Introductory Astronomy

Homework 11: Earth Not to be handed in. Homework solutions are posted already.

1. The Earth is a slightly oblate sphere: i.e., it bulges a bit at the equator. The **DIFFERENCE** between the equatorial and polar radii (i.e., $R_{\text{equator}} - R_{\text{pole}}$) is approximately:

   a) 6378 km. b) 1 astronomical unit. c) 60 Earth radii. d) 21 km. e) 1000 km.

2. In order for chemical differentiation to occur near the time of its formation, the Earth then was:

   a) cold. b) stone cold. c) lukewarm. d) much closer to the Sun. e) hot.

3. Three main ingredients in understanding the internal structure of the Earth are

   a) seismology, the primordial solar nebula composition, and modeling.
   b) seismology, the primordial solar nebula composition, and biology.
   c) seismology, biology, and cryptology.
   d) seismology, biology, and cosmotology.
   e) the primordial solar nebula composition, extinct marine invertebrates, and undesirable activities.

4. The central region of the Earth is believed to be

   a) hot and composed mainly of solid iron. b) cold and composed mainly of solid iron. c) hot and composed of gold. d) cold and composed of uranium. e) hot and composed of uranium.

5. The composition of the Earth's crust is dominated by:

   a) oxygen (O) and uranium (U) in about a 1 to 1 ratio by mass.
   b) oxygen (O) and silicon (Si) in about a 2 to 1 ratio by mass.
   c) oxygen (O) and iron (Fe) in about a 1 to 1 ratio by mass.
   d) oxygen (O) and hydrogen (H) in about an 8 to 1 ratio by mass.
   e) argon (Ar) and kryptonite (Ke) in about a 3 to 2 ratio by mass.

6. The Earth's crust is:

   a) divided into continental and oceanic components. The former is about 20–70 km thick and latter, about 6000 km thick.
   b) divided into continental and oceanic components. The former is about 20–70 km thick and latter, about 6–10 km thick.
   c) divided into continental, oceanic, and Hibernian components. The first is about 20–70 km thick. The second is about 6–10 km thick. The third has negative thickness.
   d) divided into continental, oceanic, and Nevadan components. The first is about 20–70 km thick. The second is about 6–10 km thick. The third has negative thickness.
   e) about 6000 km thick.

7. The surface of the Earth is mainly kept warm by:

   a) geothermal heat from the interior.
   b) electromagnetic radiation from the Sun.
   c) radioactive decay heat from radioactive isotopes on the surface.
   d) natural natural gas fires in near-surface caves.
   e) artificial natural gas fires in near-surface caves.

8. The Earth's surface is divided into crustal plates. The plates:

   a) have been fixed and unchanging since the Earth formed.
   b) are pushed around and renewed by geological activity.
   c) are heavily scarred by impact craters.
   d) float directly on a sea of molten iron and nickel.
   e) are pushed around and renewed by geological activity. The temperature of their upper surfaces is over 1000 K due to heat flow from the interior.

9. "Let's play *Jeopardy*! For $100, the answer is: The divergent, convergent, and transform boundaries occur between these geological features."

   What are _____, Alex?

   a) oceans b) earthquakes c) glaciers d) alluvial plains e) tectonic plates

10. Plate tectonics is driven by:

    a) magnetic fields. b) the solar wind. c) comet impacts. d) convective heat flow in the mantle. e) convective heat flow in the atmosphere.

11. If the solar system formed about 4.6 billion years ago, why are Earth rocks mostly younger than one billion years old?

    a) Impacts by young asteroids have resurfaced the Earth.
    b) The solar wind has rejuvenated Earth rock.
    c) Internal-heat-driven geological activity and erosion have continually renewed most of Earth's surface rocks.
    d) Internal-heat-driven geological activity and erosion have renewed once only most of Earth's surface rocks.
    e) The Earth formed only within the last billion years.

12. The Earth's crust is added to by _____ and is removed by _____?

    a) impact craters; convergent boundaries (i.e., subduction zones often in oceanic trenches)
    b) impact craters; volcanoes
    c) impact craters; impact crater also
    d) divergent boundaries (i.e., rifts, often oceanic rifts surrounded by oceanic ridges); convergent boundaries (i.e., subduction zones often in oceanic trenches)
    e) divergent boundaries (i.e., rifts, often oceanic rifts surrounded by oceanic ridges); volcanoes

13. A volcano is:

    a) a vent in the Earth's surface from which liquid water is expelled at irregular or regular intervals.
    b) a vent in the Earth's surface from which lava, ash, and steam are expelled often at irregular intervals.
    c) a crustal plate that is pushed around and renewed by geological activity. The temperature of its upper surface is over 1000 K due to heat flow from the interior.
    d) a mountain in a folded mountain range.
    e) an inhabitant of Vulcan.

