Introductory Astronomy **NAME:**

Homework 11: The Earth: Homeworks and solutions are posted on the course web site. Homeworks are **NOT** handed in and **NOT** marked. But many homework problems ($\sim$ 50–70 %) will turn up on tests.

Answer Table

	a	b	c	d	e
1.	O	O	O	O	O
2.	O	O	O	O	O
3.	O	O	O	O	O
4.	O	O	O	O	O
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36.	O	O	O	O	O

Name:

	a	b	c	d	e
37.	O	O	O	O	O
38.	O	O	O	O	O
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58.	O	O	O	O	O
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61.	O	O	O	O	O
62.	O	O	O	O	O
63.	O	O	O	O	O
64.	O	O	O	O	O
65.	O	O	O	O	O
66.	O	O	O	O	O
67.	O	O	O	O	O
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71.	O	O	O	O	O
72.	O	O	O	O	O

1. Did you complete reading the Introductory Astronomy Lecture before the **SECOND DAY** on which the lecture was lectured on in class?

   a) YYYessss! b) Jawohl! c) Da! d) Sí, sí. e) OMG no!

2. "Let's play *Jeopardy*! For $100, the answer is: This geometrical shape is normal for massive astronomical bodies where gravity and the pressure force dominate the structure."

   What is a/an _____, Alex?

   a) sphere b) ellipse c) corona d) cone e) snow cone

3. 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.

4. 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.

5. 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 cosmetology.
   e) the primordial solar nebula composition, extinct marine invertebrates, and undesirable activities.

6. 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.

7. Of the Earth's surface, liquid water covers about:

   a) 10 %. b) 30 %. c) 71 %. d) 95 %. e) 99 %.

8. 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.

9. 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.

10. The upper rigid layer of the Earth is called the _____ and it is of order _____ kilometers deep.

    a) lithenosphere; 6000 b) lithosphere; 6000 c) lithosphere; 100 d) asthenosphere; 100 e) lithenosphere; 100

11. 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.

12. 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.

13. "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

14. 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.

15. 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.

16. 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

17. Most tectonic plate boundaries are under the ocean, but a few cross land: e.g.,

a) across Iceland (the Mid-Atlantic Ridge) and southern California from the Gulf of California to about San Francisco (the San Andreas Fault).
b) across Iceland (the Mid-Pacific Ridge) and southern California from the Gulf of California to about San Francisco (the San Fernando Fault).
c) across Nevada (the Las Vegas Wash) and northern California from San Francisco to the Klamath River Valley (the Sonoma Fault).
d) across Nevada (the Las Vegas Wash Basin) and northern California from San Francisco to the Klamath River Valley (the Sonoma Default).
e) across Nevada (the Mifault) and northern California from San Francisco to the Klamath River Valley (the Yurfault).

18. 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.

19. In the Permian period about 250 million years ago, the Earth is believed to have had one large supercontinent called:

    a) Panama. b) Pangaea. c) Pangloss. d) Pan-Am. e) Panic.

20. 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.

21. "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)

22. For respiration we need:

    a) oxygen in any compound whatever. b) carbon monoxide (CO). c) molecular oxygen (O_2). d) krypton gas. e) neon gas.

23. 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.

24. The greenhouse effect for the Earth is explained as follows:

    a) The solar radiation peaks in the **VISIBLE** and the Earth's atmosphere is about 50 % transparent in the **VISIBLE**. Thus, a lot of solar radiation reaches the Earth's surface where it is mostly absorbed: this heats the surface. The surface radiates **INFRARED (IR) RADIATION** to which the atmosphere is fairly opaque and a large fraction of the **IR ENERGY** plus energy directly absorbed in the atmosphere from the Sun is radiated back to the Earth. Now an overall balance between energy absorbed and radiated from the Earth's surface must be achieved in order to keep the Earth in a steady state. In order to radiate enough to balance both the energy flow directly from the Sun and the energy flow from the atmosphere, the Earth surface temperature is **HIGHER** than it would be in the absence of the high **IR ABSORPTION** of the atmosphere and, in fact, a bit **HIGHER** than it would be with no atmosphere at all. The **INCREASE** of the mean Earth temperature caused by the comparatively high **IR ABSORPTION** of the atmosphere is the greenhouse effect.
    b) The solar radiation peaks in the **INFRARED (IR)** and the Earth's atmosphere is about 50 % transparent in the **IR**. Thus, a lot of solar radiation reaches the Earth's surface where it is mostly absorbed: this heats the surface. The surface radiates **RADIO RADIATION** to which the atmosphere is fairly opaque and a large fraction of the **RADIO ENERGY** plus energy directly absorbed in the atmosphere from the Sun is radiated back to the Earth. Now an overall balance between energy absorbed and radiated from the Earth's surface must be achieved in order to keep the Earth in a steady state. In order to radiate enough to balance both the energy flow directly from the Sun and the energy flow from the atmosphere, the Earth surface temperature is **LOWER** than it would be in the absence of the high **RADIO ABSORPTION** of the atmosphere and, in fact,

a bit **LOWER** than it would be with no atmosphere at all. The **DECREASE** of the mean Earth temperature caused by the comparatively high **RADIO ABSORPTION** 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.

25. 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.

26. Given a temperature difference and insulation between two bodies, the rate of heat flow between these two bodies increases with _____ temperature difference and _____ insulation.

a) decreasing; with increasing b) increasing; with increasing c) decreasing; with decreasing
d) increasing; with decreasing e) increasing; is unaffected by

27. 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.

28. 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 if the content crosses the 700–800 ppm threshold.

a) 2300. b) 2200. c) 2100. d) 2050. e) 2020!!!

29. 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. Also increased ocean water temperature, will cause the ocean water to expand.
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.

30. 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 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.

31. 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.
d) biological activity.
e) the solar wind and comets.

32. The molecular oxygen (O_2) in the Earth's atmosphere is probably mainly due to:

a) photosynthesis. b) catalysis. c) analysis. d) direct outgassing from rock.
e) cometary impacts.

33. 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.