OCR
RECOGNISING ACHIEVEMENT

ADVANCED SUBSIDIARY GCE

CHEMISTRY B (SALTERS)

Candidates answer on the question paper

OCR Supplied Materials:
- *Data Sheet for Chemistry B (Salters)* (inserted)
- *Advance Notice: 'Earth-Venus-Mars'* (inserted)

Other Materials Required:
- Scientific calculator

Duration: 1 hour 45 minutes

Candidate Forename		Candidate Surname	

Centre Number						Candidate Number				

INSTRUCTIONS TO CANDIDATES

- Write your name clearly in capital letters, your Centre Number and Candidate Number in the boxes above.
- Use black ink. Pencil may be used for graphs and diagrams only.
- Read each question carefully and make sure that you know what you have to do before starting your answer.
- Answer **all** the questions.
- Do **not** write in the bar codes.
- Write your answer to each question in the space provided. Additional paper may be used if necessary but you must clearly show your Candidate Number, Centre Number and question number(s).

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 *'Earth-Venus-Mars'* 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 **16** pages. Any blank pages are indicated.

Answer **all** the questions.

1 Iodine can be extracted from some types of seaweed which have taken up iodine compounds from the seawater. Iodine is present in seawater, as both iodide, I^-, and iodate, IO_3^-, ions.

(a) Give the oxidation state of iodine in I^- and IO_3^-.

I^- .... IO_3^- .... **[2]**

(b) Iodate ions can be converted to iodide ions by reacting them with a solution of sulfur dioxide. The reaction that occurs is represented by **equation 1.1**.

$$IO_3^- + 3SO_2 + 3H_2O \longrightarrow 6H^+ + 3SO_4^{2-} + I^-$$ **equation 1.1**

(i) Which element has been oxidised in the reaction represented by **equation 1.1**?

.... **[1]**

(ii) A solution contains IO_3^- ions at a concentration of 0.15 mol dm^{-3}.

Calculate the concentration of IO_3^- ions in the solution in g dm^{-3}.

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

M_r: IO_3^-, 174.9

concentration = ... g dm^{-3} **[2]**

(iii) **Equation 1.2** is the incomplete half-equation for the conversion of iodate ions to iodide ions. Complete and balance **equation 1.2**.

$$IO_3^- + \text{...........}\ H^+ + \text{...........} \longrightarrow I^- + 3H_2O$$ **equation 1.2** **[2]**

(c) When silver nitrate solution is added to a solution containing iodide ions, a reaction occurs.

(i) What would be **seen** when this reaction occurs?

....

.... **[2]**

(ii) Write the ionic equation for the reaction, including state symbols.

$$\longrightarrow$$

[2]

(d) Iodine, I_2, can be obtained by burning seaweed. The intermolecular bond between the iodine molecules is instantaneous dipole–induced dipole.

Explain how this type of intermolecular bond forms.

....

....

....

....

....

....

.... **[3]**

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

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

.... **[2]**

(ii) Write the electron configuration for the highest energy sub-shell for iodine. (For example, for lead it would be $6p^2$).

.... **[1]**

(iii) Chlorine atoms are more readily reduced than iodine atoms.

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

.... **[1]**

(iv) Using your answers to **(i)**, **(ii)** and **(iii)**, suggest why chlorine atoms are more readily reduced than iodine atoms.

....

....

....

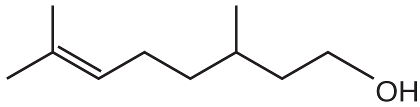
....

....

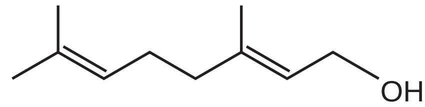
.... **[2]**

[Total: 20]

2 Rose oil, which is extracted from rose petals to use in perfumes, consists of a mixture of chemicals. The skeletal formulae of two of the chemicals, citronellol and geraniol, are shown below.



citronellol



geraniol

(a) Give the molecular formula of **citronellol**.

