Solutions for class #6 from Yosumism website

Problem 48:

Lab Methods⇒}Uncertainty

The general equation for uncertainty is given by $\delta f/f = \sqrt{\sum_i (\frac{\delta x_i}{x_i})^2}$, where $f = \Pi_i x_i$ and δx_i is the generalized standard deviation of quantity x_i.

So, for this case, one has $f = ma$ and thus its uncertainty is given by $\delta f/f = \sqrt{(\frac{\delta m}{m})^2 + (\frac{\delta a}{a})^2}$. (Basically, one has $x_1 = m$ and $x_2 = a$.)

This is choice (C).

YOUR NOTES:

Problem 49:

Advanced Topics⇒}Scintillator

The maximal speed the muons can travel at is slightly less than c. Thus, since the distance is $x = 3m$, the time required would be $c = x/t \Rightarrow t = x/c = 1E-8$. The largest scintillator time is the one closest to this, which is 1 ns, as in choice (B).

YOUR NOTES:

Problem 58:

Atomic⇒}Orbitals

Eliminate (E) immediately since the superscripts do not add to 11. Each superscript stands for an electron.

Eliminate (B) because the s orbital can only carry 2 electrons.

Ground state means none of the electrons are promoted, and there are no states with unfilled gaps in them.

Eliminate (A) since it promotes the 2p electron to 3s, leaving a unfilled orbital of lower energy.

Eliminate (D) since it promotes the 3s electron to 3p, leaving an empty orbital of lower energy.

Choice (C) is it.

YOUR NOTES:

Problem 59:

Atomic⇒}Orbital

The ground state of Helium has $1s^2$ which is $l=0\, n=1$.

However, because both electrons are in the same l and n state, the Pauli Exclusion Principle (no two electrons can have exactly the same quantum number) requires that one have $s=1/2$ and the other has $s=-1/2$ for a combined total spin of $s=0$, as in a spin singlet.

Thanks to user cakedamber for pointing this out.

(Compare with things in the p orbitals, which have $l=1$, allowing for $m_l=-1,0,1$.)

YOUR NOTES:

Problem 60:

Electromagnetism⇒}Cyclotron Frequency

The cyclotron frequency is given by $F=qvB=mv^2/r \Rightarrow qB=mv/r=m\omega$, where one merely equates the Lorentz Force with the centripetal force using $v=r\omega$ to relate angular velocity with velocity.

So, $\omega=qB/m$. Plug in the quantities to get choice (D).

YOUR NOTES:

Problem 69:

Optics⇒}Speed of Light

The speed of light is related to the index of refraction by $n=c/v$. Thus, the minimal velocity the particle must have is $v=c/n=2/3c$, since $n=3/2$.

YOUR NOTES:

Problem 70:

Special Relativity⇒}Gamma

$E=\gamma mc^2=100mc^2$, where ETS supplies the total energy to be 100 times the rest energy. Thus, $p=\gamma mv=100mv$, but since $\gamma=100=\frac{1}{1-\beta^2}$, where $\beta=v/c$, one has $v\rightarrow c$, as in choice (D).

YOUR NOTES:

Problem 71:

Statistical Mechanics⇒}Distributions

The Fermi-Dirac distribution, in general, gives the number of states in E_i to be $N_{FD} = N_0 \frac{1}{1+e^{-E_i/kT}}$, where N_0 is the total number of states. (The Fermi-Dirac distribution is used since there are only two states.)

Define $E_1 = \epsilon$ and $E_2 = 2\epsilon$.

The number of states in 1 is just $N_1 = N_0 \frac{1}{1+e^{-E_1/kT}} = N_0 \frac{1}{1+e^{-\epsilon/kT}}$, which is choice (B).

YOUR NOTES:

Problem 72:

Statistical Mechanics⇒}Heat Capacity

The heat capacity is just dU/dT, where ETS generously supplies U, the internal energy. Since E_1 and N_0 are constants, the first term is trivial.

The temperature-derivative of the second term is $N_0\epsilon^2/(kT^2)e^{\epsilon/kT}/(1+e^{\epsilon/kT})^2=$, as in choice (A).

(The temperature derivative is easily done if one applies the chain-rule $\frac{df}{dy}\frac{dy}{du}\frac{du}{dT}$ where $f=1/y$, $y=1+e^u$, $u=\epsilon/(kT)$.)

YOUR NOTES:

Problem 73:

Statistical Mechanics⇒}Entropy

The third law of thermodynamics says that $S(T \to 0) \to 0$.

Also, the statistical definition of entropy is just $S = NkInZ$, where Z is the partition function. For this problem, one has $Z = e^{-\epsilon/kT} + e^{-2\epsilon/kT}$. For high temperatures, one has $Z \to 1+1=2$, since $e^x \approx 1+x$ for small x (and then $1+x \approx 1$ for very small x).

Thus the entropy behaves as in choice (C).

YOUR NOTES:

Problem 75:

Advanced Topics⇒}Binding Energy

The binding energy for heavy atoms ($>200 nucelons$) is about $8MeV/nucleon$. The change in binding energy is the kinetic energy, thus the Helium atom has a kinetic energy of $(235-231)8MeV$. (The binding energy of He is ignored.) This is much larger than the kinetic energy of the He nucleus.

YOUR NOTES: