Math Extra Credit 2

February 11, 2011

1 Microwaving water(100pts.)

You have a 1200W microwave. When you put a cup of water in for 8 minutes only half evaporates. How efficient is your microwave?

2 Ideal Gas(110pts.)

A car tire is pressurized in the morning at a temperature of 20^0C to 2atm. By afternoon at a temperature of 35^0C the tire pressure has changed to 2.1atm but the volume has decreased by 2%. Use the ideal gas law to show that the reason this happened is because of a leak in the tire.

3 Molecular Speeds(100pts.)

The air around us is roughly 80% diatomic nitrogen and 20% diatomic oxygen. Which of these is faster and by how much?

4 Rydberg Formula(120pts.)

Hydrogenic atoms in an ultraviolet light fall from energy quantum state $n = 9$ to state $n = 2$ while releasing ultraviolet photons. The light has a power rating of 100W. How many photons are being released per second?

5 Quantum Mechanics(300pts.)

Solve the time-independent Schrodinger equation for a particle of mass m in a box of width a. Then find the energies.

6 Periodic Table(90pts.)

Which two atoms would have a bond that is most ionic in character?

Lithium	Carbon
Cesium	Copper
Potassium	Nitrogen
Sodium	Chlorine

7 Solid State structures(200pts.)

Which has a greater packing fraction, a diamond crystal structure or a copper crystal structure? In other words, if every atom were to be a hard sphere just big enough to touch adjacent spheres, how much empty space would be left in each structure?

8 Nuclear Energy(130pts.)

Because it has the highest binding energy per nuclion of all nuclides, $^{62}_{28}$Ni may be described as the most strongly bound. Its neutral atomic mass is 61.928349amu. Find its mass defect, total binding energy and its binding energy per nucleon.

9 Radioactivity(110pts.)

Phil finds an old bone at an archeological site and decides to date it. The site is located geographically at a position where the ratio of ^{14}C to ^{12}C in the atmosphere before the year 1900 was about $1.31 \cdot 10^{-12}$. The sample had a ratio if about $3.41 \cdot 10^{-13}$. The half-life of ^{14}C is 5730y. How old is this bone?

10 Astrophysics(90pts.)

A number of galaxies have supermassive black holes at their centers. As material sqirls around such a black hole, it is heated, becomes ionized, and generates a strong magnetic field. The resulting magnetic forces steer some of the material into highspeed jets that blast out of the galaxy and into intergalactic space. The blue light we observe from the jet has a frequency of $6.66 \cdot 10^{14}$Hz, but in the frame of reference of the jet material the light has a frequency of $5.55 \cdot 10^{13}$Hz. At what fraction of the speed of light is the jet moving toward us?