GEOL/ENVS 3520 Spring 2009 Hour Exam #2

Enter your name, the date, your ID number, and a made-up 4-digit code (for later recall and identification of your test results) on the separate test sheet.

Carefully read each of the 50 questions below and choose the best answer. Enter your answer besides the corresponding question number on the separate test sheet. 2 pts. each.

This document is double sided. Please answer questions on both sides.

1) Carbon can exist in many forms, the most stable of which are
a. highly reduced, organic forms such as hydrocarbons
b. less reduced, organic forms such as carbohydrate
c. highly oxidized, inorganic forms such as CO_2 and carbonates
d. both a.) *and* b.)
e. none of the above (all forms are comparably stable)

2) Respiration…..
a. is essentially the photosynthesis reaction run in reverse
b. is used by consumers to obtain chemical energy from carbohydrate
c. describes a process by which organic matter (such as plant litter) decays
d. occurs in both plants and animals
e. all of the above

3) Ranking Earth's various carbon reservoirs from largest to smallest (in terms of mass of C), the order is carbon in….
a. rocks, land plants & soils, the oceans, the atmosphere
b. rocks, the oceans, land plants & soils, the atmosphere
c. the oceans, land plants & soils, the atmosphere, rocks
d. the oceans, land plants & soils, rocks, the atmosphere
e. land plants & soils, the oceans, the atmosphere, rocks

4) At steady state, the residence time of carbon (or any material) within a reservoir can be determined as
a. the reservoir size divided by the rate of input
b. the reservoir size divided by the rate of output
c. the rate of input divided by the reservoir size
d. both a.) *and* b.)
e. none of the above

5) Which has the *shortest* time scale for carbon cycling
a. the living terrestrial biosphere
b. soils and dead plant remains
c. the deep ocean
d. carbon in rocks
e. all but d.) are about the same

6) Which has the *longest* time scale for carbon cycling
a. the living terrestrial biosphere
b. soils and dead plant remains
c. the deep ocean
d. carbon in rocks
e. all but d.) are about the same

7) The ocean's biological pump
a. describes the photosynthetic uptake and downward settling of carbon in the ocean
b. describes the addition of carbon to the sunlit surface by respiration
c. quickly returns carbon from the deep ocean to the ocean surface and atmosphere
d. all of the above
e. none of the above

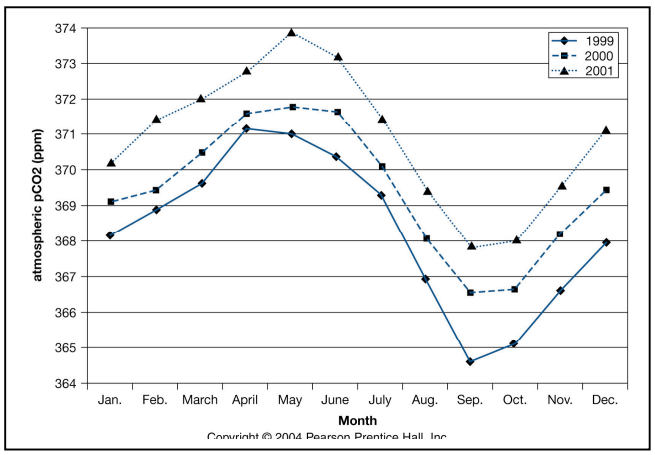

Figure 2. Monthly mean atmospheric CO_2 in 1999, 2000, and 2001

8) Looking at the graph in *Figure 2*, the seasonal variation in the amount of atmospheric CO_2 for 1999, 2000, and 2001 is due mostly to
a. burning of fossil fuels
b. cement manufacture
c. photosynthesis and respiration in the Southern Hemisphere
d. photosynthesis and respiration in the Northern Hemisphere
e. the ocean's biological pump

9) Looking again at the graph in *Figure 2*, the overall increase in CO_2 amount from 1999 to 2000 to 2001 is due mostly to
a. increasing respiration
b. increasing decay of organic matter
c. decreasing photosynthesis
d. burning of fossil fuels
e. none of the above