14. The three most abundant gases by mass in the present-day Earth atmosphere (excepting water vapor which varies in abundance) are:

    a) molecular nitrogen (N_2), molecular oxygen (O_2), and carbon dioxide (CO_2).
    b) molecular nitrogen (N_2), molecular oxygen (O_2), and argon (Ar) which is a monatomic noble gas.

c) molecular nitrogen (N_2), molecular oxygen (O_2), and ozone (O_3).
d) molecular oxygen (O_2), carbon dioxide (CO_2), and molecular hydrogen (H_2).
e) molecular oxygen (O_2), carbon dioxide (CO_2), and helium (H) which is a monatomic noble gas.

15. "Let's play *Jeopardy*! For $100, the answer is: This gas is a trace gas in the present-day Earth atmosphere, but its importance for the biosphere both in photosynthesis and as a greenhouse gas is immense."

    What is _____, Alex?

    a) molecular oxygen (O_2) b) helium (H) c) ozone (O_3) d) argon (Ar) e) carbon dioxide (CO_2)

16. The Earth's ozone (O_3) layer:

    a) is made of carbon dioxide. b) shields the Earth from solar **INFRARED** radiation. c) shields the Earth from solar **ULTRAVIOLET** radiation. d) prevented any biological activity on the early Earth. e) is made of factory soot.

17. Albedo is the fraction of light reflected (as opposed to absorbed) by an astrophysical body. In general, of course, albedo depends on wavelength. Assume that the albedo of planet is 1 for all wavelengths: i.e., it reflects all light from its upper atmosphere.

    a) The surface temperature will depend on the heat content of the interior of the planet and the heat transport properties of the planet and its atmosphere.
    b) The surface temperature of planet will absolute zero in all cases.
    c) The surface temperature of the planet will be 273.15 K (which is the freezing point of water at one Earth atmosphere pressure).
    d) The surface temperature of the planet will be 77 K (which is the boiling point of molecular nitrogen at one Earth atmosphere pressure).
    e) The surface temperature will be negative on the absolute scale.

18. The greenhouse effect is explained as follows:

    a) The solar radiation peaks in the **VISUAL** and the Earth's atmosphere is comparatively transparent in the visual. Thus a lot of solar radiation reaches the Earth's surface where much of it is absorbed: this heats the surface. The surface radiates **INFRARED (IR) RADIATION** to which the atmosphere is fairly opaque. An overall balance between energy absorbed and radiated from the Earth must be achieved in order to keep the Earth's mean temperature constant. Thus in order to keep the rate of energy outflow sufficiently high, the Earth surface temperature is higher than it would be in the absence of the high IR opacity (absorption) of the atmosphere. (**HIGHER** temperature differences between hot and cold regions cause faster heat flows from the hot to the cold region. Most of space is effectively cold in that it does not radiate a lot of energy.) The **INCREASE** of the mean Earth temperature caused by the comparatively high IR opacity of the atmosphere is the greenhouse effect.
    b) The solar radiation peaks in the **INFRARED (IR)** and the Earth's atmosphere is comparatively transparent in the IR. Thus a lot of solar radiation reaches the Earth's surface where much of it is absorbed: this heats the surface. The surface radiates **RADIO RADIATION** to which the atmosphere is fairly opaque. An overall balance between energy absorbed and radiated from the Earth must be achieved in order to keep the Earth's mean temperature constant. Thus in order to keep the rate of energy outflow sufficiently high, the Earth surface temperature is higher than it would be in the absence of the high IR opacity (absorption) of the atmosphere. (**LOWER** temperature differences between hot and cold regions cause faster heat flows from the hot to the

cold region. Most of space is effectively cold in that it does not radiate a lot of energy.) The **DECREASE** of the mean Earth temperature caused by the comparatively high radio opacity of the atmosphere is the greenhouse effect.

c) The construction of a large number of greenhouses since the early 19th century has increased the amount of carbon dioxide in the atmosphere and in theory this is slowly choking all plant life on Earth. This choking problem is the greenhouse effect.

d) The construction of a large number of greenhouses since the early 19th century resulted from the English craze for **tropical flowers,** particularly orchids. The greenhouse fad is colloquially called the greenhouse effect.

e) Greenhouses release excessive amounts of molecular oxygen into the atmosphere. Molecular oxygen is a highly reactive compound. In excessive concentrations, it is very dangerous to living tissue. The release of molecular oxygen by greenhouses is the greenhouse effect.

19. The greenhouse effect is:

a) always disastrous for life.
b) one of the factors that determine the surface temperature of a planet.
c) always good for plants.
d) one of the factors that supposedly determine the surface temperature of a planet. The scientific consensus is that it never happens at all.
e) one of the factors that determine the surface temperature of Sun.