.... **[2]**

(b) Name the **two** functional groups that are present in **both** citronellol and geraniol.

....

.... **[2]**

(c) Classify the OH groups in citronellol and geraniol as primary, secondary or tertiary.

Explain your answer.

....

....

.... **[2]**

(d) The OH group in geraniol can be oxidised by heating the geraniol under reflux with appropriate reagents.

(i) Give the reagents that would be required in order for this oxidation to occur.

....

.... **[2]**

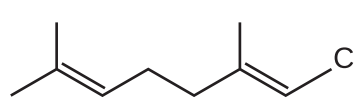
(ii) Describe the colour change you would see during the reaction.

from .... to .... **[2]**

(iii) **Name** the new functional group that forms.

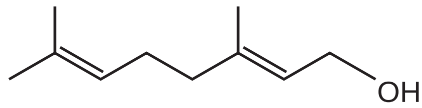
.... **[1]**

(iv) Complete the diagram below to show the full structural formula of the oxidised group that would form from geraniol.



[1]

(e) Geraniol can exhibit *E/Z* isomerism due to the structure of the molecule around the C=C nearest to the OH group. One isomer is shown below.



(i) Draw the skeletal formula of the other isomer.

[2]

(ii) Explain why there are no *E/Z* isomers arising from the C=C at the other end of the molecule.

....

....

.... **[1]**

(f) A student adds bromine water drop by drop to 1 cm^3 of geraniol 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 volume of citronellol.

(i) Describe and explain the **similarities** the student would observe between the two experiments.

....

....

....

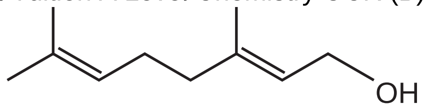
.... **[3]**

(ii) Describe and explain the **difference** the student would observe between the two experiments.

....

....

.... **[2]**



geraniol

(iii) Give the **skeletal** formula of the product that forms from the reaction of geraniol with bromine.

[2]

(iv) Classify the reaction of bromine with citronellol by underlining **two** words from the following list.

addition **electrophilic** **nucleophilic** **radical** **substitution** **[2]**

[Total: 24]

3 A lightning strike provides energy to start reactions between chemicals present in the atmosphere. One possible reaction sequence involving gaseous substances is shown below.

$N_2 + 4O_2 \rightarrow 2NO + 2O_3$ **equation 3.1**

$NO + O_3 \rightarrow NO_2 + O_2$ **equation 3.2**

$NO_2 + O \rightarrow NO + O_2$ **equation 3.3**

$NO_2 + OH \rightarrow HNO_3$ **equation 3.4**

(a) The reactions represented by **equations 3.1** and **3.2** involve the formation of oxides of nitrogen.

Give an example of a human activity that gives rise to oxides of nitrogen.

....

.... **[1]**

(b) Some of the species involved in the reactions shown in the equations above are radicals.

(i) Circle **one** substance in the list below that represents the formula of a radical.

HNO_3 **N_2** **NO** **[1]**

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

....

.... **[1]**

(iii) NO_2 and OH are also radicals. Give the name that is used to describe the type of radical reaction illustrated by **equation 3.4**.

.... **[1]**

(c) The reaction represented by **equation 3.4** has a low activation enthalpy.

(i) Suggest why this reaction has a low activation enthalpy.

....

.... **[1]**

(ii) Suggest why, even though this reaction has a low activation enthalpy, it still occurs slowly in the atmosphere.

....

.... **[1]**

(iii) Describe and explain how the rate of a reaction varies under different temperature conditions.

In your answer, you should make clear how the points you make are linked to one another.

....

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....

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....

....

.... **[5]**

(d) **Equations 3.2** and **3.3** represent the process in which NO reacts with ozone in the stratosphere.

$$NO + O_3 \rightarrow NO_2 + O_2$$ **equation 3.2**

$$NO_2 + O \rightarrow NO + O_2$$ **equation 3.3**

(i) Combine **equations 3.2** and **3.3** to produce the overall equation for the process.