10) If both photosynthesis and respiration were to increase in a warmer world with more CO_2, we might then expect that in the future
a. the amplitude of seasonal curves might *decrease* compared to those in Figure 2
b. the amplitude of seasonal curves might *increase* compared to those in Figure 2
c. the amplitude of seasonal curves will not change compared to those in Figure 2
d. only the annual average CO_2 will change compared to annual averages for Figure 2
e. can't tell from the information given

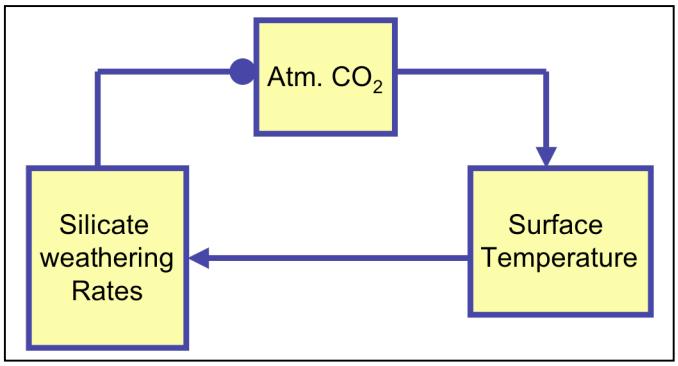

Figure 3

11) In the feedback loop shown above, a sudden rise in temperature would be
a. moderated by increased silicate weathering which will act to lower atmospheric CO_2
b. amplified by increased silicate weathering which will act to lower atmospheric CO_2
c. moderated by decreased silicate weathering which will act to lower atmospheric CO_2
d. amplified by decreased silicate weathering which will act to raise atmospheric CO_2
e. none of the above

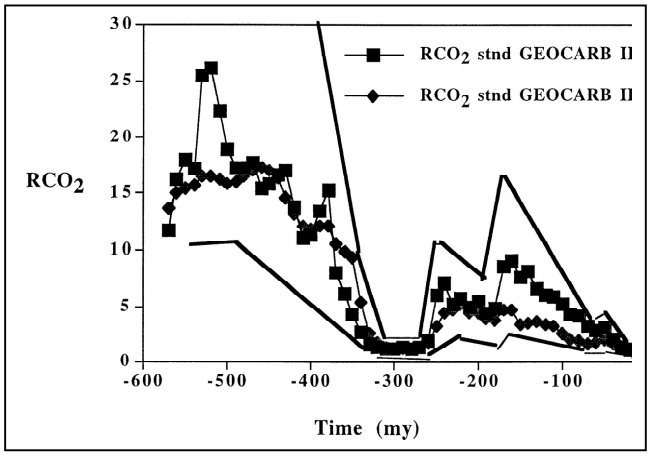

Figure 4: Change in CO_2 (expressed as the ratio of model CO_2 vs. the present value, or RCO_2) arising from various geological and biological perturbations to the long term C-cycle in Berner's GEOCARB model.

12) In *Figure 4* above the decline in modeled CO_2 accelerated ~350 MY ago and some factors that may have acted to draw down atmospheric CO_2 may have been
a. appearance/expansion of vascular (woody) plants
b. increased formation and burial of organic C
c. increased silicate weathering
d. increased volcanism
e. all but d)

13) The decline in atmospheric CO_2 during the Cenozoic (i.e. the last 65 MY) be attributed to
a. a decrease in rates of sea-floor spreading and volcanic degassing of CO_2
b. an increase in rates of sea-floor spreading and volcanic degassing of CO_2
c. an increase in rates of uplift of the Tibetan Plateau and weathering
d. both a.) and c.)
e. both b.) and c.)

14) During the Late Paleocene Thermal Maximum
a. the ocean and atmosphere warmed suddenly
b. large amounts of C were released suddenly
c. the oceans acidified dramatically
d. the amount of C released was comparable to the amount of fossil fuel available for burning in the near future
e. all of the above

15) Close inspection of the CO_2 record from ice spanning the last 1000 years shows the first sustained rise in CO_2 began ~1750 AD, slightly before the start of the Industrial Revolution. This can be attributed to
a. fossil fuel burning
b. cement manufacture
c. forest cutting and land use change in North America
d. increasing strength of the ocean's biological pump
e. decreased soil respiration

