P102 Fall 2009 – Recitation 9 (practice for exam 2)

Problem 1:

Why is it that the spectrum of light emitted by an atom is often said to be a "fingerprint" for that atom?

Problem 2 :

If there are only approximately 100 different atomic elements (types of atoms) in our world, how is it that you can identify many, many more than 100 different types of substances in the world around you?

Problem 3:

Suppose we find a rock and geologists tell us that when that rock was formed in a volcano it would have contained an equal amount of Iridium-192 (Z=77, symbol = Ir) and Bismuth-209 (Z=83, symbol = Bi). Suppose that Iridium-192 and Bismuth-209 are both naturally radioactive. Also, suppose that Iridium-192 decays with a half-life of 500,000 years and Bismuth-209 decays with a half-life of 1 million years. If the rock is two million years old and you measure the amount of Iridium-192 and Bismuth-209 in the rock, what ratio for the amount of Iridium-192 to Bismuth-209 would you expect to measure?

Problem 4:

The strong force is mediated by gluons in the same way the electromagnetic force is mediated by

a) electrons.
b) neutrinos.
c) Z particles.
d) protons.
e) photons.

Problem 5:

A nucleus X decays into a nucleus Y and emits some form of radiation as shown by the reaction below.

$$^{50}_{21}X \rightarrow ^{50}_{20}Y + ?$$

The particle that is emitted (symbolized above as "?") is

a) an alpha particle.
b) a negative beta particle (electron)
c) a positive beta particle (positron).
d) a photon.
e) a neutron.

Problem 6

By each description on the left, put the letter of the answer on the right that best fits. There may be more than one answer on the right that works, in which case any of the correct answers is sufficient.

___ One type of quark found in neutrons

___ Force carrier (gauge boson) for electromagnetic interaction

___ Force carrier (gauge boson) for strong interaction

___ Only undiscovered particle predicted by the Standard Model of particle physics

___ Particle that can pass through light years of lead without interacting

___ One of the particles mediating the weak interaction (force carrier for weak interaction)

___ A particle made up of three quarks

___ An example of a meson

___ An example of a lepton

___ A massless particle

(3 pts) List below three of the five particles listed to the right which are known to be made of other particles (have constituents).

_____

a. electron
b. muon neutrino
c. proton
d. pion
e. charm (c) quark
f. W
g. gluon
h. higgs
i. Z
j. top (t) quark
k. muon
l. photon
m. up (u) quark
n. graviton
o. hydrogen atom
p. hadron
q. baryon

Problem 7 (true or false):

a) _____ In typical multi-electron atoms, the electrons all reside in the atom's lowest energy quantum state.
b) _____ If a sample of uranium-235 is subcritical, a nuclear explosion is imminent.
c) _____ According to quantum field theory, the gluon is the virtual particle (gauge boson) responsible for conveying the strong nuclear force.
d) _____ The force of gravity is many times stronger than the weak nuclear force.
e) _____ A typical chemical reaction involves changes in energy of millions of electron-volts.
f) _____ Water is a chemical compound.
g) _____ Carbon dioxide (CO_2) is an isotope of carbon monoxide (CO).
h) _____ According to quantum field theory, the Z particle is the virtual particle (gauge boson) responsible for conveying the strong nuclear force.
i) _____ According to quantum theory, the more precisely the position of an electron is determined the better known is the electrons velocity.
j) _____ The Higgs particle was discovered (first seen) in 2006.
k) _____ A chain reaction refers to the chemical processes that occur when hydrogen is mixed with oxygen and a match.
l) _____ The strong nuclear force is stronger than the electromagnetic force.
m) _____ Nuclear fission is the energy source that powers stars.
n) _____ In quantum mechanics, the wave function specifies the exact position of a particle.
o) _____ Young stars are formed mostly of hydrogen.

Problem 8

A quantum state is

a) a term that refers to atoms that are able to emit photons.
b) a state that is smaller than most other states – for example, Rhode Island.
c) a phrase describing the frame of mind of a physicist who is contemplating the complicated aspects of matter.
d) a reference to the potential spatial regions and energies allowed for particles according to quantum mechanics.
e) the place where a particle is seen to be located.

Problem 9

You walk into a room that is contaminated with radioactive material. What factors are important in determining the potential danger to you of the radioactive material?

a) the location of the material relative to you.
b) the activity of the sample.
c) the time you spend in the proximity of the sample.
d) the type of radiation emitted by the sample.
e) All of the above.

Problem 10

Which of the four fundamental forces binds the nucleus together, and which binds the atom [electron orbits] together?

a) Strong nuclear force binds the nucleus, weak nuclear force binds the atom.
b) Gravity binds the nucleus, electromagnetic force binds the atom.
c) Weak nuclear force binds the nucleus, strong nuclear force binds the atom.
d) Electromagnetic force binds the nucleus, strong nuclear force binds the atom.
e) Strong nuclear force binds the nucleus, electromagnetic force binds the atom.

Problem 11

Quarks interact with other particles in nature via

a) the strong nuclear force.
b) the weak nuclear force.
c) the electromagnetic force.
d) gravitation.
e) all of the above.

Problem 12

The source of energy for the creation of most gold atoms (a gold atom is heavier than an iron atom) used in jewelry is

a) the gravitational collapse of a star.
b) a goldsmith's smelter.
c) The fission of a heavier element such as radium or hafnium.
d) the shock wave of a supernova explosion at the end of the stellar life cycle for a large star.
e) the heat at the center of the earth.

Problem 13

Carbon is

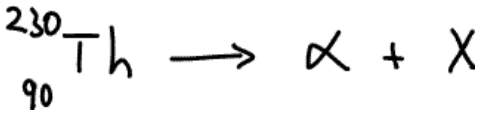
a) an element.
b) a chemical compound.
c) made up entirely of protons.
d) chemically inert (unreactive).
e) never found in stars.

Problem 14

A nuclear fusion process occurs and is described by the equation below. Determine and provide the unknown nucleus (symbolized by X) in the equation.

Problem 9 (6 points):

Suppose the nucleus below undergoes alpha decay, what is the nucleus left behind?



Would you expect this process to release energy or absorb energy?

Problem 15

In the quark model of particle physics, is it possible to have a baryon with an electric charge of +2? If so, give a possible example. If not, why?

Problem 16

Briefly describe the relationship between quantum uncertainty and radioactive decay.

Problem 17

The iodine isotope ^{131}I is a naturally radioactive nucleus that emits a beta (e-) with a half-life of 8 days. Because iodine is absorbed by the thyroid gland, people with malfunctioning thyroids can be treated medically by drinking a solution laced with ^{131}I. The radioactive iodine decays and causes tissue damage preferentially in the thyroid.

a) What nuclear isotope does the ^{131}I become when it decays?

b) If a sample of ^{131}I sitting on the hospital shelf has an activity of 200 decays per second today, how much time will pass before that activity drops to 25 decays per second?

Problem 18

In 1929, one of the big players in physics at the time, P.A.M. Dirac, said of quantum mechanics, "The underlying physical laws necessary for the mathematical theory of a large part of physics and the whole of chemistry are thus completely known …" Briefly defend or dispute Dirac's assertion that quantum mechanics explains chemistry.