic converters, which convert NO_x to oxygen and nitrogen.

Individually, NO and NO_2 have extremely short lifetimes of the order of seconds, but by considering the two compounds together as NO_x, the lifetime is essentially lengthened to many hours. Hence, NO and NO_2 display strong diurnal (daily) cycles and their concentrations will display a seasonal cycle. In urban areas, NO_x can reach levels of 100 ppbv (parts per billion by volume), and in particularly polluted environments ppmv (parts per million by volume) levels, whereas clean maritime levels are only 5–10 pptv (parts per trillion by volume). The major loss processes for NO_x are conversion to HNO_3 by reacting with an $HO^\bullet$ radical or by dry deposition of NO_x.

$$NO_2 + HO^\bullet \rightarrow HNO_3$$

HNO_3 can be removed by wet and dry deposition, constituting a loss of NO_x from the atmosphere. In the **troposphere**, in the presence of volatile organic compounds, NO_x can promote the formation of ozone and can also be used to form temporary nitrate reservoirs such as nitroethaneperoxoate or peroxyacetylnitrate (PAN), which is an alkanoyl nitrate ($CH_3C(O)O_2NO_2$). PAN can allow NO_x to be transported away from source regions and influence chemistry on regional and global scales. For most sources, NO_x is emitted in the form of NO. Natural sources of NO are from soil processes and lightning discharge, while an ever-increasing source is that from the high-temperature combustion of fossil fuels.

$$O + N_2 \rightarrow NO + N$$

$$N + O_2 \rightarrow NO + O$$

There are considerable uncertainties within the budget for NO_x, such as the soil and lightning source strength, although the burden from fossil fuels is reasonably well defined and set to increase globally, despite the growing use of **three-way catalysts** in vehicles that reduce nitrogen oxide exhausts to nitrogen and oxygen.

Opportunity NO_x

Nitrous oxide (N_2O) is an important greenhouse gas. Its current atmospheric mixing ratio is about 310 ppbv, compared with an estimated pre-industrial level of around 285 ppbv. N_2O has an extremely long lifetime (~150 years) and is virtually inert in the troposphere, being destroyed in the **stratosphere** by direct photolysis and reaction with excited oxygen atoms.

$$N_2O \rightarrow N_2 + O$$

$$N_2O + O^* \rightarrow 2NO$$

$$N_2O + O^* \rightarrow N_2 + O_2$$

Nitrous oxide is released to the atmosphere from both soils and aquatic systems with undisturbed soils, cultivated soils and oceans making up the bulk of the known sources. Denitrifying bacteria transform nitrate to N_2 and some N_2O under anaerobic conditions (in the absence of oxygen), which can then escape to the ocean surface and enter the atmosphere. There are many uncertainties, including the estimation of the ocean source, since N_2O is both lost to and emitted from the oceans. Since it delivers NO_x to the stratosphere, N_2O plays an important role in controlling the abundance of stratospheric ozone.

Glossary

Dry deposition the chemical or physical removal of particles and gases from the atmosphere by impact with the Earth's surface.

Stratosphere the second major layer of Earth's atmosphere, just above the troposphere and below the mesosphere, between 10 and 50 km altitude.

Three-way catalyst a catalytic converter used in vehicle exhausts to decrease the toxicity and levels of harmful engine emissions. A three-way catalyst converts NO_x to oxygen and nitrogen, oxidises carbon monoxide to carbon dioxide and oxidises uncombusted hydrocarbons to carbon dioxide and water.

Troposphere the lowest portion of Earth's atmosphere. It contains approximately 90% of the atmosphere's mass and 99% of its water vapour and aerosols.

Wet deposition the removal of substances from the atmosphere to Earth's surface through incorporation in rain, snow, hail, fog, etc.

Nitrogen is an element essential to life, not only in its building blocks but also in its processes. It is therefore important to understand how nitrogen is transferred through its various compounds from a biological perspective, and also how human activities affect it. With a better understanding of the latter, we can look at how to minimise nitrogenous pollution, so this continues to be a highly active area of research.

END OF ADVANCE NOTICE ARTICLE