16) Organic carbon stored as fossil fuels can be oxidized to produce CO_2 and
a. this happens naturally as a consequence of weathering
b. this happens during combustion of fossil fuels by humans
c. a.) *and* b.) are both true but a.) happens faster
d. a.) *and* b.) are both true but b.) happens faster
e. neither a.) *nor* b.) are true

17) Based on measured anthropogenic carbon inventories, we know that
a. all of the C emitted due to fossil fuel burning remained in the atmosphere
b. about half the C emitted due to fossil fuel burning remained in the atmosphere
c. about half the C emitted due to fossil fuel burning was taken up by the oceans
d. most of C emitted due to fossil fuel burning was taken up by the land biosphere, even after accounting for effects of deforestation
e. both b.) *and* c.)

18) Any uptake of anthropogenic carbon by the oceans reduces the amount that accumulates in the atmosphere, but the down side is
a. ocean acidification
b. consumption of the carbonate ion needed for organisms to build shells
c. sea level rise
d. both a.) *and* b.)
e. both a.) *and* c.)

19) Once emitted, CO_2 not taken up immediately by other surface reservoirs tends to accumulate in the atmosphere because
a. CO_2 is chemically *stable* and thus has a *long* lifetime in the atmosphere
b. CO_2 is chemically *unstable* and thus has a *long* lifetime in the atmosphere
c. CO_2 is chemically *stable* and thus has a *short* lifetime in the atmosphere
d. CO_2 is chemically *unstable* and thus has a *short* lifetime in the atmosphere
e. none of the above

20) According to various analyses of global average surface temperature, 10 to 11 of the warmest years since globally distributed records from thermometers became available in ~1880 have
a. been distributed randomly throughout the length of the record
b. tended to occur within the early part of the record
c. tended to occur within the middle part of the record
d. occurred in the last 12 years
e. none of the above

21) Observations of enhanced warming in the high latitudes of the Northern Hemisphere could be attributed to
a. a temperature - sea ice - ocean heat flux feedback
b. more land in the Northern Hemisphere
c. a snow and ice – albedo feedback on land
d. all of the above
e. chance

22) The satellite record of tropospheric temperature change since the late 1950's
a. has always agreed with the record of surface temperature change from thermometers over the same interval
b. is now in broad agreement with the record of surface temperature change from thermometers over the same interval
c. requires careful corrections to account for decay of the satellite orbit, associated drift in observing times, and separation of tropospheric and stratospheric signals
d. both a.) *and* c.)
e. both b.) *and* c.)

23) The response of *stratospheric* temperature to either increased greenhouse gas or increased solar irradiance forcing will be
a) the same, i.e. both drive warming
b) the same, i.e. both drive cooling
c) opposed, i.e cooling for greenhouse forcing and warming for solar forcing
d) opposed, i.e warming for greenhouse forcing and cooling for solar forcing
e) can't guess without a detailed model

24) During the 20th Century, the global average change in length of small glaciers has most likely been
a. dominated by temperature change
b. dominated by precipitation change
c. minimal, since temperature and precipitation effects on small glacier length have been comparable and offsetting
d. all of the above
e. none of the above

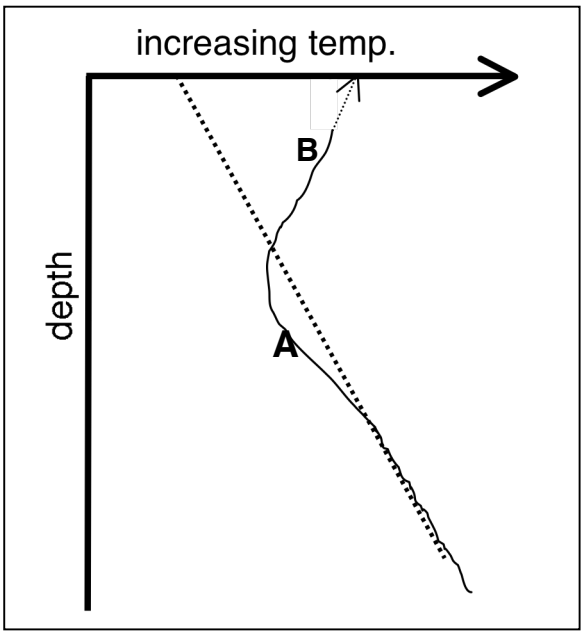

Figure 5: Idealized geothermal temperature v. depth profile (dotted line) and borehole temperature observations (thin line w/ arrow). *Temperature increases to the right.*

