ASTR 321-Fall 2009

Problem set #2

Abundances & orbits

due thursday oct 15

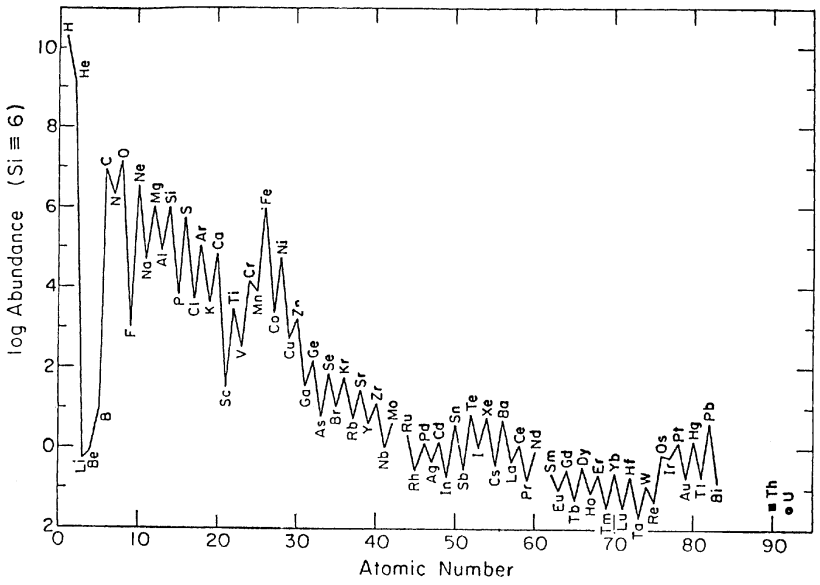
NAME:_____

1) The following is a log plot of our best estimate of the relative **atomic** abundances that the solar system formed from. Consider a region of the solar nebula were all the Fe, Mg and Si condensed to form solid grains of MgO, SiO_2 and Fe metal. All of the carbon formed CO which remained as gas in the nebula and the left over oxygen (after making Mg and Si oxides and CO) then formed water that condensed to ice. If a body formed from the condensed solid materials (ice + the oxides + metal) what would the weight percent abundance ice be in the body?

Use the plot below giving the relative atomic abundances of the elements in the Sun. If you wanted to get the H/C mass ratio from the plot: Log H is ~10.2 and log C is ~7 so the **atom** C/H ratio is $10^7/10^{10.2} \sim 6.3 \times 10^{-4}$. The plot is for atom ratios and to convert to mass ratios you must take into account molecular weights. For example the C/H ***atom ratio*** of 6.3×10^{-4} will yield a 12 times larger ***mass ratio*** of 7.5×10^{-3} ratio because carbon is 12 times more massive than hydrogen. For this problem you can use the following masses: H=1, C=12, O=16, Mg=24, Si=28 and Fe=56.

Relative Abundances (Atomic) of the Elements in the Sun

Note: it is difficult to read C and O from the plot so make oxygen =7 & carbon = 6.7

