Physics 10164 - Exam 4A

Each problem is worth 25 points. Partial credit will be given provided you show all work and are solving parts of the problem correctly. Points will be deducted if you don't show your work even if you get the right answer. Clearly indicate your answer with a circle of a box and remember to include correct units and significant figures.

1. A spaceship passing Earth has a proper length of 850 meters, but an observer at rest watching it go by measures its length to be 620 meters.

a) What is the ship's speed, expressed as a fraction of c (e.g. 0.75c or 0.23c, something like that)?

b) How long in Earth time will it take this ship to reach the Sun, in minutes? The Sun is 1.50 x 10^{11} meters away.

c) How long in ship time will it take, in minutes?

a) $\gamma = \frac{850}{620} = 1.371 = \frac{1}{\sqrt{1-\frac{v^2}{c^2}}}$

$1.880 = \frac{1}{1-\frac{v^2}{c^2}}$

$1.880 - 1.880\frac{v^2}{c^2} = 1 \Rightarrow \frac{v^2}{c^2} = \frac{-0.880}{-1.880}$

$\boxed{v = 0.68c}$

b) $d = vt \Rightarrow t = \frac{d}{v} = \frac{1.50\times10^{11}}{.68(3\times10^8)} = 735$

$= \boxed{12\text{ min}}$

c) $t_{ship} = \frac{t_{Earth}}{\gamma} = \boxed{8.9\text{ min}}$

2. Sodium has a work function of 2.46 eV. Light illuminates the sodium, and the electrons released are measured to have a maximum speed of 2.4 x 10[6] m/s. What is the wavelength of the light illuminating the sodium?

$$(KE)_{max} = \frac{hc}{\lambda} - \phi$$

$$(KE)_{max} = \frac{1}{2}(9.11 \times 10^{-31})(2.4 \times 10^{6})^2$$
$$= 2.62 \times 10^{-18}\ J$$

$$\phi = 2.46\ eV = 3.94 \times 10^{-19}\ J$$

$$\frac{hc}{\lambda} = (KE)_{max} + \phi = 3.01 \times 10^{-18}\ J$$

$$\lambda = \frac{(6.626 \times 10^{-34})(3 \times 10^{8})}{3.01 \times 10^{-18}} = 6.6 \times 10^{-8}$$

or $\boxed{66\ nm}$

3. Radon gas has a half-life of 3.83 days. If 5.00 grams of radon gas is present at t = 0,

a) What mass of radon gas (in grams) will be present after 1.25 days have passed?

b) After how many days will the radon gas mass be 10.0% of its initial value?

$$T_{1/2} = 3.83\ d$$

$$\lambda = \frac{0.693}{T_{1/2}} = 0.18\ d^{-1}$$

a) $$M = 5.0\, e^{-\lambda t}$$

$$= 5.0\, e^{-(0.18)(1.25)}$$

$$= \boxed{3.99\ g}$$

b) $$\frac{N}{N_0} = 0.10 = e^{-\lambda t}$$

$$-2.3 = -(0.18)t$$

$$t = \frac{2.3}{0.18} = \boxed{12.8\ \text{days}}$$

4. Find the energy released in the fission reaction, in MeV:

$n + {}^{235}U \rightarrow {}^{88}Sr + {}^{136}Xe + 12\ n$

The n represents a neutron with mass 1.008665 u
The mass of ^{235}U is 235.043923 u
The mass of ^{88}Sr is 87.905614 u
The mass of ^{136}Xe is 135.907220 u

The TCU campus uses about 2.0 billion kW-hr of energy per year. How many kg of Uranium would be needed to satisfy this?

$$M_{in} = 1.008665 + 235.043923$$

$$= 236.052588$$

$$M_{out} = 87.905614 + 135.907220 + 12(1.008665)$$

$$= 235.916814$$

$$E = \Delta mc^2 = (0.135774)(931.5\ \frac{MeV}{c^2})$$

$$= 126.5\ MeV \sim \boxed{130\ MeV}$$

$$= 2.02 \times 10^{-11}\ J$$

$$E_{TOT} = 2.0 \times 10^9\ kW\text{-}hr \cdot \frac{3.60 \times 10^6\ J}{kW \cdot hr} = 7.2 \times 10^{15}\ J$$

$$\text{Number of reactions} = \frac{7.2 \times 10^{15}}{2.0 \times 10^{-11}} = 3.6 \times 10^{26}$$

$$M_{TOT} = (3.60 \times 10^{26}\ atoms)(235\ \frac{amu}{atom})(1.67 \times 10^{-27}\ \frac{kg}{amu})$$

$$= \boxed{140\ kg}$$