**Chapter 1: The Water Planet**

**Answers to Study Problems**

1. Earth’s mean radius can be defined as the radius of a sphere having the same volume as Earth. This is called the volumetric radius (Rv) and it is easily calculated from the equatorial radius (Re) and the polar radius (Rp) using:

Rv = cube root (Re 2 × Rp)

Using the values given in figure 1.8 for the lengths of Earth’s equatorial and polar radii, calculate Earth’s volumetric radius, or mean radius, in kilometers and miles.

Solution:

Re = 6378.1 km and Rp = 6356.8 km

Rv = cube root [(6378.1) 2 × 6356.8] = 6371 km (3959 mi)

1. If it is 2:30 P.M. at your location when it is noon along the Prime Meridian, what is your longitude?

Solution:

First calculate the difference in time = (12:00 – 14:30) = −(2 hours and 30 minutes)

Difference in longitude for 2 hours = 2 hr × (15°/hr) = 30°

Difference in longitude for 30 minutes = 30 min × (15’/min) = 450’ = 7° 30’ = 7.5°

Total difference in longitude is = 37.5°

Since the original time difference was negative, longitude is West.

Answer: 37.5° West

1. If it is 8:40 A.M. at your location when it is noon along the Prime Meridian, what is your longitude?

Solution:

First calculate the difference in time = (12:00 – 08:40) = +(3 hours and 20 minutes)

Difference in longitude for 3 hours = 3 hr × (15°/hr) = 45°

Difference in longitude for 20 minutes = 20 min × (15’/min) = 300’ = 5°

Total difference in longitude is = 50°

Since the original time difference was positive, longitude is East.

Answer: 50° East

1. Use Table 1.3 to determine the volume of water held in the atmosphere. Use Figure 1.16 to determine how much water is removed from the atmosphere by precipitation over the oceans and the land each year. Using these two estimates, calculate how many times the water in the atmosphere is replaced in a year.

Solution: (380,000 km3/yr) / (13,000 km3) = 29 times / yr

1. The mean depth of the ocean can be calculated by knowing the average depth of each individual ocean and the percent of the five ocean basins, and the percent of the total world ocean area they cover. Use estimates of these values given in table 1.4 to verify the average depth of the world ocean in meters and feet.

Solution:

Pacific(3972 m × 50.1%) + Atlantic(3646 m × 23.3%) + Indian(3741 m × 19.8%) + Southern(3270 m × 5.4%) + Arctic(1205 × 1.4%) = 3774 m or 12,381 ft

1. Determine the distance between two locations: 110°W, 38.5°N and 110°W, 45°N. Express this distance in nautical miles and kilometers.

Solution:

Because the longitudes of the two points are the same, the distance between the points is based on the change in latitude only. Students need to recall that 1° of latitude equals 60 nautical miles and that 1° of latitude is divided into 60 minutes.

45.0° N - 38.5° N = 6.5° of latitude,

6.5° × (60 nm/° latitude) = 390 nm = 722.3 km

1 km = .540 nm; therefore, 1 nm = 1.852 km

1. Use the volume of the oceans and Earth’s surface area to calculate the depth of a hypothetical ocean covering the entire globe. Express this depth in meters and feet.

Solution:

Volume of the oceans is ~1.335 × 109 km3; surface area of Earth is ~5.098 × 108 km2.

Single ocean depth = volume / surface area

(~1.335 × 109 km3 ) / (~5.098 × 108 km2 ) = 2.619 km = 2619 m = 8593 ft

**Chapter 1: The Water Planet**

**Chapter 1: Quick Review Questions**

**1.1 Cosmic Beginnings**

1. The universe formed roughly 13.7 billion years ago in an event we call the Big Bang. The Big Bang model of formation postulates that all energy and matter in the universe was initially concentrated in an extremely hot, dense singularity smaller than an atom. This singularity experienced a cataclysmic explosion that caused the universe to expand rapidly and cool.
2. Our solar system formed as a result of the collapse of a rotating interstellar cloud of gas and dust called a nebula. This occurred roughly 5 billion years ago.
3. Heat was added to the early Earth’s interior by three processes: 1) as particles of all sizes bombarded the planet and a portion of their energy was converted to heat on impact, 2) the growing size of Earth compressed the interior, and 3) the decay of radioactive elements released heat. When the temperature was high enough to melt iron and nickel, they migrated to Earth’s center and lighter elements migrated toward the surface.
4. Sources of the early oceans and atmosphere include: 1) the release of water, hydrogen, and oxygen during the heating and differentiation of the planet with associated volcanc activity, and 2) water added by comet-like balls of ice or ice meteorites that have collided with Earth through time.

