RLP-ESA · RLP Earth Science A — The Universe, Deep Time and a Changing Surface

Unit 1: The Sun, the Stars and the Universe

Practice Workbook. The same problems, in the same order, as the Practice sections of the online lessons.

Name _____ Period _____

Lesson 1.1 — Why the Sun Shines

FLUENCY

1. Convert 60 kPa to atm.

2. Convert 25 kPa to atm.

3. Four hydrogen-1 atoms (1.007825 u each) fuse into one helium-4 atom (4.002603 u). What mass is 'missing', and what percentage of the starting mass is it?

4. How much energy is released if 1.0 kg of mass is converted completely to energy? ($c = 2.998 \times 10^8$ m/s)

5. Light travels 1.496×10^{11} m from the Sun to Earth at 2.998×10^8 m/s. How long does the trip take, in seconds and minutes?

APPLICATION

6. The Sun's luminosity is 3.828×10^{26} W. How much mass does it convert to energy each second, and each year (1 year = 3.156×10^{7} s)?

7. At that rate for 10 billion years, what fraction of the Sun's mass (1.989×10^{30} kg) is converted to energy? Does this threaten the Sun's stability?

8. The solar constant at Earth (1.000 AU) is 1,361 W/m^2. Sunlight spreads as $1/d^2$. What is it at Mars (1.524 AU) and at Jupiter (5.203 AU)?

CHALLENGE

9. Use the solar constant (1,361 W/m^2) and Earth's distance (1.496×10^{11} m) to calculate the Sun's luminosity. Explain the geometry.

REVIEW

10. A sample has mass 1,344.0 g and volume 150.0 cm^3. Find its density and, using a density table, suggest what it could be.

11. Convert 60 km/h to m/s.

Lesson 1.2 — Ellipses, Orbits and Kepler's Laws

FLUENCY

1. An asteroid has a semi-major axis of 9 AU. What is its orbital period?

2. A comet has a period of 8 years. What is its semi-major axis?

3. An ellipse has semi-major axis 12 cm and center-to-focus distance 3 cm. What is its eccentricity?

4. An object orbits at 0.5 AU. What is its period in days?

APPLICATION

5. Ceres orbits at a = 2.77 AU. Predict its period.

6. Neptune's semi-major axis is 30.07 AU. How many Earth years is one Neptune year, and how many orbits has it completed since its discovery in 1846 (to 2026)?

7. A geostationary satellite orbits at a = 42,164 km from Earth's center. Use $T = 2\pi\sqrt{(a^3/GM)}$ with $GM = 3.986 \times 10^{14}\ m^3/s^2$ to find its period in hours.

CHALLENGE

8. A GPS-like satellite must have a period of exactly 12 hours. Find its orbital radius and its height above Earth's surface (radius 6,371 km).

REVIEW

9. Convert 300 km to m.

10. What volume does 40.0 g of water (density 1.0 g/cm^3) occupy?

Lesson 1.3 — Arguing for the Big Bang

FLUENCY

1. A galaxy's hydrogen line (656.3 nm in the lab) is observed at 662.9 nm. Find z and the recession speed.

2. Using H_0 = 70 km/s/Mpc, how fast does a galaxy 150 Mpc away recede?

3. A galaxy recedes at 3,500 km/s. With $H_0 = 70$ km/s/Mpc, how far away is it?

APPLICATION

4. A galaxy's hydrogen line appears at 690.0 nm. Find its speed and distance ($H_0 = 70$ km/s/Mpc).

5. Estimate the age of the universe as $1/H_0$ for $H_0 = 70$ km/s/Mpc (1 Mpc = 3.086×10^{19} km; 1 yr = 3.156×10^7 s).

6. Repeat the $1/H_0$ estimate for $H_0 = 67$ and 73 km/s/Mpc. Does the disagreement change the conclusion that the universe had a beginning?

CHALLENGE

7. The cosmic microwave background has a temperature of 2.725 K. Use Wien's law ($\lambda = 2.898 \times 10^{-3}$ m·K / T) to find its peak wavelength, and explain why it is called a microwave background.

REVIEW

8. Find the slope of the line through (−6, −9) and (−3, −9).

9. Convert 60 mL to L.

Lesson 1.4 — Stars as Element Factories

FLUENCY

1. A radio or wireless signal has frequency 101.7 MHz. Using $c = 3.0 \times 10^8$ m/s, find its wavelength.

2. A wave has frequency 1000 Hz and wavelength 3.4 m. What is its speed?

3. Use Wien's law to find the peak wavelength of the Sun's surface at 5,772 K.

4. A red dwarf has a surface temperature of 3,000 K. Where does its spectrum peak?

5. A star's spectrum peaks at 290 nm. What is its surface temperature?

APPLICATION

6. Betelgeuse's surface is roughly 3,600 K and Rigel's roughly 12,100 K (approximate values). Find each peak wavelength and explain the stars' colors.

7. A fluorescent lamp shows bright green and violet lines, but an incandescent bulb shows a continuous rainbow. What kind of source makes each, and what can the lines tell an astronomer about a star?

8. Name the event that made each: carbon in your body, most of the helium in the universe, the iron in your blood, the gold in a ring, the lead in a cube of Missouri galena.

CHALLENGE

9. By the Stefan-Boltzmann law, each square meter of a star emits power proportional to T^4. How many times more power per square meter does a 11,544 K star emit than the 5,772 K Sun?

REVIEW

10. A sample has mass 179.2 g and volume 20.0 cm^3. Find its density and, using a density table, suggest what it could be.

11. Convert 1250 mL to L.

Unit 1 checkpoint

1. Why does the Sun lose mass as it shines?
   A. It evaporates into space only
   B. Fusion converts about 0.7% of the fused mass into energy
   C. Its gravity weakens
   D. It burns hydrogen with oxygen
2. The Sun converts about _____ × 10^9 kg of mass to energy every second.
3. An asteroid's semi-major axis is 16 AU. What is its period?
   A. 16 years
   B. 32 years
   C. 64 years
   D. 256 years
4. True or false: A planet moves fastest when it is farthest from the Sun.
5. An ellipse with a = 20 cm and c = 5 cm has eccentricity _____.
6. A galaxy's spectral line is shifted from 500.0 nm to 505.0 nm. What is its recession speed?
   A. About 300 km/s
   B. About 3,000 km/s
   C. About 30,000 km/s
   D. It is approaching
7. True or false: The cosmic microwave background is evidence for a hot, dense early universe.
8. Which elements did the Big Bang produce?
   A. All the elements up to iron
   B. Mostly hydrogen and helium, with a trace of lithium
   C. Mostly carbon and oxygen
   D. Gold and uranium
9. A star's spectrum peaks at 400 nm. About what is its surface temperature?
   A. About 1,200 K
   B. About 4,000 K
   C. About 7,200 K
   D. About 72,000 K
10. True or false: Fusion inside a massive star releases energy all the way up to gold.
11. Sunlight takes about _____ minutes to reach Earth.

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