

Example Mid-Term Exam and Study Sheet

For exam on Wednesday November 3, 1999

Closed Book, Closed Notes. This is longer than the actual exam will be. The questions on the real exam will be similar, however.

Answer using well-constructed short paragraphs, containing complete sentences.

1. Explain why the fact that Earth has active plate tectonics is so important for life on Earth. What would happen to Earth's regenerative capacity if Earth's plate movement stopped?
2. What is the human population of Earth? When was it half of its current value? When do you expect it to double again?
3. How did the formation of oceans make Earth's subsequent evolution so different from that of Venus?
4. Explain the difference between emission and reflection of radiation. Why is the difference important for understanding the greenhouse effect of the atmosphere?
5. What location on Earth receives the greatest daily averaged insolation at the top of the atmosphere, and in what season does this occur? Explain thoroughly.
6. What are the two properties of the atmosphere that give rise to the greenhouse effect?
7. Draw a picture of the cold and warm frontal structure associated with a midlatitude cyclone. Show where the warm and cold air is and which way the wind blows. Explain how this structure moves heat poleward.
8. Draw a picture of the Asian Monsoon system during summer. Explain why the air flows the way it does. Where is the precipitation.
9. Draw a picture of the Asian Monsoon system during winter. Explain why the air flows the direction it does. Where is the precipitation?
10. Draw a picture of Africa. Locate the Sahel region on the map. What season does the rain fall in the Sahel and why?
11. As the Predator approaches Earth in his space cruiser, his infrared vision detects three dark spots along the equator of the planet. Where are they? Why are they dark spots as viewed in infrared from space?
12. The carbon dioxide in the atmosphere is expected to double in the next century compared to preindustrial Earth because humans are burning fossil fuels at an accelerating rate. If this is so, why are we not worried about burning up all the oxygen too?
13. Explain why Venus has a carbon dioxide atmosphere, and Earth has very little carbon dioxide in it. Where did all the outgassed carbon dioxide go on Earth?
14. Why is it important that Earth's emission temperature is close to the triple point of water?
15. Explain the greenhouse effect. What characteristics of the atmosphere are necessary to make the greenhouse effect work.
16. What meteorological phenomenon is responsible for the atmospheric poleward transport of heat in middle latitudes?
17. What meteorological entity is responsible for the equatorward flux of thermal and latent energy in the tropics?
18. Explain why the subtropical latitudes are dry at the surface.

19. Explain how the Asian Monsoon works. Why does it rain in India in summer, but not in winter? Draw a picture, if it will help your discussion.
20. What meteorological phenomenon is responsible for most of the rainfall in middle latitudes?
21. Why does the atmosphere transport more heat poleward in winter?
22. Why don't we have damaging windstorms in middle latitudes during summer?
23. Explain in words what saturation vapor pressure is.
24. Explain some climatological fact using the dependence of saturation vapor pressure on temperature.
25. Explain why carbon dioxide absorbs infrared radiation, but molecular oxygen does not.
26. If you took the water vapor in the atmosphere and made it into a cloud with a top at 5km, would the surface temperature warm or cool relative to a clear atmosphere.
27. Draw a graph of the annually-averaged insolation at the top of the atmosphere as a function of latitude.

Solve the following numerical problems. Show all of your work in the blue books and underline or draw a box around your final answer. Be sure to include units. If you don't have a calculator, go as far as you can without one, by putting the numbers and units in the appropriate places in the formula you are using. (40 points total)

1. If the computing power of an integrated circuit doubles every 18 months(1.5 years), how long does it take for the power to increase by a factor of 10. Give an approximate answer accurate to within one year.
2. The deep ocean contains about 40,000 gigatonnes of carbon. The exchange rate between the mixed layer and the deep ocean is 35 gigatonnes carbon per year. What is the residence time of carbon in the deep ocean?
3. What would be the emission temperature of Mars, if Mars was twice as far from the sun as Earth is from the sun, and the albedo of Mars is 15%? compared to Earth's 30% The solar constant at Earth is 1380 Wm^{-2} , and its emission temperature is 255K.
4. At what rate would coal need to be supplied to provide the electricity needed by a city of 1 million people, if the average person uses energy at the rate of 3 kilowatts, the energy content of coal is $29 \times 10^6 \text{ J kg}^{-1}$, and the efficiency of the coal-fired electrical generation plant is 30%. a) Give your answer in metric tonnes of coal per year. b.) How many tonnes of coal per person per year is needed?

Possibly useful facts below:

$$T_{\text{emission}} = \sqrt[4]{\frac{I_0(1 - \text{albedo})}{\sigma}} ; \quad \sigma = 5.67 \times 10^{-8} \text{ W m}^{-2} \text{ K}^{-4} ; \quad I = I_o \left(\frac{R_o}{R} \right)^2$$

$$T_d = \frac{0.693}{r} ; \quad T_r = \frac{A}{f} ; \quad E = mc^2 ; \quad I = I_o \cos \theta ; \quad \frac{I_o}{4}(1 - \alpha) = \sigma T_e^4$$

$$L = 2.5 \times 10^6 \text{ J kg}^{-1} ; \quad c_p = 1004 \text{ J kg}^{-1} \text{ K}^{-1} ; \quad 86,400 \text{ seconds per day, } 365 \text{ days a year.}$$

$$\sqrt[4]{2} = 1.189, \quad \sqrt[4]{3} = 1.316, \quad \sqrt[4]{3} = 1.414, \quad \sqrt[4]{5} = 1.495$$