[1]

(ii) Explain how **equations 3.2** and **3.3** show that NO could be a catalyst for the breakdown of ozone.

....

.... **[1]**

(iii) In this process NO is a homogeneous catalyst.

Explain what is meant by the term *homogeneous*.

....

....

.... **[1]**

(iv) Explain why a reaction is faster in the presence of a catalyst.

....

....

.... **[2]**

(e) Ozone is present in both the stratosphere and the troposphere.

(i) Explain how the presence of ozone in the **stratosphere** benefits us.

....

....

....

....

.... **[3]**

(ii) Give **one** disadvantage of a build-up of **tropospheric** ozone.

....

.... **[1]**

[Total: 20]

4 Chlorofluorocarbons, CFCs, have been used for a variety of applications, including as blowing agents for plastics. Since the discovery that CFCs cause environmental damage, alternative compounds have been used.

(a) The table below gives data for some compounds that could be used in place of CFCs. ODP is the Ozone Depletion Potential.

compound	formula	boiling point /K	flammable	ODP	price
A	$CFCl_3$	297	no	1.0	medium
B	CF_2Cl_2	243	no	1.0	medium
C	CF_3CCl_2H	302	no	0.02	high
D	CF_3CH_2F	247	no	0.0	very high
E	$CH_3CH_2CH_3$	231	yes	0.0	low

(i) Give the systematic name of **compound D**.

.... **[2]**

(ii) CFCs were used as blowing agents for plastics like expanded polystyrene. The CFC was incorporated into the plastic as it was being produced. The CFC vaporised during the polymerisation reaction, so it ‘blew’ tiny bubbles in the plastic.

Use data from the table to suggest **one** advantage and **one** disadvantage of **compound C** as a replacement for **compound A** as a blowing agent.

advantage: ....

....

disadvantage: ....

.... **[2]**

(iii) Chemicals used as refrigerants need to be volatile. **Compound B** has been used as a refrigerant because it has a suitable volatility.

Suggest from the list in the table, **one** substance of similar volatility to be a suitable replacement for **compound B** as a refrigerant.

.... **[1]**

(b) A student decided to make the halogenoalkane 1-bromobutane, C_4H_9Br, by reacting butan-1-ol, C_4H_9OH, with hydrobromic acid.

$$C_4H_9OH + HBr \rightarrow C_4H_9Br + H_2O$$

The student wanted to make at least 5 g of 1-bromobutane. Research shows that the reaction typically produces a 45% yield.

(i) Calculate the relative molecular masses of butan-1-ol and 1-bromobutane.

M_r: C_4H_9OH = ...

M_r: C_4H_9Br = ... **[1]**

(ii) Calculate the mass of butan-1-ol that would be needed to produce 5.0 g of 1-bromobutane if the reaction produces a 100% yield.

mass of butan-1-ol = ... g **[2]**

(iii) Calculate the mass of butan-1-ol that would be needed to produce 5.0 g of 1-bromobutane if the reaction produces a 45% yield.

mass of butan-1-ol = ... g **[1]**

(c) The reaction was carried out by heating the mixture of butan-1-ol and hydrobromic acid under reflux for 30 minutes.

(i) Describe how you would carry out the process of heating under reflux in the laboratory.

....

.... **[1]**

(ii) Suggest **two** reasons why *heating under reflux* is used for this reaction.

....

....

.... **[2]**

(d) After heating under reflux, the mixture was allowed to cool. The 1-bromobutane was separated from the mixture and dried. 1-Bromobutane is a liquid that is more dense than water and immiscible in water.

(i) Describe how the 1-bromobutane layer can be separated from the aqueous layer.

....

....

.... **[2]**

(ii) Give the name of a suitable drying agent for the 1-bromobutane.

