GEOL/ESS 2000, Geochemical Cycles and the Earth System, Exam I 9/20/2013

Closed book, closed notes. Be sure to write your name on the upper right of the exam. In any question recalling a numerical answer, show the steps you made in obtaining that answer. You should not need a calculator.

1) (15 points) Fusion Explain in at most four or five sentences why fusion requires very high temperatures to operate. (This could be either fusion of ^{1}H plus ^{1}H to form ^{2}H, or fusion of ^{1}H plus ^{2}H to form ^{3}He. That is, I'm looking for a general requirement for fusion, not specific to a given set of elements.) To do this, you need to explain which two of the four fundamental forces are <u>always</u> involved in fusion, and why high temperatures are necessary for the reaction to proceed, even though it may liberate energy in the end. As a hint, this has something to do with the range of the forces. Note there is a third fundamental force which is <u>sometimes</u> involved, for example in in the first reaction given above, but <u>not</u> in the second. You do not need to describe its role here.)

2) (5 points) Nuclear Energy, Circle the correct answer:
To release nuclear energy using ^{12}C as fuel you would want to:

a) Fuse multiple carbon nuclei to form heavier elements

b) Split up carbon nuclei to form helium or other lighter elements

3) (15 points) Nucleosynthesis and Radioactive Decay

Using the following portion of the chart of the nuclides, answer the following questions:

3A (5 points) Is ^{136}Xe more likely to be created by the P, or S, or R process?

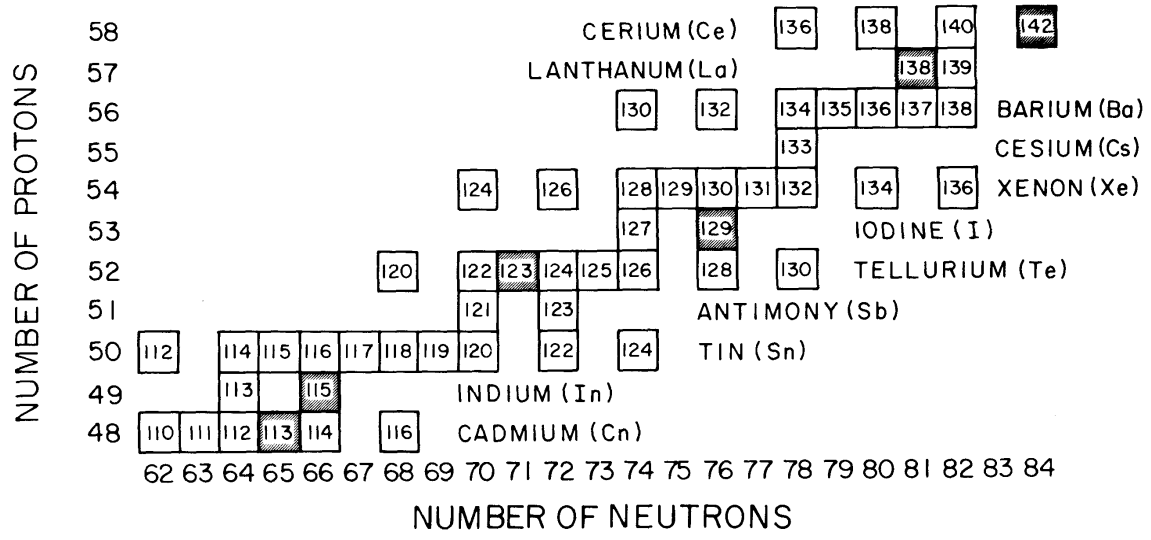
_____

3B (5 points) Is ^{128}Xe more likely to be created by the P, or S, or R process?

_____

3C (5 points) ^{129}I decays to ^{129}Xe with a half life of 15.7 million years. Does this decay occur by Beta Decay, Alpha Decay, or Electron Capture?

_____



4) (5 points) Radioactive decay the early solar system.

In some meteorite components we find an unusual excess of ^{26}Mg, which is thought to be formed by the decay of the very short-lived ^{26}Al. The ^{26}Al has a half-life of only 0.7 million years. Suppose we have two meteorite components, A and B, and both formed from the same pool of materials, but at slightly different times. When we analyze A and B we find that when B formed there was 8 times less ^{26}Al remaining than when A formed. How much time passed between the formation of A and B? Give your answer both in half lives, and in years.

5) (5 points) Earth's Water

In the standard equilibrium condensation model temperatures at the location where the earth will form should be high enough that only "dry" minerals would condense. Yet we know the Earth does have some water, even if when considered as a fraction of the whole, it is a relatively small percentage. The water may have been delivered late during the accretion of the planets, as some fraction of material from one part of the nebula was flung into other parts. Where in the early solar nebula do we know that water (or OH bearing minerals) is present? What evidence do we have for its presence there?

6) (10 points) Carbonaceous Chondrites

The CAI's (Calcium-Aluminum rich Inclusions) are one of the three components of carbonaceous chondrite meteorites which are thought to be relicts of material originally condensed in the solar nebula. What are the other two components? List them and then list the order in which all three components condense, from start to finish, as the nebula cools.

7) (4 pts) A question about the Sun soon after its formation. Circle the correct statement:

a) When the Sun was relatively young it was approximately 30% fainter than it is today.

b) When the Sun was relatively young it was approximately 30% brighter than it is today.

