PHYSICS 6 HOUR EXAM 1 SPRING 2003

NAME_____

This is a closed book, closed notes exam. You may use calculators.
Make sure you show all your work! You will get partial credit for correct intermediate steps.

Useful data and equations:

Avogadro's Number: **No** = 6.0×10^{23}

1 Mole (of substance with atomic mass number [or atomic weight] A)
= A grams, which contains **No** units

speed or velocity = v = distance/time or v = d/t

acceleration = change of velocity over time = $\Delta v / \Delta t$

acceleration due to gravity = g = 9.8 m/s^2 $d = (1/2)gt^2$

Force = mass × acceleration Work = force × distance Power = Energy/time

Classical Momentum = p = m u (m = mass, u = velocity)

Classical Kinetic Energy = $1/2\ mv^2$

Velocity of light: c = 3×10^8 meter/sec **Relativity relations:**

time dilation: $t = \dfrac{t_0}{\sqrt{1 - \dfrac{v^2}{c^2}}}$ length contraction: $L = L_0\sqrt{1 - \dfrac{v^2}{c^2}}$

velocity addition $u = \dfrac{u' + V}{1 + \dfrac{Vu'}{c^2}}$

momentum: $p = \dfrac{m_0 u}{\sqrt{1 - \dfrac{u^2}{c^2}}}$ energy: $E = \dfrac{m_0 c^2}{\sqrt{1 - \dfrac{u^2}{c^2}}} = K + m_0 c^2$

Rest Energy = m_0c^2 **Units:** Mass: 1 Kilogram Energy: 1 J(oule) = 1 Kg m^2 / sec^2 ;
1 electron Volt (eV) = 1.6×10^{-19} J Power: 1 Watt = 1 J/s

Grades:	points	/possible points	
I		/80	
II		/40	(each part is 10 points)
III		/40	(each part is 10 points)
Total:		/160	

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I. Multiple choice -- circle the **one best answer**. 10 points each.

1) The number of atoms in **one mole** of some element, Avogadro's number, is a number most comparable to the number of

a. piano tuners in the world
b. protons in an atom.
c. hairs on a head.
d. grains of sand on all the beaches of the world.
e. people in the world.

2) $_{92}^{235}U$ and $_{92}^{238}U$

a. are two different elements.
b. have the same number of protons and neutrons.
c. have the same number of protons, but different number of neutrons.
d. have the same number of neutrons, but different number of protons.
e. can undergo fusion.

3) Einstein's postulates that form the basis of the theory of relativity include

a. the speed of light depends on the speed of the source.
b. the speed of light is independent of the speed of the source.
c. the speed of light depends on the speed of the observer's reference frame.
d. physical phenomena can distinguish different inertial frames of reference.
e. light is an electromagnetic wave.

4) According to Special Relativity

a. material objects can accelerate at a constant rate indefinitely.
b. moving clocks advance faster than stationary clocks.
c. moving meter sticks appear lengthened.
d. rest mass can increase indefinitely with motion.
e. material objects can not accelerate to speeds greater than c.

5) Maxwell's theory of Electromagnetism showed that

a. visible light is not an Electromagnetic wave.
b. Electromagnetic waves propagate at the speed of sound.
c. the ether is the source of electric force fields.
d. Electromagnetic waves propagate because of the interplay between changing electric and magnetic force fields.
e. visible light consists of particles.

6) A car is traveling on a straight road at 60 miles per hour. Which of the following is **not** true of the car?

a. It is in uniform motion.
b. It will cover 10 miles in 10 minutes.
c. It is accelerating at $g=9.8\ m/s^2$.
d. Its frame of reference is an inertial frame.
e. Its motion (position vs. time) is linear.

7) Total rest-energy of a single small nucleus at rest

a. is a classical energy quantity.
b. can power all of Boston for one year.
c. can do no work unless it is converted to other forms of energy.
d. is completely converted to chemical energy in a coal fired power plant.
e. is greater than the energy emitted by the sun (in fusion reactions).

8) Nuclear weapons that use fission as their explosive energy source primarily

a. convert chemical energy to rest-energy.
b. convert part of the binding energy of a few nuclei to other forms of energy.
c. involve the same kind of conversion of energy as in the sun.
d. convert kinetic energy of nuclei to rest-energy.
e. convert part of the binding energy of roughly $\mathbf{N_{avogadro}}$ nuclei to other forms of energy.

II. A ball is dropped straight down from the top of a tower. The ball hits the ground in 5 sec. Ignore special relativity in what follows, i.e. use classical physics, and ignore air resistance.

a. Does the ball fall with constant speed or does it accelerate?

b. How tall is the tower?

c. If the ball is thrown from the tower horizontally at 10 m/s, how long does it take to reach the ground?

d. In the latter case, how far from the tower does the ball land?

III. The neutral Kaon (K^0) is a particle that has an average decay time of 9×10^{-11} sec after which it usually turns into two particles, $\pi^+ + \pi^-$.

a. If a $\mathbf{K^0}$ is created and then travels in a lab at 0.8c what is its average decay time in the lab frame of reference?

b. How far does it travel before decaying (on the average) in the lab?

c. Suppose the π^+ is produced along the direction of the $\mathbf{K^0}$ motion and has a velocity of 0.75c **in the $\mathbf{K^0}$ rest frame.** What is the π^+ velocity in the lab?

d. The $\mathbf{K^0}$ has a mass of 8.85×10^{-28} Kg. What is its rest-energy? (Use units of Joules or electron volts).