**1.2 Earth’s Age and Time**

1. Earth is approximately 4.5 billion years old.
2. Estimates of Earth’s age have changed over the past few hundreds of years as the methods used to estimate it have changed. Early estimates were not based on scientific processes. Later scientific methods were based on incomplete information. The current estimate of Earth’s age is based on radiometric dating that has been repeatedly tested. It is unlikely that the estimate of Earth’s age will change significantly in the future.
3. Rocks are dated by measuring the relative abundance of radioactive isotopes in them.
4. After two half-lives, 25% of the original parent isotope would be left.
5. The appearance or disappearance of fossil types was used to set the boundaries of geologic time units before radiometric dating.
6. This is because Earth’s axis of rotation is tilted 23.5˚ with respect to the plane of its orbit around the Sun.

**1.3 Earth’s Shape**

1. Earth’s shape is nearly spherical. It is actually an oblate spheroid, slightly flattened at the poles and bulging at the equator.
2. Earth isn’t a perfect sphere because it is not completely rigid. Earth’s rotation causes it to bulge at the equator and flatten at the poles.
3. Given Earth’s size, the difference in elevation from the highest mountain to the deepest ocean depth is relatively small. Consequently, Earth’s surface can be thought of as very smooth.

**1.4 Where on Earth are You?**

1. This is a mechanical exercise for students.
2. Circles of latitude vary in diameter with distance from the equator. The equator is the only circle of latitude with a unique diameter. It’s diameter is larger than any other circle of latitude. The prime meridian is one half the circumference of a circle of longitude. All circles of longitude are the same diameter so the choice of the prime meridian is arbitrary.
3. This is because Earth’s axis of rotation is tilted 23.5˚ with respect to the plane of its orbit around the Sun.
4. Time and longitude are directly related because Earth rotates through 15˚ of longitude in one hour of time.
5. We will not always be able to use the North Star to determine latitude in the North Hemisphere because Earth’s axis of rotation rotates very slowly, making one complete revolution in about 26,000 years. Consequently, it does not always point directly to the North Star.
6. Latitude and Longitude for the following cities:

|  |  |  |
| --- | --- | --- |
| **City** | **Latitude** | **Longitude** |
| **Chicago, IL** | **41.85˚N** | **87.65˚W** |
| **Montreal, Canada** | **45.51˚N** | **73.55˚W** |
| **Buenos Aires, Argentina** | **34.60˚S** | **58.38˚W** |
| **London, England** | **51.52˚N** | **0.11˚W** |
| **Vienna, Austria** | **48.21˚N** | **16.37˚E** |
| **Peking, China** | **39.91˚N** | **116.40˚E** |
| **Tokyo, Japan** | **35.68˚N** | **139.77˚E** |
| **Cape Town, South Africa** | **33.98˚S** | **18.42˚E** |
| **Nairobi, Kenya** | **1.28˚S** | **36.82˚E** |
| **Canberra, Australia** | **35.28˚S** | **149.13˚E** |
| **Papeete, Tahiti** | **17.53˚S** | **149.57˚W** |

**1.5 Modern Navigation**

**(No questions)**

**1.6 Earth is a Water Planet**

1. Water cycles through the entire planetary environment. Balanced inputs and outputs of water can only be assured for Earth as a whole, not for subregions.
2. Climate zones have distinct temperature and moisture characteristics. These characteristics have a major influence on rates of evaporation and precipitation so water moves through reservoirs at different rates in different climate zones.
3. Two example routes are: 1) mountain lake-atmosphere (evaporation), atmosphere-ocean (precipitation), and 2) mountain lake-groundwater (infiltration), groundwater-ocean (underground flow). The water would spend the least time in the atmosphere and the longest time as groundwater.
4. Earth’s surface is 71% water and 29% land.
5. There is more Earth surface area covered by water in the Southern Hemisphere than in the Northern Hemisphere. There is more Earth surface area covered by land in the Northern Hemisphere than in the Southern Hemisphere.
6. Roughly 80% of land is at an elevation below 2 km while about 85% of the ocean floor is at a depth greater than 2 km.
7. Pacific, Atlantic, Indian, Southern, Arctic.