Problem 4:

a) [4 pts] Compare the nucleosynthesis evolution of low-mass (stars like the sun) and high-mass (20 solar mass) stars. In particular, describe all of the hydrostatic and and/or explosive phases of element formation for each type of star. List the elements that are fused (or burned), the order that they happen during stellar evolution and the most likely products of those reactions.

b) [3 pts] What is the heaviest element that can be fused in low-mass and high-mass stars and why? What about iron fusion? When does it occur, or if not, why not? What about the heaviest elements such as precious metals? How are they formed? Describe the processes?

c) [3 pts] How do we know that nucleosynthesis occurs in stars? Give specific examples of observations that indicate element formation must occur in certain stars. What stage of evolution are these stars in, and how are the elements that we observe formed inside the star?

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Astro #4

a) In a low mass star, once it reaches the main sequence it will burn H to He via the P-P chain for billions of years. As He ash builds in the core, eventually the H-burning will occur in a shell instead of in the core. As more ash builds, the He core becomes degenerate and will spark in a He-flash up to several times to break the degeneracy and stably burn He to C and O. But, unlike the He ash, the C/O ash that builds up in the core is unable to break it's degeneracy + the star dies as a C/O white dwarf.

For the high mass star, it burn H to He via the CNO cycle. After that, it builds up a core of concentric shells of various elements (listed in order below) Due to the large mass of the star, it is not necessary for the core to become degenerate to transition from burning one element to another.

$$H \rightarrow He \rightarrow C \rightarrow O \rightarrow Ne \rightarrow Mg \rightarrow Si \rightarrow Fe$$

Once the core becomes filled w/ enough Si ash to begin Si burning, the Ni^{52} ash which subsequently decays to Fe^{56} no more fusion occurs, as fusion of iron into another element requires the addition of energy from its surroundings, instead of releasing energy during the process.

b) In a low mass star, the heaviest elements fused are C/O; heavier elements are not fused b/c the central temperatures of low mass are not high enough for more advanced fusion processes to occur.

In high mass stars, the heaviest element that can be fused is Fe. Fusing elements heavier than iron requires adding energy to the system instead of releasing energy.

The reason we find elements heavier than iron is because during core-collapse SN, the large amounts of neutrons present allow s and r process elements to form. Since neutrons are electrically neutral, they don't need to overcome the Coloumb potential to collide w/ the atomic nuclei. However, these neutron rich isotopes are unstable, and

b) when they decay they leave a proton in the nucleus and create heavier element.

c)