25) In the idealized borehole temperature profile above, which do you think happened more recently
a. the *warming* indicated by the deviation at "B"
b. the *cooling* indicated by the deviation at "A"
c. the *cooling* indicated by the deviation at "B"
d. the *warming* indicated by the deviation at "A"
e. can not tell from the information given

26) Which of the following factors is generally a *negative* radiative forcing
a. increasing greenhouse gas concentrations
b. increased aerosols and albedo clouds associated with large volcanic eruptions
c. increasing aerosols from fossil fuel burning
d. both b.) *and* c.)
e. both a.) *and* c.)

27) In addition to using sun spots, we can extend the record of estimated solar irradiance change beyond absolute measurements from satellites using
a. crude, pre-Galilean telescopes
b. measurements of the "cosmogenic" isotope ^{14}C in tree rings
c. measurements of photons trapped in tree rings
d. measurements of watts trapped in tree rings
e. none of the above

28) The record of solar indicators going back 1000 years documents
a. unchanging solar activity and irradiance
b. an uninterrupted 11-year solar cycle
c. a number of distinct *minima* in solar activity during which the 11-year cycle was reduced or absent
d. the gradual increase in irradiance of 1% per 100 million years since the Earth formed 4.5 billion years ago
e. none of the above

29) Combined temperature responses to altered radiative forcing arising from natural changes in solar activity and volcanic eruptions explain
a. little of the reconstructed temperature variability *before* 1900
b. much of the reconstructed temperature variability *before* 1900
c. much of the reconstructed temperature variability *after* 1900
d. both a.) *and* c.)
e. both b.) *and* c.)

30) Observed temperature changes since 1900 over various land and ocean areas are best matched by
a. models that take into account ***only*** natural variations in radiative forcing
b. models that take into account ***only*** human caused variations in radiative forcing
c. models that take into account ***both*** natural and human caused variations in radiative forcing
d. random climate noise
e. none of the above

31) Jim Hansen's prediction given to the US Senate and House of Representatives in 1988 has largely been substantiated by observations since then. Dr. Hansen's prediction was based on
a. luck
b. an expectation that the growing radiative forcing from GHGs would soon dominate the forcing from natural causes
c. an assertion that radiative forcing from GHGs was all that mattered
d. an expectation that radiative forcing from natural sources would subside
e. a non-scientific bias against energy interests

32) The seasonal change in sea-ice extent is greater in the Antarctic than in the Arctic because
a. the maximum extent in the Arctic is limited by land
b. the maximum extent in the Antarctic is limited by land
c. not all Arctic sea ice melts in summer (*yet!*)
d. both a.) *and* c.)
e. both b.) *and* c.)

33) Sea ice
a. enhances the transfer of energy from the ocean to atmosphere
b. limits the transfer of energy from the ocean to the atmosphere
c. does not influence the transfer of energy from the ocean to the atmosphere
d. only influences the surface albedo
e. none of the above

34) The record of decreasing Arctic sea ice cover
a. is too short to be useful
b. is consistent with (but even faster than) expectation from warming in models
c. is consistent with the operation of a positive feedback
d. can be extrapolated to zero at or before ~ 2050
e. all but a.)

35) Recent observations from Greenland indicate that
a. melt area is increasing significantly
b. the margins of the ice sheet are thinning
c. the speed of ice flow near the margins is increasing
d. all of the above
e. none of the above

36) An ice shelf (such as the *Larsen B* on the Antarctic Peninsula)
a. is the same as sea ice
b. is the floating extension of a large glacier or ice sheet
c. contributes *directly* to sea level rise when it disintegrates and melts since it is already floating
d. all of the above
e. none of the above

37) 21,000 years ago, there was much more ice on land than now and subsequent melting lead to a rise in global sea level of
a. about 120 millimeters based on dating of submerged coral reefs
b. about 120 centimeters based on dating of submerged coral reefs
c. about 120 meters based on dating of submerged coral reefs
d. about 120 meters based on coastal tide gauges and satellites
e. none of the above

