1) On this moon with a thick atmosphere, \( \text{Titan} \)
a) it is possible to stand in a hydrocarbon rain on a methane/nitrogen lake.
b) spectroscopy indicates the presence of free oxygen \( (O_2) \).
c) the rotation rate is such that the same side always faces the sun.

2) On this world (oriented in the slide as it is seen in Earth’s sky),
a) Mare Crisium (the Sea of Crisis) is visible mostly in the waning phases.
b) the crater Copernicus is older than the flood basalts that form the maria.
c) we are certain there are footprints of aliens. \( \text{Luna} \)

3) The deep blue feature is on a planet that
\( \text{Neptune} \)
a) is about 30 AU from the sun.
b) absorbs more energy from the sun than it radiates.
c) has ammonia compounds in its atmosphere.

4) This world is unique for
\( \text{Earth} \)
a) active volcanoes.
b) solid water.
c) sticks.

5) Valhalla, pictured here, is
\( \text{Callisto} \)
a) on Europa.
b) the largest volcano in the solar system.
c) the largest impact crater in the solar system.

6) The vertical striations in this image
\( \text{Aurora} \)
a) are caused by the solar wind impacting Earth’s magnetosphere and particles high in its atmosphere.
b) show electrical discharges between the ionosphere and tropospheric thunderstorms.
c) are flaws on the film.

7) The Earth feature shown is the
\( \text{Chicxulub} \)
a) Barringer Meteor Crater in Arizona.
b) Chicxulub Crater in Yucatán.
c) Manicouagan Crater in Quebec.

8) The Galileo images of this world
\( \text{Io} \)
a) indicate motions in a liquid water mantle.
b) show lots of impact craters.
c) show powerful many volcanoes are active.

9) The mountain shown surrounded by clouds is
\( \text{Olympus Mons on Mars} \)
a) on Earth.
b) the largest volcano in the solar system.
c) the largest impact crater in the solar system.

Listen to the voice of the wind and the ceaseless message that forms itself out of silence.
-- Ranier Maria Rilke

The secret of seeing is to sail on solar wind. Hone and spread your spirit till you yourself are a sail, whetted, translucent, broadside to the merest puff.
-- Annie Dillard
The following questions do not reference slides but are still each worth two points.

10)² The density of the Earth
   a) indicates that the material in the center is probably the same as the material on the surface.
   b) indicates that the material in the center is probably different from the material on the surface.
   c) was known by the Greek natural philosopher, Eratosthenes.

11)² Rift valleys are formed when
   a) continents are ripped apart by tectonic activity.
   b) the population of a valley such as the St. Lawrence valley are politically divided along sharp lines.
   c) the sea floor crumples due to the collision of tectonic plates.

12)² The continents on the surface of Earth
   a) moved in the geologic past but are now in their final positions.
   b) are moving even as we sit here taking this silly exam.
   c) will erode away and eventually disappear.

13)² Earth’s geologic activity is driven by
   a) heat from the sun being absorbed by the surface.
   b) the moon’s tidal forces.
   c) heat within that is created by radioactive decay.

14)² The greenhouse effect
   a) occurs because the visible light absorbed by the ground is re-radiated as infrared light that is then absorbed by greenhouse gases like CO₂, CH₄, and H₂O, heating the atmosphere.
   b) occurs when the atmosphere lets infrared light in but not out (like a one-way mirror).
   c) does not operate on any planet other than Earth.

16)² The age of the Earth is estimated at roughly
   a) 4.6 thousand years.
   b) 4.6 million years.
   c) 4.6 billion years.
   d) more than 10 billion years.

15)² The free oxygen in Earth’s atmosphere
   a) was released by chemical reactions in the early oceans.
   b) allowed land life to evolve by forming the ozone layer.
   c) was present in the primeval atmosphere.

17)² The day on Venus
   a) is many Earth months long.
   b) is only a few Earth hours long.
   c) is much brighter than the Venussian night.

18)² The largest volcano in the solar system is
   a) Mauna Kea on Earth.
   b) Prometheus on Io.
   c) Olympus Mons on Mars.

Wind over lake: the image of inner truth.
-- I Ching

"Earth's aura, our air, is unusual. It turns out on examination to be unlike any other atmosphere we know of. It has strange properties that make it necessary to include the air we breathe amongst Earth's growing collection of rare and unreasonable things."

Describe two of the "strange properties" of Earth's atmosphere as compared to those of Mars and Venus.

- Lacks CO\textsubscript{2} due to the oceans having absorbed it and locked it in rocks
- Is mostly N\textsubscript{2} and O\textsubscript{2} where the O\textsubscript{2} was released by life
- Is at the temperature and pressure at the triple point of water
  -- water present as a gas, liquid and solid

20) Explain why moving objects on Earth are deflected and how this and the Hadley convection cells account for the fact that the prevailing winds in the latitudes of the U.S. come from the west.

Since the equator rotates faster than the poles (to get all the way around the Earth in 24 hours), anything that changes latitude will be at a different speed than the new latitude and appear to be deflected by a force that is named the Coriolis force (that also works on particles move E and W).

Air driven aloft at the ITCZ descends in the STHPC at about 30° N. This air spreads north & south. The northward moving air is deflected to its right by the coriolis force which is eastward. Thus the prevailing winds here come from the west.

21) Complete the following table:

<table>
<thead>
<tr>
<th>Celestial Event</th>
<th>Definition</th>
<th>α</th>
<th>δ</th>
<th>PL</th>
<th>Subsolar Latitude (Name)</th>
<th>Date</th>
<th>Constellation</th>
</tr>
</thead>
<tbody>
<tr>
<td>VERNAL EQUINOX</td>
<td>Sun crossing celestial equator moving north</td>
<td>0°</td>
<td>0°</td>
<td>0°</td>
<td>Equator</td>
<td>3/21</td>
<td>Pisces</td>
</tr>
<tr>
<td>SUMMER SOLSTICE</td>
<td>Sun at northernmost point</td>
<td>6°</td>
<td>+23.5°</td>
<td>90°</td>
<td>Tropic of Cancer</td>
<td>6/21</td>
<td>Taurus</td>
</tr>
<tr>
<td>AUTUMNAL EQUINOX</td>
<td>Sun crossing celestial equator moving south</td>
<td>12°</td>
<td>0°</td>
<td>180°</td>
<td>Equator</td>
<td>9/21</td>
<td>Virgo</td>
</tr>
<tr>
<td>WINTER SOLSTICE</td>
<td>Sun at southernmost point</td>
<td>18°</td>
<td>-23.5°</td>
<td>270°</td>
<td>Tropic of Capricorn</td>
<td>12/21</td>
<td>Sagittarius</td>
</tr>
</tbody>
</table>

The last word in ignorance is the person who says of an animal or plant: "What good is it?" If the land mechanism as a whole is good, then every part is good, whether we understand it or not. If the biota, in the course of aeons, has built something we like but do not understand, the who but a fool would discard seemingly useless parts? To keep every cog and wheel is the first part of intelligent tinkering.

-- Aldo Leopold