12-1. What are the important thermonuclear reactions leading up to the formation of iron?

Hydrogen fusion (primarily via the CNO cycle in massive stars) forms helium; helium fusion (primarily via the triple-alpha reaction) forms carbon; carbon then fuses with carbon, most commonly to produce a neon nucleus and a helium nucleus; neon then typically absorbs a gamma-ray photon in the high temperature environment, causing it to photodisintegrate to form oxygen and helium; oxygen nuclei then often fuse with other oxygen nuclei to form silicon; finally silicon fuses with alpha particles, one step at a time to a number of possible nuclei all of which are ultimately converted to become iron or radioactive nickel 56.

12-8. When we say that the Moon has a radius of 1080 miles (1737 km), we mean that this is the smallest radius that encloses all of the Moon’s material. In this sense, is it correct to think of the Schwarzschild radius as the radius of a black hole? Why or why not?.

The Schwarzschild radius is not a radius in this sense. As far as we know, the collapsing core of the star continues to contract without cessation until it becomes a singularity of zero size at the center of the Schwarzchild-radius black hole.

12-10. What are the differences between a Type Ia and a Type II supernova?

There are several differences. In a Type Ia supernova, a formerly stable white dwarf accretes mass from an evolving binary companion to approach its Chandrasekhar mass limit which is associated with a zero size, but as this happens the shrinking star undergoes a series of fusion reactions, starting with carbon and oxygen fusion which occur at a furious rate, releasing sufficient energy that the star completely blows up, all remaining matter going into an exploding remnant with no core whatsoever left behind. All that remains is the binary companion of the former white dwarf which now, with the disintegration of the companion to which it was previously gravitationally bound becomes a high velocity runaway star. In the type II supernova, the primary energy source is not the nuclear reactions, but the gravitational energy released in the collapsing core. That collapsing core may become, depending upon its mass and other details of the explosive events which accompany its collapse, a white dwarf, a neutron star, or a black hole. As with a type I supernova, an expanding remnant is ejected into the interstellar medium.

12-12. What is the similarity between a nova and an X-ray burster? How are they different?

Both involve an evolving star in a close binary system shedding mass onto a compact, previously more massive binary companion which has already shed its outer layers to become a white dwarf (nova) or a neutron star (X-ray burster). In the nova, hydrogen accumulates on the white dwarf’s surface until it ignites in a short-lived (several days) but violent fusion reaction on the white dwarf’s surface. Most of the mass of the hydrogen layer (only a tiny fraction of the white dwarf’s total mass) is ejected. In the burster, Hydrogen falls onto the neutron star’s surface and instantly fuses to form helium, producing a continuous creation of weak X-rays, but eventually the accumulating helium layer on the neutron star fuses in a brief (several seconds) outburst of X-rays which give the burster its name. Both of these outbursts will occur repeatedly as mass transfer continues after the described outbursts. In the case of the nova, the subsequent outburst typically occurs years, decades, centuries or even millennia later. The next outburst of an X-ray burster typically occurs only hours or days later. The much shorter period until the next outburst, compared with a nova, is a consequence of the much smaller surface area of a neutron star as compared with a white dwarf which accumulates the critical thickness of a layer necessary for the next outburst in a much shorter period of time.