38) Relative to the period 1880 - 1993, rates of sea level rise fr. 1993-2003 have
a. fallen by about 50%
b. risen by about 50%
c. remained constant
d. varied so much that comparison of average rates is difficult
e. none of the above

39) Which of the contributions to recent sea level change can be assessed and predicted most reliably, that from
a. small glaciers
b. the Greenland Ice Sheet
c. the Antarctic Ice Sheet(s)
d. thermal expansion of sea water
e. all the above are comparably difficult to assess and predict

40) Some projections suggest that the East Antarctic Ice Sheet will *grow* as the world warms because
a. the albedo will decrease
b. warmer air holds more moisture
c. East Antarctica is so cold net melting is unlikely
d. both b.) *and* c.)
e. the Antarctic is completely isolated from the rest of the Earth's climate system

41) Most model forecasts of future sea level rise should be regarded as conservative (minimum) estimates because
a. they do net yet include factors like rapid ice sheet sliding that might greatly increase the amount and speed of sea level change
b. they do not yet include the effect of increased continental precipitation and runoff
c. thermal expansion coefficients for sea water might be much greater than assumed
d. the East Antarctic Ice may grow faster than predicted
e. none of the above

42) The geologic record of the last 35 million years or so indicates
a. a positive relationship or coupling between atmospheric CO_2 concentration and global sea level
b. a negative relationship or coupling between atmospheric CO_2 concentration and global sea level
c. little or no relationship between atmospheric CO_2 concentration and global sea level
d. all of the above
e. none of the above

43) "Polar amplification"
a. is restricted to high latitude warming arising from positive feedbacks
b. is restricted to high latitude warming arising from negative feedbacks
c. includes high latitude warming and (e.g. ice age) cooling from positive feedbacks
d. includes high latitude warming and (e.g. ice age) cooling from negative feedbacks
e. is restricted to the instrumental record

44) The infamous "hockey stick" refers to
a. a 1000-yr temperature reconstruction with absolutely no uncertainty
b. a 1000-yr temperature reconstruction marked by greater uncertainty in the past
c. a 1000-yr CO2 reconstruction with absolutely no uncertainty
d. a 1000-yr CO2 reconstruction marked by greater uncertainty in the past
e. none of the above

45) The mid-range (average) of IPCC "business as usual" forecasts of global average surface warming by the end of the century is
a. about 1 °C (v. a 1960-91 base period)
b. about 1 °F (v. a 1960-91 base period)
c. about 3 °C (v. a 1960-91 base period)
d. about 3 °F (v. a 1960-91 base period)
e. none of the above

46) The *transient climate response* to radiative forcing will be less than the eventual *equilibrium response* because
a. there may be some slow feedbacks within the climate system
b. there may be some slow responding reservoirs of mass and energy in the climate system
c. it takes a long time to emit radiation once it is absorbed
d. both a.) and b.)
e. none of the above

47) “Commitment warming” refers to
a. warming that will occur even after GHG concentrations and radiative forcing have stabilized
b. warming that has already been realized
c. the fact that we are already committed to more GHG emissions
d. the possibility that solar irradiance will increase
e. none of the above

48) “Commitment CO_{2}” and “commitment warming” indicate
a. that we are committed to more fossil fuel burning
b. that human activities will permanently influence climate and sea level
c. that the climate system will rebound completely from changes due to human activities
d. not much, as the concept is not based on plausible physics and chemistry
e. that conspiracy theory has penetrated the field climate science

49) The European heat wave in the summer of 2003
a. could easily have occurred by chance
b. had less than a one in a million likelihood of occurring by chance
c. killed an estimated 30,000 people, mostly elderly
d. both a.) *and* c.)
e. both b.) *and* c.)

50) Which is (are) TRUE:
a. ”global warming” and “greenhouse warming” are precisely the same
b. “global warming” refers to an objective analysis of temperature change from thermometers and other indicators
c. “greenhouse warming” refers to that part of global warming that can be attributed to human enhancement of the greenhouse effect
d. both a.) *and* b.)
e. both b.) *and* c.)