20. The heat flow into the Earth from the Sun is more or less constant averaged over the course of day.

a) Greenhouses gases, mainly $\mathbf{H_2O}$ and $\mathbf{CO_2}$, keep a fraction of this heat flow from flowing back into space. Thus there is a continual increase in atmospheric heat and temperature.
b) Greenhouses gases, mainly $\mathbf{H_2O}$ and $\mathbf{H_2}$, keep a fraction of this heat flow from flowing back into space. Thus there is a continual increase in atmospheric heat and temperature.
c) Greenhouses gases, mainly $\mathbf{H_2O}$ and $\mathbf{H_2}$, provide extra insulation for the Earth's atmosphere. In order to balance the heat flow in with a heat flow out, the mean equilibrium temperature of the Earth's surface must be higher than in the absence of the greenhouse gases.
d) Greenhouses gases, mainly $\mathbf{H_2O}$ and $\mathbf{CO_2}$, provide extra insulation for the Earth's atmosphere. In order to balance the heat flow in with a heat flow out, the mean equilibrium temperature of the Earth's surface must be higher than in the absence of the greenhouse gases.
e) Greenhouses gases, mainly $\mathbf{H_2O}$ and $\mathbf{CO_2}$, provide extra insulation for the Earth's atmosphere. In order to balance the heat flow in with a heat flow out, the mean equilibrium temperature of the Earth's surface must be higher than in the absence of the greenhouse gases. The greenhouses gases are **RESPONSIBLE** for the Earth's mean temperature being about 80°C rather than −18°C.

21. From about 1960 to 2000, the Earth's atmosphere CO_2 content increased from about 315 ppm (parts per million) to about 370 ppm. Assuming the rate of increase is constant, in about what year will the content be 800 ppm? (Of course, constant increase is unlikely. There are several trends, some of them certainly varying, acting to increase and decrease CO_2 content.) Wally Broecker of Lamont-Doherty Earth Observatory and winner of the 12th Nevada Medal in 1998 or 1999 (for science I suppose though nothing on the Nevada Medal lecture notice says so) suggests the possibility—only possibility mind—that a catastrophic change in global climate could occur over a few decades when the content crosses the 700–800 ppm threshold.

a) 2300. b) 2200. c) 2100. d) 2050. e) 2010!!!

22. Why would one expect an increase in carbon dioxide in the Earth's atmosphere to cause a rise in sea level?

a) A carbon dioxide increase would tend to **DECREASE** the Earth's greenhouse effect leading to an increase in overall world temperatures. An increase in temperatures would tend to melt some of the polar ice caps, and so raise the sea level.
b) A carbon dioxide increase would tend to **INCREASE** the Earth's greenhouse effect leading to an increase in overall world temperatures. An increase in temperatures would tend to melt some of the polar ice caps, and so raise the sea level.
c) Carbon dioxide **INTERACTS** readily with atmospheric molecular hydrogen to form water vapor. Thus new water vapor would be created by increased carbon dioxide. This water vapor would mostly condense out and add to the oceans.
d) Carbon dioxide **DOES NOT INTERACT** with atmospheric molecular hydrogen to form water vapor. Thus new water vapor would be created by increased carbon dioxide. This water vapor would mostly condense out and add to the oceans.
e) A carbon dioxide increase would tend to **INCREASE** the Earth's greenhouse effect leading to an increase in overall world temperatures. An increase in temperatures would **NECESSARILY** cause more rain, and so raise the sea level.

23. Carbon dioxide and water vapor are the main causes of the Earth's greenhouse effect. Without the greenhouse effect the Earth would be colder than it is. Human burning of fossil fuels is very probably increasing the carbon dioxide gas content of the Earth's atmosphere.

a) Thus the mean temperature of the Earth will go **UP**.
b) Thus the mean temperature of the Earth will go **DOWN**.
c) In the simplest picture, the mean temperature of the Earth should increase and this could have many bad consequences. But there may be complex feedback mechanisms and other human generated effects that prevent any change or even cause a reduction in mean temperature. Moreover, completely natural trends in the global climate are also present. They may completely overwhelm any anthropogenic effects. Thus everyone is **UNCONCERNED** about burning fossil fuels.
d) In the simplest picture, the mean temperature of the Earth should increase and this could have many bad consequences. But there may be complex feedback mechanisms and other human generated effects that prevent any change or even cause a reduction in mean temperature. Moreover, completely natural trends in the global climate are also present. They may completely overwhelm any anthropogenic effects. Nevertheless, many people are **CONCERNED**. The simplest picture may be more or less right.
e) Thus the mean temperature of the Earth will go down and then up.

24. In the most current understanding, what is the source of the Earth's original permanent atmosphere and its water? The source is:

a) gravitational accumulation of gases directly from the solar nebula.
b) the giant impact that caused the Moon's formation.
c) outgassing from rock caused by internal-heat-driven geological activity and possibly comet impacts. Recent evidence (circa 1999), however, from Comet Hale-Bopp suggests comets may **NOT** have been important contributors.
d) biological activity.
e) the solar wind and comets. Recent evidence (circa 1999), however, from Comet Hale-Bopp suggests comets may **NOT** have been important contributors.

25. Gas atoms or molecules in the rarefied upper region of a planet's atmosphere can escape to infinity (i.e., become unbound from a planet) since there they are unlikely to collide with other particles on their way out. Assume that the upper atmosphere is shielded from the solar wind by a magnetic field. For a given gas molecule of molecular mass m, the two main factors that determine how fast the gas molecules escape from the upper atmosphere are:

a) planet surface gravity and temperature.
b) upper atmosphere carbon dioxide content and temperature.
c) upper atmosphere gravity and temperature.
d) upper atmosphere biological activity and gravity.
e) planet surface biological activity and temperature.