PHYS 122 HWK 10

26.4

a) use time dilation:

$\Delta t = \gamma \Delta t_p \Rightarrow \Delta t_p = (1/\gamma)\Delta t$

$\gamma = [1 - v^2/c^2]^{-1/2} = [1-(0.950)^2]^{-1/2} = 3.20$

$\Rightarrow \Delta t_p = \left(\frac{1}{3.20}\right)(4.42\ yrs) = \boxed{1.38\ yrs}$

b) use length contraction:

$L = L_p\sqrt{1-v^2/c^2} = (4.20\ ltyrs)\left(\frac{1}{\gamma}\right) = 1.31\ ltyrs$

-or- use $\Delta d = v\Delta t$

$\Delta d = (0.950c)(1.38\ yrs) = \boxed{1.31\ ltyrs}$

26.6

a) to an observer on the ship the time between each heartbeat is the same as it is for the astronaut, so the heartbeat is $\boxed{70\ beats/min}$

b) to an observer on the ship more time passes between each heartbeat; for this observer what seemed like a minute to the heart seems longer:

$\Delta t = \gamma(1\,min) = (1-(0.9)^2)^{-1/2}(1\,min) = 2.29\,min$

so the heartrate is

$\frac{70\ beats}{2.29\,min} = \boxed{30.5\ beats/min}$

26.12 a) To the second observer it seems as though observer A is moving backwards at a speed 0.955c.

$L = L_p\sqrt{1-v^2/c^2} = L_o\sqrt{1-(.955)^2} = \boxed{0.300\,L_o}$

b) We need to know the proper length of the moving rod (its length in observer B's frame):

$L_p = \gamma L = (1-(0.955)^2)^{-1/2} L_o = 3.37 L_o$

$\Rightarrow \frac{\text{rod A}}{\text{rod B}} = \frac{0.300\,L_o}{3.37\,L_o} = 0.0880 = \boxed{8.80 \times 10^{-2}}$ according to observer B

26.20

relativistic $p_r = \gamma m v$ $\Rightarrow$ $p_r = \gamma p_{nr}$

nonrelativistic $p_{nr} = mv$

a) the error in p is 1.00% when $p_r = 1.01\,p_{nr}$,

or $\gamma = 1.01 = [1 - v^2/c^2]^{-1/2}$

$\Rightarrow [1-v^2/c^2]^{1/2} = 0.\overline{9900}$

$\Rightarrow 1 - v^2/c^2 = 0.9803$

$\Rightarrow v^2/c^2 = 0.0197 \Rightarrow \boxed{v = 0.140c}$?

b) the error in p is 10.0% when $p_r = 1.1\,p_{nr}$, or

$\gamma = 1.1 = [1 - v^2/c^2]^{-1/2}$

$\Rightarrow [1-v^2/c^2]^{1/2} = 0.\overline{90}$

$\Rightarrow 1 - v^2/c^2 = 0.826$

$= v^2/c^2 = 0.174 \Rightarrow \boxed{v = 0.417c}$

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26.28)

a) $E_r = mc^2 = (1.67495\times10^{-27}\,kg)\,c^2 = \boxed{1.51\times10^{-10}\,J} = \boxed{942.24\ MeV}$

b) $E_t = \gamma mc^2 = [1-(0.950)^2]^{-1/2}(1.51\times10^{-10}\,J) = \boxed{4.82\times10^{-10}\,J} = \boxed{3.01\ GeV}$

c) $KE = E_t - E_r = 4.82\times10^{-10}\,J - 1.51\times10^{-10}\,J = \boxed{3.32\times10^{-10}\,J} = \boxed{2.07\,GeV}$

26.32)

The energy required for the acceleration is just ΔE_K, the change in kinetic energy.

a) $\Delta KE = (\gamma_f - 1)m_ec^2 - (\gamma_i - 1)m_ec^2 = (\gamma_f - \gamma_i)m_ec^2$

$= [(1-(0.900)^2)^{-1/2} - (1-(0.500)^2)^{-1/2}](8.188\times10^{-14}\,J)$

$= [2.294 - 1.155](8.188\times10^{-14}\,J)$

$= \boxed{9.33\times10^{-14}\,J}$

b) $\Delta KE = [(1-(0.990)^2)^{-1/2} - (1-(0.900)^2)^{-1/2}](8.188\times10^{-14}\,J)$

$= [7.089 - 2.294](8.188\times10^{-14}\,J)$

$= \boxed{3.93\times10^{-13}\,J}$

27.12)

In order to stop electron ejection, KE_{max} must be equal to the energy used by an e^- traversing ΔV_s

$KE_{max} = hf - \phi = e\Delta V_s$

$\Rightarrow \phi = hf - e\Delta V_s = (6.63\times10^{-34}\,Js)(3.0\times10^{15}\,Hz) - 7.0\,eV$

$= 12.4\,eV - 7.0\,eV = \boxed{5.4\,eV}$

27.14

In order for the photoelectric effect to be observed KE_{max} must be greater than zero, so do part (b) first

b) $KE_{max} = hf - \phi$

but $f = c/\lambda$, so $KE_{max} = h(c/\lambda) - \phi$

lithium:

$$KE_{max} = (6.63\times10^{-34}\ \text{J}\cdot\text{s})(3.00\times10^{8}\ \text{m/s})/(400\times10^{-9}\ \text{m}) - \phi$$
$$= 4.97\times10^{-19}\ \text{J} - (2.30\ \text{eV})(1.602\times10^{-19}\ \text{J/eV})$$
$$= \boxed{1.284\times10^{-19}\ \text{J} \quad \text{or} \quad 0.801\ \text{eV}}$$

beryllium:

$$KE_{max} = 4.97\times10^{-19}\ \text{J} - (3.90\ \text{eV})(1.602\times10^{-19}\ \text{J/eV})$$
$$= -1.28\times10^{-19}\ \text{J}$$

(since this is negative no photoelectric effect will be seen)

mercury:

since the work function for mercury is even larger than that of beryllium, its max. KE will be negative as well

a) only $\boxed{\text{lithium}}$ exhibits a photoelectric effect

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Binding Energy

The binding energy is the energy equivalent to the mass difference between an atom and the sum of its parts, via $E = mc^2$.

a)
missing mass = mass(1 proton + 1 neutron + 1 electron) − mass (^2H)
$= 1.007276\,u + 1.008665\,u + 5.49\times10^{-4}\,u - 2.014102\,u$
$= 0.002388\,u$

$E_b = (0.002388\,u)(931.5\text{ MeV}/u) = \boxed{2.224\text{ MeV}}$

b)
missing mass = mass(2 protons + 2 neutrons + 2 electrons) − mass (^4He)
$= 4.033\,u - 4.002603\,u$
$= 0.030377\,u$

$\Rightarrow \boxed{E_b = 28.296\text{ MeV}}$

c)
missing mass = mass(26 protons + 30 neutrons + 26 e^-'s) − mass (^{56}Fe)
$= 56.4634\,u - 55.93494\,u$
$= 0.52846\,u$

$\Rightarrow \boxed{E_b = 492.26\text{ MeV}}$

d)
missing mass = mass(92 protons + 146 neutrons + 92 e^-'s) − mass (^{238}U)
$= 239.985\,u - 238.051\,u$
$= 1.93420\,u$

$\Rightarrow E_b = 1801.71\text{ MeV} = \boxed{1.80171\text{ GeV}}$