8) (6 pts) a) We have discussed, in class, the point that our Sun is getting brighter as time passes. Is this a **Forcing** or **Perturbation** of the Earth system? (circle one)

b) The eruption of Mt. Pinatubo in 1991 led to global cooling for a few years, but then the effect was gone. Is this a **Forcing** or **Perturbation** of the Earth system? (circle one)

9) (6 pts) In the simple systems diagram below,

a) When the component A gets bigger, component B: **gets bigger** **gets smaller** (circle one)

b) The linkage of system components in the diagram above is a:

Positive Linkage Negative Linkage (circle one)

10) (6 pts) Steady State. A bathtub is being filled with *water flowing into the tub at a rate **of 18 gallons per minute***. The hapless parent who is trying to fill the bath for his kid has not noticed that the drain is open. Water flows out of the bathtub at a rate given by:

Outflow = Kh, where K is a constant (K = 2 gallons/minute/inch) and h is the water depth (in.)

Use the concept of steady state (inflow = outflow) to calculate how deep the water will be at steady state, in inches:

Possibly useful *9/2=4.5 8/2 = 4 15/2 = 7.5 18/2=9 19/2=9.5*

11) (10 pts) Below is a systems diagram describing the effect of Earth's snow and ice cover on albedo (reflectivity) and the Earth's global average surface temperature T_s. I know you haven't seen this particular diagram before, but you know what the linkages mean and should be able to interpret them:

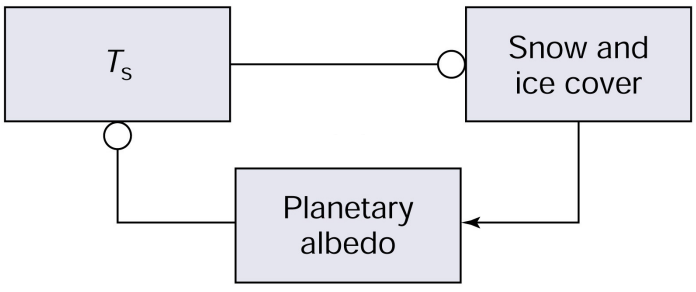
a) How many components does this system have?

b) Does an **increase** in snow and ice cover lead to a **decrease** or **increase** in the planetary albedo? (circle one)

c) Does a decrease in surface temperature T_s cause a **decrease** or **increase** in snow and ice cover globally? (circle one)

d) Is this feedback loop "positive" or "negative"? That is, does this system tend to counteract perturbations/forcings, or does it tend to amplify them?

e) According to this diagram, the record loss of arctic sea ice in amounts of millions of square kilometers in 2007 and again in 2012 should result in what effect on the Earth's surface temperature, T_s?



12) (12 pts) The diagram below left shows two dependences from the "daisyworld" example. Please answer the following questions:

a) The curved, inverted-parabola in Figure 1 represents (circle one):

i) The dependence of temperature on daisy coverage

ii) The dependence of daisy coverage on temperature.

Figure 1 for question #12:

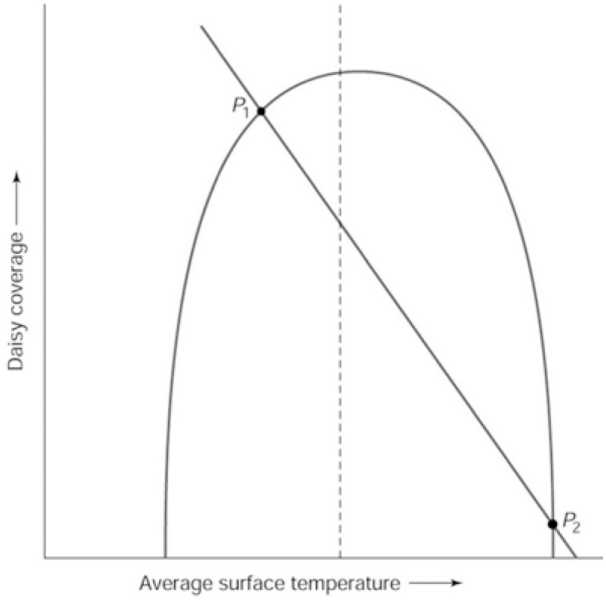
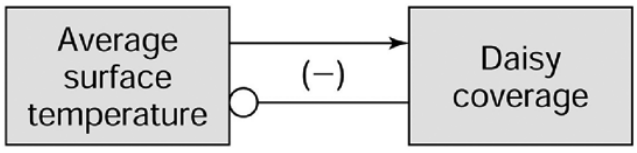


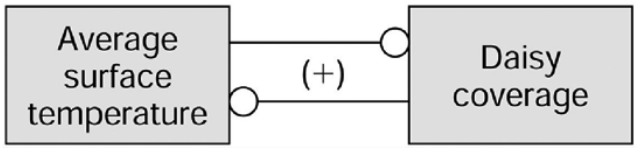
Illustration of "Daisyworld":

In the figure above left, two points P_1 and P_2 occur for which the *dependence of daisy coverage on temperature* and the *dependence of temperature on daisy coverage* are simultaneously true.

b) Using the systems diagram below, determine which feedback system represents an unstable state and which represents a stable state. In addition, determine which diagram corresponds to which point (P_1 or P_2) in the diagram above.



A: Stable or Unstable (circle one)?



B: Stable or Unstable (circle one)?

c) “Positive Feedback” is when a system **amplifies** the effect of a perturbation or forcing.

TRUE FALSE (circle one)

d) “Negative Feedback” is when a system **amplifies** the effect of a perturbation or forcing.

TRUE FALSE (circle one)

e) Do daisies on “daisyworld” get to live at their optimum (“favorite”) temperature most of the time?

f) If daisies on “daisyworld” *are* living at their optimum temperature, what is about to happen (in the long-term context of a sun that gets brighter and brighter and considering the stability of the system at this point)?