....

.... **[1]**

(iii) The 1-bromobutane is contaminated with another organic liquid.

Name the process you would use to separate these two liquids.

.... **[1]**

[Total: 16]

5 This question is based on the Advance Notice article ***'Earth-Venus-Mars'*** which is provided as an insert to this paper.

(a) Explain what is meant by *ultraviolet dissociation* of a molecule and how it occurs. Give an example from the article to support your explanation. Name the **type** of bond fission that is occurring.

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

....

....

....

....

.... **[4]**

(b) Calculate how many times as much nitrogen gas there is near the surface of Venus than there is near the surface of the Earth.

answer = ... times as much **[2]**

(c) The article says that, on Venus, some of the carbon dioxide was 'baked out of the rocks'.

Suggest an explanation, in chemical terms, of the meaning of 'baking carbon dioxide out of the rocks'.

....

....

....

.... **[2]**

(d) Explain how carbon dioxide in the atmosphere absorbs infrared radiation.

....

....

....

.... **[2]**

(e) Infrared spectroscopy can be used to show that a sample of air contains water vapour.

Suggest what the main feature of the infrared spectrum of water would be, giving an appropriate wavenumber range.

....

....

.... **[2]**

(f) A sample of Earth's air contains 0.0014% water vapour. Calculate the proportion, in ppm, of the Earth's air sample that is made from water vapour containing a deuterium atom.

answer = ... ppm **[2]**

(g) Discuss factors that account for differences in the temperature on Mars compared to the temperature on Earth. In your answer you should:

- explain why there is less water vapour and carbon dioxide in the atmosphere of Mars than there is in Earth's atmosphere.
- explain how this reduction in the amounts of water vapour and carbon dioxide in the atmosphere of Mars has contributed to much lower temperatures on Mars than on Earth.

In your answer, you should make clear how the steps you describe are linked to one another.

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.... **[6]**

[Total: 20]

END OF QUESTION PAPER

Earth-Venus-Mars

adapted from www.astronomynotes.com

Introduction

Venus, Earth and Mars are all at similar distances from the Sun. It is believed that they formed out of the same material and had approximately the same initial temperatures 4.5 billion years ago. Long ago these three planets probably had moderate enough temperatures suitable for life. However, Venus is now much too hot for life and Mars is too cold for life. What happened to these two planets and why are they so different from the comparative paradise here on Earth? This article explores these three planets in more detail in order to answer this important question and what the answer to this question might say for the future of the Earth.

Venus

Venus is about 95% the size of the Earth and has 82% of the Earth's mass. Like Earth, Venus has a rocky crust and an iron-nickel core. But the similarities stop there. Venus has a thick atmosphere made of 96% carbon dioxide (CO_2), 3.5% nitrogen (N_2) and 0.5% other gases. At Venus' surface, the atmospheric pressure is 91 times the Earth's surface atmospheric pressure. Anyone exploring Venus would need a very powerful cooling system: the surface temperature is above 700 K. This is hot enough to melt lead and is over twice as hot as it would be if Venus did not have an atmosphere. Why does Venus have such a thick atmosphere and why is it so hot on its surface?

Greenhouse Effect

Venus is so hot because of a greenhouse effect that prevents heat from escaping into space. On a planet, certain gases like carbon dioxide or water vapour in the atmosphere prevent heat energy in the form of infrared radiation from leaking out into space. These so-called greenhouse gases allow *visible* light from the Sun to pass through and heat up the surface of the planet. The surface gets warm enough to emit *infrared* light. Some of the infrared radiation is absorbed by the greenhouse gases and some is radiated back towards the surface, keeping the surface warm. On Venus, the super-abundance of CO_2 in its atmosphere is responsible for the huge greenhouse effect. Venus' greenhouse effect probably started from the presence of a lot of water vapour, but Venus is now a very dry place.

