Astronomy 162 – Winter Quarter 2007
Homework #2

Due in class Tuesday, February 13

Instructions

This handout is just a worksheet. Homework answers must be turned in on the bubble sheets provided. You can pick up additional bubble sheets during class.

Using a #2 pencil only (no pens), please fill out the following info:

1. Your full name, **last name** first, first name last, and remember to bubble in the letters.
2. Bubble in your answers under questions 1-5 in the fields provided on the form.
3. There is no need to bubble in any ID numbers

Please turn in your homework in class on Tuesday, Feb. 13. **No late homework will be accepted**.

This homework assignment consists of the 5 questions below + 1 extra credit problem at the end. The non-extra-credit problems have equal weight.

1) A main-sequence O star has a temperature of 60,000K while on the main sequence. When it runs out of hydrogen in its core, it will evolve across the H-R diagram with a constant luminosity to become a red supergiant with a temperature of 3000K. How much will its radius grow?

   a) It will be the same radius as before
   b) 160,000x larger
   c) 400x larger
   d) 20x larger

2) Evil aliens bent on mischief find the cosmic fuel box and turn off the Sun's nuclear fusion. What would we see happen to the Sun?

   a) The sun will explode as a supernova
   b) The sun will shine for about 1 million years until the last photon from the core can random walk to the surface, and then it will go dark
   c) The sun will keep shining by the Kelvin-Helmholtz mechanism for millions of years, and then it will go dark
   d) The sun will immediately go dark

(turn page over)

3) The Sun has a mass of 1 M_{sun} and a main-sequence lifetime of t_{ms}=10 billion years. How long will a star with a mass of 5 M_{sun} star live on the main sequence?

a) 1.25 trillion years (1.25×10^{12} years)
b) 25 billion years (2.5×10^{11} years)
c) 400 million years (4×10^{8} years)
d) 80 million years (8×10^{7} years)

4) In a star cluster that is 10 billion years old, stars with masses=1 M_{Sun} are "turning off" the main sequence. What is the age of a cluster where the stars leaving the main-sequence have luminosity of 625 L_{Sun}?

a) 1.25 trillion years (1.25×10^{12} years)
b) 25 billion years (2.5×10^{11} years)
c) 400 million years (4×10^{8} years)
d) 80 million years (8×10^{7} years)

5) A Cepheid variable star is 100 kpc (kiloparsecs) away and has pulsation period of 10 days. You observe a second Cepheid variable in a distant galaxy with the same 10-day pulsation period, but it appears to be 10,000 times fainter than the first Cepheid. What is the distance to this galaxy?

a) 100 kpc
b) 1000 kpc
c) 10,000 kpc
d) 1,000,000 kpc

EXTRA CREDIT PROBLEM

Nuclear reactions, in the proton-proton chain or CNO cycle for example, can seem rather complicated. However, they follow clear rules that can be used to determine what the results of a particular reaction will be. There are two rules that we will not use in this problem, but that I mention here just as an FYI. The first is the conservation of the total energy+mass of the system. The second is the conservation of momentum. Conservation meant that those quantities are the same both before and after the reaction. What you will need to solve the problem are the following conservation rules.

Things that are conserved in nuclear reactions

CHARGE

Proton (p) +1
Neutron (n) 0
Electron (e^-) -1
Positron (e^{+}) +1
Neutrino (ν_e) 0

Anti-neutrino ($\overline{\nu}_e$) 0
Photon (γ) 0

LEPTON NUMBER
Proton 0
Neutron 0
Electron +1
Positron -1
Neutrino +1
Anti-neutrino -1
Photon 0

NUCLEON NUMBER
Proton +1
Neutron +1
Electron 0
Positron 0
Neutrino 0
Anti-neutrino 0
Photon 0

Let's take the first reaction in the proton-proton chain

$$p + p \rightarrow {}^{2}H + e^{+} + \nu_e$$

On the left hand side of the equation, we have

Charge=2
Lepton number =0
Nucleon number=2

So on the right hand side, we'd better have the same numbers. Let's check

Charge: The ^{2}H has one proton, so that's +1 and the positron gives another +1. 1+1=2. That works.
Lepton number: ^{2}H has one proton and one neutron, so its lepton number is 0. The positron has a lepton number -1 and the neutrino a lepton number of +1. 0-1+1=0. That works.
Nucleon number: ^{2}H has one proton and one neutron, that is 2 nucleons. Everything else on the right hand side has a nucleon number of 0. Nucleon number=2. That works.

EXAMPLE:
Fill in the blanks with the appropriate missing particle

From the first reaction of the CNO

$^{12}\mathrm{C} + \mathrm{p} \rightarrow ^{13}\mathrm{N} + \_$

On the left-hand side, we have
Charge +7 (6 protons in the C nucleus + 1 proton)
Nucleon number +13 (12 protons+neutrons in the C nucleus + 1 proton)
Lepton number 0

On the right-hand side, we already have
Charge +7 (7 protons in the N nucleus)
Nucleon number +13 (13 protons+neutrons in the N nucleus)
Lepton number 0

Looks like everything matches up, but we are told that there is a particle missing. So we need a particle with lepton number 0, charge 0 and nucleon number 0. That particle is the photon (particle of light). The answer to the question is

$^{12}\mathrm{C} + \mathrm{p} \rightarrow ^{13}\mathrm{N} + \gamma$

ASSIGNMENT:
Following the example, fill in the blanks with the appropriate missing particle. One particle per blank. The periodic table in Box 5-5 of your book will probably come in handy. The number in the upper left corner of the box tells you the number of protons in the nucleus of each element.

(1) $^{2}H + p \rightarrow ^{3}He + \_\_$
(2) $^{7}Be + e^{-} \rightarrow ^{7}Li + \_\_$
(3) $^{13}C + ^{4}He \rightarrow ^{16}O + \_\_$
(4) $^{13}N \rightarrow ^{13}C + \_\_ + \_\_$
(5) $^{16}O + ^{16}O \rightarrow ^{32}S + \_\_$
(6) $^{16}O + ^{16}O \rightarrow \_\_ + n$
(7) $^{16}O + ^{16}O \rightarrow ^{28}Si + \_\_$
(8) $^{16}O + ^{16}O \rightarrow \_\_ + p$
(9) $^{20}Ne + \_\_ \rightarrow ^{16}O + ^{4}He$
(10) $^{28}Si + \_\_ \rightarrow ^{27}Al + p$