

Goldilocks–February 11

- Scores on 6 questions were low
 - Better preparation for questions that require several steps of reasoning
 - Questions will be on homework for Mon
 - Questions will be on Test 2
- How to do some questions on the test
- Goldilocks problem

How to

- Mars is moving in retrograde motion when it is
 1. In the west just after sunset
 2. In the east just before sunrise
 3. High in the sky just after sunset
 4. High in the sky at midnight
- You cannot memorize the answer to this type of problem.
- To do problem
 - One key idea: Mars moves with retrograde motion when the Earth is catching up to it.
 - Deduce whether Earth is catching up from other information

Goldilocks #1

- Venus is too hot; Mars is too cold. Why is the earth just right, not too cold and not too hot?
- Venus is too close to the sun, and Mars is too far.
 - This is part of the answer.
- Reflected light is 2nd ingredient.
- Greenhouse effect is 3rd ingredient.
- History is 4th.

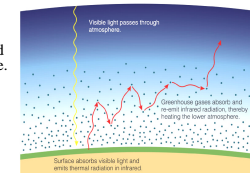


Planet	Pressure	Sunlight relative to Earth	Reflected	Temp	Actual Temp	Greenhouse warming
Venus	90 atm	1.92	76%	-44 C	477 C	521 C
Earth	1 atm	1.00	30%	-18 C (0F)	15 C (59F)	33 C
Mars	0.006 atm	0.43	25%	-63 C	-45 C	8

Table from Rampino & Caldeira, 1994, Ann. Rev. Astron. & Astrophys, 32, p83.

Greenhouse effect

- Greenhouse effect
 - Sunlight is absorbed by the planet's surface
 - Surface emits infrared radiation
 - Infrared radiation is absorbed by CO₂ & H₂O and reradiated many times before it escapes into space. CO₂ & H₂O acts like a blanket.
- Without the greenhouse effect, earth would be frozen.
- Mars has a small greenhouse effect
- Why did Venus evolve to have such a large greenhouse effect?



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Goldilocks #2 (Carl Sagan's Paradox)

- The sun was 30% fainter 3 Byrs ago. The earth received 30% less sunlight, but there was liquid water back then. Why did the earth stay just right, not too cold and not too hot?
- When the sun became brighter, the earth became warmer.
 - More evaporation \Rightarrow more rain
 - More rain \Rightarrow loss of more CO₂, sequestered in rock
 - Less CO₂ \Rightarrow less greenhouse effect
 - Less greenhouse \Rightarrow Earth cools, lessening effect of sun brightening
- If sun becomes fainter, the earth cools.
 - Less evaporation \Rightarrow less rain \Rightarrow more CO₂ is released from rocks by volcanoes \Rightarrow more greenhouse effect \Rightarrow Earth warms, lessening effect of sun dimming
- Walker, Hays, & Kasting (1981) discovered this effect, which provides negative feedback.



Why did feedback fail on Venus?

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- 1. Why did feedback fail on Venus?
 - a. Too hot to rain
 - b. Type of rocks cannot sequester CO₂
 - c. There is no plate tectonics
 - d. Venus was born without water.

- Venus lost its water
 - Ultraviolet light broke water into oxygen and hydrogen
- Q2 The hydrogen escaped into space and the oxygen did not. What is the primary reason?
 - a. Venus has less mass than the earth.
 - b. Hydrogen moves very fast because its mass is small.
 - c. Venus is hotter than the earth.
 - d. Oxygen can react with carbon.

Why did Mars become so cold?

- Read & think.