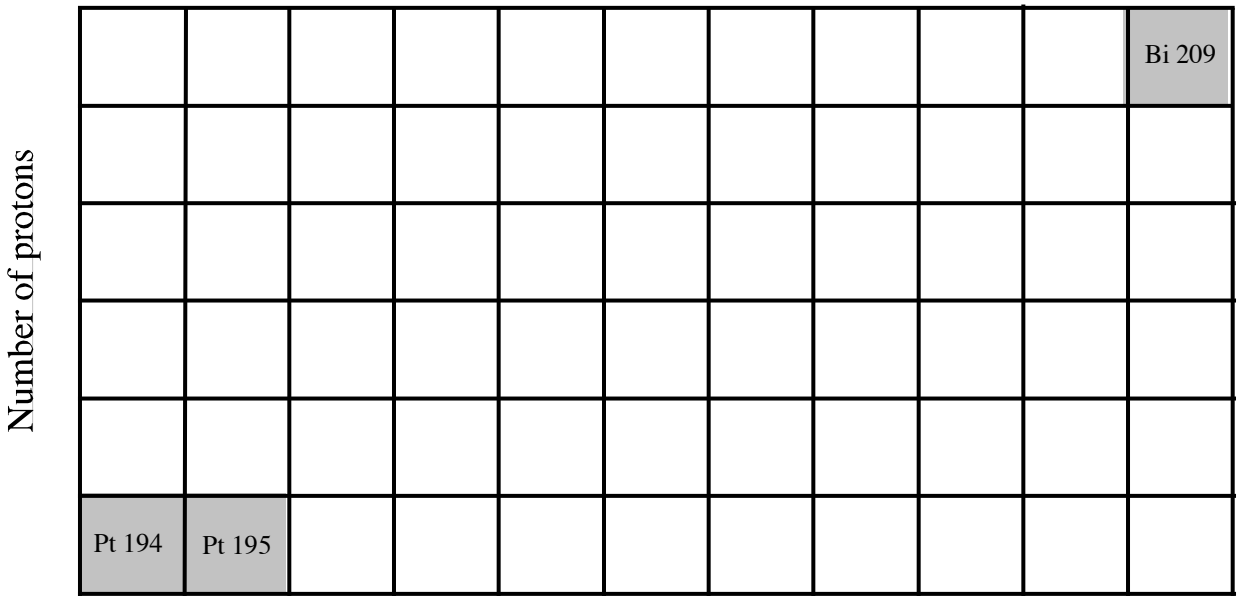


2) The following is a list of all of the stable isotopes of the elements platinum (Pt, 78 protons), gold (Au, 79 protons), mercury (Hg, 80 protons), thallium (Tl, 81 protons), lead (Pb, 82 protons), and bismuth (Bi, 83 protons).

platinum	**^{194}Pt, ^{195} Pt, ^{196} Pt, ^{198}Pt**
gold	**^{197}Au**
mercury	**^{198}Hg, ^{199}Hg, ^{200}Hg, ^{201}Hg, ^{202}Hg, ^{204}Hg,**
thallium	**^{203}Tl, ^{205}Tl**
lead	**^{204}Pb, ^{206}Pb, ^{207}Pb, ^{208}Pb,**
bismuth	**^{209}Bi**

In addition to these stable isotopes, ^{204}Tl and ^{205}Pb have half lives that are long enough so that the s process can pass through them and make heavier elements. Note: there is a branching point at ^{204}Tl and the S process can go both to the next heavier Tl isotope and the next heavier element (^{204}Pb).

All of the other isotopes of these elements are radioactive with lifetimes that are shorter than the time-scale of the slow (S) neutron capture process. Starting with ^{194}Pt mark the location of each of the listed isotopes on the following plot of neutron number VS proton number and draw a line that shows the path of the S process from ^{194}Pt to ^{209}Bi. The S process goes to the right until a short lived radioactive isotope is reached. When this isotope β decays (emits an electron aka a *beta particle*) the product is the next heavier element with one more proton and one less neutron. The purely "R" stable isotopes lie to the right of the path of the S process. Which stable isotope of mercury can only be made by the R process ?
ANS= ____Hg



Hint: If the isotopes are plotted is correctly then isotopes with the same mass (# of neutrons plus # of protons) lie on lines with a slopes of –1.

3) An asteroid orbits the Sun on a low inclination prograde (same direction as Earth) orbit with an aphelion 3 AU and perihelion of 1AU. It is on a collision course with the center of the Earth! What are the following properties of its orbit?

Orbital period= (yr)
Ratio of short axis to long axis
eccentricity =
V_{1AU}= (km/s)
V_{3AU}= (km/s)
ratio of potential energy to kinetic energy at 1 AU=

4) What velocity change (meters/s) at 3 AU is required so that it just misses Earth? (hint: what velocity increase is needed at 3AU to increase the perihelion distance by the radius of the Earth?)

If the asteroid hit the Earth, what would the impact speed (km/s) be (include the gravitational effects of the Earth)? hint: $V_{impact}^2 = V_\infty^2 + V_{esc}^2$, V_∞ is the relative speed between the Earth and comet before acceleration by Earth.

5) The following plot shows the radial velocity of star Rho CrB (a 1 solar mass star) that varies with a period of 39.84 days. The sinusoidally varying doppler shift of the star's spectral lines indicate the presence of a planet orbiting the star in a circular orbit. The velocity is the due to the star's orbit about the center of mass of the star and its planet. Use Kepler's 3rd law to determine the distance between the planet and the star and the mass of the planet (relative to the mass of Jupiter). Assume that the orbit is viewed edge on.