Quantum/Nuclear Physics

AP Physics – Mr. Hall

WORKSHEET #1

Name: ______________________

1. Determine the number of protons, electrons, and neutrons each of these isotopes possesses: K-40, O-20, and U-234.

	protons	electrons	neutrons
K-40	19	19	21
0-20	8	8	12
U-234	92	92	142

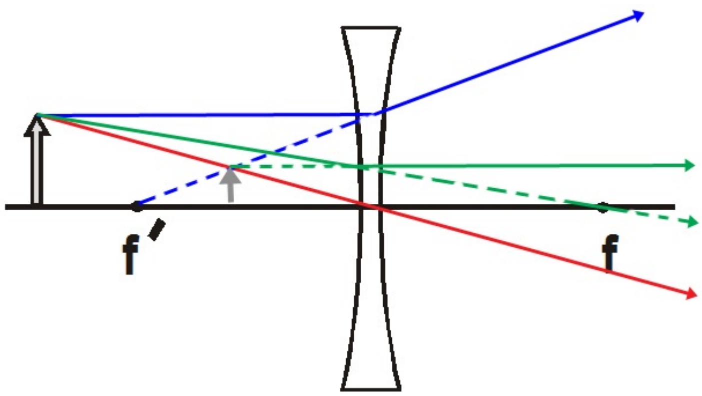
2. Complete the following nuclear reactions:

a. ${}^{95}_{36}Kr \rightarrow \underline{{}^{95}_{37}Rb} + {}^{0}_{-1}e + \bar{\nu}$

b. $\underline{{}^{144}_{60}Nd} \rightarrow {}^{140}_{58}Ce + {}^{4}_{2}He$

c. ${}^{14}_{6}C \rightarrow {}^{14}_{7}N + \underline{{}^{0}_{-1}e}$

3. Construct the image on the drawing below via ray tracing.



4. Convert a mass defect of 0.115 g to Joules

a. $E = mc^2 = 0.115\times10^{-3}$ kg · $(3.00\times10^8$ m/s$)^2 = 1.035\times10^{13}$ J = $\boxed{1.04\times10^{13}\text{ J}}$

b. 1.04×10^{13} J · (1 eV/1.6×10^{-19} J) · (1 MeV/1,000,000 eV) = 6.46875×10^{25} MeV = $\boxed{6.47\times10^{25}\text{ MeV}}$

5. A lithium-6 nucleus has a mass of 6.015 121 u. The mass of a single proton is 1.007 276 u, and the mass of a single neutron is 1.008665 u. (a) What is the mass defect for lithium and (b) what is the binding energy for lithium?

a. $\Delta m = 3m_p + 3m_n - m_{Li} = 3\cdot1.007276\text{ u} + 3\cdot1.008665\text{ u} - 6.015121\text{ u} = \boxed{0.032702\text{ u}}$

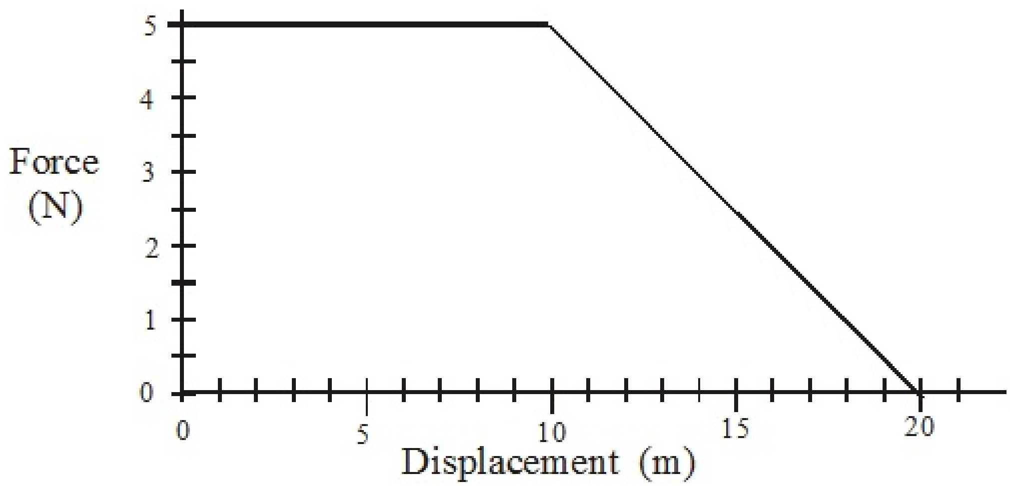
b. $E = mc^2 = 0.032702$ u · (1.66×10^{-27} kg/1 u) · $(3.00\times10^8$ m/s$)^2$ = $\boxed{4.89\times10^{-12}\text{ J}}$

6. The sun radiates energy at the rate of 3.92×10^{26} W. (a) What is the change in the sun's mass in one second? (b) How much mass does the sun lose in the lifetime of your average earthling (say, 75 years)?

a. $m = E/c^2 = (P \cdot t)/c^2 = (3.92\times10^{26}\ W \cdot 1\ s)/(3.00\times10^8\ m/s)^2 =$ $\boxed{4.36\times10^9\ kg}$

b. $4.36\times10^9\ kg/s \cdot (3600\ s/1\ h) \cdot (24\ h/1\ d) \cdot (365.25\ d/1\ y) \cdot 75\ y =$ $\boxed{1.03\times10^{19}\ kg}$

7. A 2.50 kg object moves along a straight line. The net force that acts on the object varies with its displacement as shown on the graph. The object starts from rest at ***x = 0*** and a time of ***t = 0***. It is displaced a total distance of ***20.0 m***. Find: (a) The acceleration of the object at ***x = 5.00 m***. (b) The time taken for the object to travel the first ten meters. (c) The amount of work done by the force in displacing the object the 20.0 m. (d) The speed of the object at ***x = 10.0 m***. (e) The speed of the object at x = 20.0 m. (f) the change in momentum as the object moves from ***10.0 m*** to ***20.0 m***.



a. $a = F/m = 5.00\ N/2.50\ kg =$ $\boxed{2.00\ m/s^2}$

b. $x = x_o + v_o t + \frac{1}{2} a t^2$

$10\ m = 0\ m + 0\ m/s \cdot t + \frac{1}{2}(2.00\ m/s^2) \cdot t^2$

$t = (10\ s^2)^{\frac{1}{2}} =$ $\boxed{3.16\ s}$

c. Area under the line: $5\ N \cdot 10\ m + 2.5\ N \cdot 10\ m =$ $\boxed{75.0\ J}$

d. $v^2 = v_o^2 + 2ad$

$v = (2ad)^{\frac{1}{2}} = (2 \cdot 2.00\ m/s^2 \cdot 10\ m)^{\frac{1}{2}} =$ $\boxed{6.32\ m/s}$

(can also be found by setting W=KE and solving for v. See 7e)

e. All of the work is turned into KE, so $\Delta KE = W$

$W = \frac{1}{2} mv^2$ so $v = (2W/m)^{\frac{1}{2}} = (2 \cdot 75\ J / 2.5\ kg) =$ $\boxed{7.75\ m/s}$

f. $\Delta p = m\Delta v = 2.5\ kg \cdot (7.75\ m/s - 6.32\ m/s) = 3.575\ kg{\cdot}m/s =$ $\boxed{3.58\ kg{\cdot}m/s}$