RLP-ESB · RLP Earth Science B — Water, Climate, Resources and Hazards

Unit 2: Weather, Climate and the Energy Balance

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

Name _____ Period _____

Lesson 2.1 — Same Average, Different Year: Weather, Climate and Sunlight

FLUENCY

1. Convert 1250 g to kg.

2. Convert St. Louis's July normal high of 89.6 °F and San Francisco's of 66.3 °F to °C.

3. Kansas City's normal highs are 38.4 °F in January and 88.3 °F in July. What is its annual range in °F and °C?

4. Springfield, Missouri, is at 37.2° N. How high is the noon Sun at the June solstice (declination +23.4°) and the December solstice (−23.4°)?

APPLICATION

5. In Kirksville (40.1° N), compare the noon sunlight per square meter at the June and December solstices using the sine of the Sun's height.

6. In the flashlight lab, the spot covered 40 squares at 90° and 80 squares at 30°. What is the relative energy per square at 30°, and how does it compare with sin 30°?

7. Explain why air reaching San Francisco on a July morning is cool and foggy while air reaching St. Louis is hot and humid.

CHALLENGE

8. At the Arctic Circle (66.6° N) the noon Sun at the June solstice is how high, and how does the energy per square meter compare with St. Louis's June noon Sun (38.75° N)? Why is the Arctic still cool with 24 hours of daylight?

REVIEW

9. Review (Unit 1): Table Rock Lake held 2,880,200 acre-feet on April 1, 2023, and its storage at the top of the flood-control pool is 3,462,000 acre-feet (USACE). What percentage of that capacity was filled?

Lesson 2.2 — Why the Coast Stays Mild: Heating Water and Sand

FLUENCY

1. How much energy warms 0.200 kg of water by 3.0 °C? (c = 4,184 J/(kg·°C))

2. 2,000 J is added to 0.100 kg of dry sand (c = 830 J/(kg·°C)). What is the temperature rise?

3. 2,000 J is added to 0.100 kg of water. What is the temperature rise?

APPLICATION

4. A lamp delivers 5,000 J to each of 0.200 kg of sand and 0.200 kg of water. Find each temperature rise and their ratio.

5. In the lab, sand rose 9.0 °C and water 2.5 °C. What ratio did you measure, and why is it smaller than the ideal ratio of about 5?

6. Use specific heat to explain why San Francisco's annual range (8.5 °F) is so much smaller than St. Louis's (49.2 °F).

CHALLENGE

7. How much energy warms 1 m^3 of seawater (1,025 kg, c ≈ 4,006 J/(kg·°C)) by 1 °C, compared with 1 m^3 of air (1.2 kg, c = 1,005)? What does the ratio mean for where Earth's extra heat is stored?

REVIEW

8. Review (Unit 1): a 200 mL sample of gravel holds 70 mL of water in its pores. What is its porosity?

Lesson 2.3 — What Changes Climate? Orbits, Sun, Volcanoes and Gases

FLUENCY

1. Use $\Delta F = 5.35 \ln(C/280)$ to find the forcing when CO_2 reaches 350 ppm.

2. Find the forcing for a doubling of CO_2 (560 ppm).

3. The Sun's output varies by 0.1% of 1,361 W/m^2. Averaged over the globe after reflection (× 0.7 / 4), how large is that change?

APPLICATION

4. Mauna Loa CO_2 was 316.91 ppm in 1960 and 414.21 ppm in 2020. Find the forcing (relative to 280 ppm) in each year and the change.

5. After the June 1991 eruption of Pinatubo, global temperature fell about 0.5 °C for a year or two. Why did the cooling not last?

6. Match each driver to its time scale: Milankovitch cycles, the solar cycle, a large volcanic eruption, rising greenhouse gases.

CHALLENGE

7. How many times larger is today's CO_2 forcing (424.61 ppm) than the solar-cycle swing of about 0.24 W/m^2? Explain why a forcing that acts in one direction matters more than one that swings up and down.

REVIEW

8. Compare a magnitude 7.0 earthquake with a magnitude 6.0 earthquake. About how many times larger is the ground-motion amplitude, and about how many times more energy is released?

Lesson 2.4 — The Greenhouse Effect by the Numbers

FLUENCY

1. How much power per square meter does a surface at 288 K emit? ($\sigma = 5.67 \times 10^{-8}$)

2. Find Earth's absorbed sunlight per square meter: 1,361 W/m^2, albedo 0.30.

3. Find Earth's no-greenhouse temperature for albedo 0.30.

APPLICATION

4. Find the no-greenhouse temperature if Earth's albedo were 0.25 and if it were 0.35.

5. Mars receives 586 W/m^2 and has an albedo of about 0.25. Find its no-greenhouse temperature. (Its thin CO_2 atmosphere adds only a few degrees.)

6. Venus receives about 2,601 W/m^2 and reflects about 76% of it. Find its no-greenhouse temperature and compare with its measured surface temperature of about 737 K. What explains the difference?

CHALLENGE

7. Without feedbacks, a forcing ΔF changes the emitting temperature by about $\Delta F / (4\sigma T^3)$ at $T = 255$ K. Estimate the no-feedback warming for doubled CO_2 ($3.7\ W/m^2$) and compare with the IPCC best estimate of about 3 °C.

REVIEW

8. A sample starts with 100 g of an isotope whose half-life is 1600 years. How much remains after 4,800.0 years?

Unit 2 checkpoint

1. Which describes climate rather than weather?
   A. A heavy fog in Kansas City this morning
   B. St. Louis's hot, humid summers averaged over 30 years
   C. A thunderstorm tomorrow
   D. Today's wind speed
2. Kansas City's July high of 88.3 °F is about _____ °C.
3. Why does the ground receive less energy per square meter when the Sun is low?
   A. The Sun is farther away
   B. The same beam spreads over a larger area
   C. The Sun is cooler in winter
   D. Clouds are always thicker
4. The same energy is added to equal masses of sand and water. Which warms more?
   A. Water
   B. Sand, about five times as much
   C. Both equally
   D. Neither

5. True or false: Coastal climates have small annual temperature ranges partly because of water's high specific heat.

6. Which cause of climate change acts over tens of thousands of years?
   A. Volcanic eruptions
   B. The sunspot cycle
   C. Milankovitch cycles
   D. El Niño

7. True or false: A cooling stratosphere while the lower atmosphere warms is a fingerprint of increased greenhouse gases.

8. Earth absorbs about _____ W/m² and would be about 255 K without greenhouse gases.

9. Which gases are greenhouse gases?
   A. Nitrogen and oxygen
   B. Water vapor, carbon dioxide and methane
   C. Argon and neon
   D. Only ozone

10. Using $\Delta F = 5.35 \ln(C/280)$, what is the forcing at 420 ppm?
    A. About 0.5 W/m²
    B. About 2.2 W/m²
    C. About 3.7 W/m²
    D. About 5.4 W/m²

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