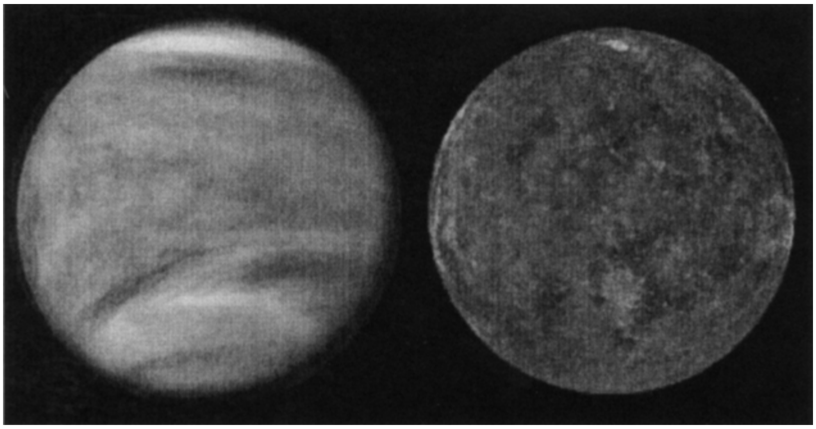


Fig. 1 Venus' cloud tops in UV (left) and Venus' surface imaged with radar (right)

Runaway Greenhouse

Venus was originally cooler than it is now and it had a greater abundance of water several billion years ago. Also, most of its carbon dioxide was locked up in the rocks. Through a process called a runaway greenhouse, Venus heated up to its present blistering hot level. Because Venus is slightly closer to the Sun than the Earth is, its water never liquefied and remained in the atmosphere to start the greenhouse heating. As Venus heated up, some of the carbon dioxide in the rocks was 'baked out'. The increase of atmospheric carbon dioxide enhanced the greenhouse heating. That baked more carbon dioxide out of the rocks (as well as any water) and a runaway feedback loop occurred. This feedback loop occurred several billion years ago, so Venus has been very hot for several billion years. The loss of water from the rocks means that Venus' rocks are harder than the rocks of Earth and its lithosphere is now probably too thick and hard for plate tectonics to occur. The water Venus originally had is now gone because of a process called ultraviolet dissociation.

Ultraviolet Dissociation of Water

Venus' early water was hot enough to remain in a gaseous form and thus (without an ozone layer) was dissociated by ultraviolet radiation from the Sun. The oxygen atoms produced combined with other atoms and the low-mass hydrogen escaped into space. Eventually the water disappeared. On Earth, however, the ozone layer protected the water vapour from the high-energy UV radiation that would cause dissociation.

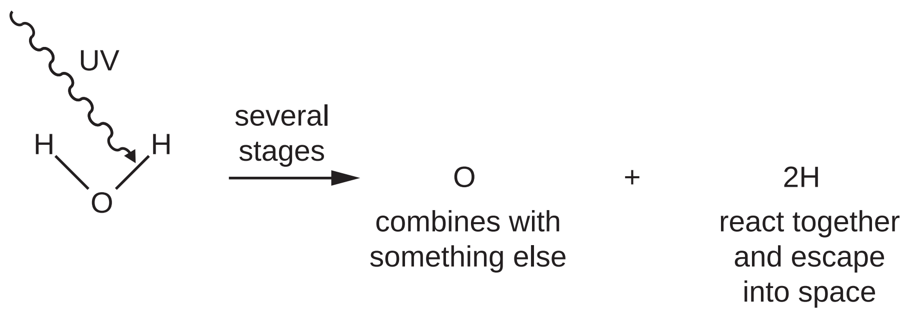
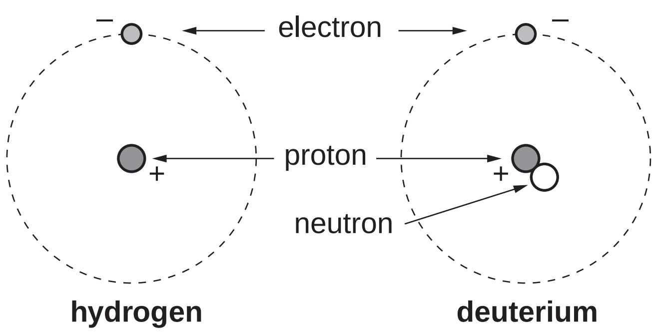


Fig. 2 Ultraviolet dissociation of water

Hydrogen/Deuterium Ratio

How is it known that Venus originally had more water? Clues come from comparing the relative abundances of hydrogen isotopes on Venus and Earth. An isotope of a given element will have the same number of protons in the atomic nucleus as another isotope of that element but not the same number of neutrons. An isotope with more particles in the atomic nucleus will be more massive (heavier) than one with fewer particles in the nucleus.



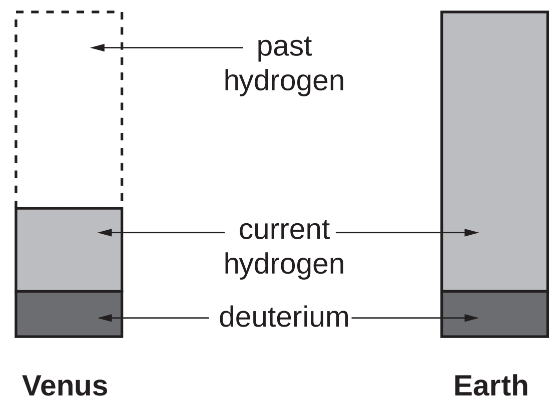
Two isotopes of hydrogen. The deuterium isotope has an extra neutron in the nucleus.

Fig. 3 Hydrogen isotopes

Ordinary hydrogen has only one proton in the nucleus, while the isotope *deuterium* has one proton plus one neutron. Therefore, deuterium is about twice as heavy as ordinary hydrogen and will thus be less likely to escape.

On Earth the ratio of ordinary hydrogen to deuterium (H/D) is 1000 to 1, while on Venus the proportion of deuterium is about ten times greater – the H/D ratio is 100 to 1. The H/D ratios on Venus and Earth are assumed to have been originally the same, so something caused the very light hydrogen isotopes on Venus to preferentially disappear. An easy explanation for it is the ultraviolet dissociation of water.

Water vapour started the greenhouse heating. Carbon dioxide was baked out of the rocks, further aggravating the greenhouse effect. A runaway greenhouse started. The end result was all of the carbon dioxide in the atmosphere and the water dissociated away. The flowchart on page 5, up to the last arrow, occurred several billion years ago. The diamond at the end describes the current state: CO_2 maintains the extremely hot temperature.



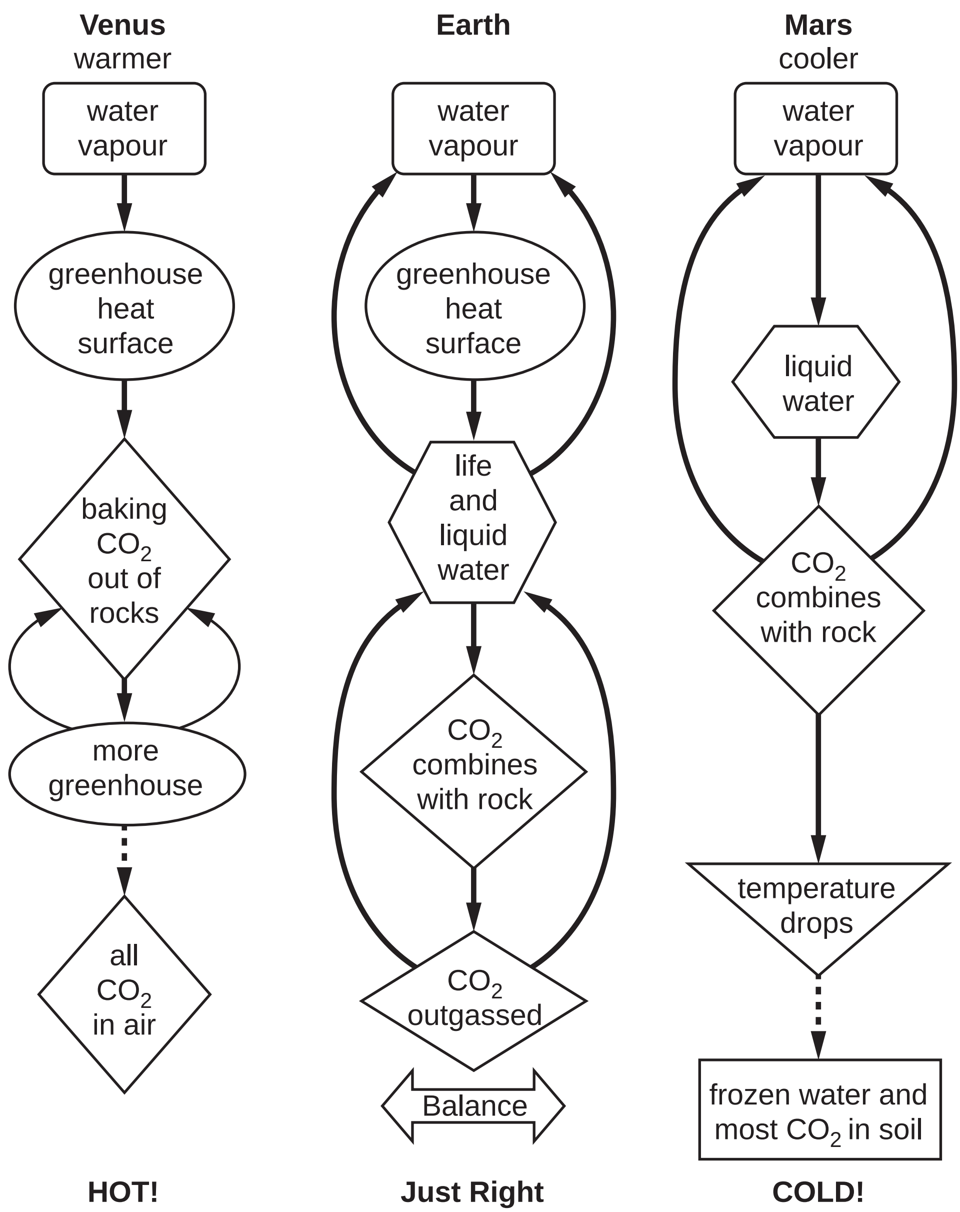
Proportions of hydrogen to deuterium on Venus and Earth are very different – ordinary hydrogen isotope was preferentially removed on Venus.

Fig. 4 Comparison of hydrogen isotopes on Earth and Venus

Earth-Venus-Mars Comparison

This is a flowchart summary of the histories of the terrestrial planet atmospheres of Venus, Earth and Mars. It shows the histories side-by-side so it is easier to compare the planet histories.

The chart for Venus, up to the dashed arrow, describes the runaway greenhouse process that happened a few billion years ago. The bottom diamond describes the current condition. The chart for Mars, up to the dashed arrow, describes the runaway refrigerator process that happened a couple of billion or more years ago, due to Mars' greater distance from the Sun than either of the other two planets. The bottom rectangle describes the current condition. The chart for Earth describes the carbon dioxide cycle as it currently operates. The Earth exists balanced between the two extremes of Venus and Mars.



Venus has a runaway greenhouse effect and no water left. Earth has life and liquid water keeping temperature balanced and most of its CO_2 in the rocks. Mars has a runaway refrigerator with water frozen in permafrost layer and most of its CO_2 in the rocks or frozen on the surface.

Fig. 5 Comparing the atmospheres of Venus, Earth and Mars