(Ch9)

Q1) Chromium has the electron configuration [Ar]$4s^1 3d^5$. What are the ground-state L and S values? [Use Hund's rule to calculate the total m_l and m_s values].

a) $L = 0$ and $S = 3$
b) $L = 2$ and $S = 0$
c) $L = 1$ and $S = 2$
d) $L = 0$ and $S = 0$
e) $L = 1$ and $S = 1$

Q2) Give the spectroscopic notations for an electron with $n = 5$ and $\ell = 4$?

a) $5G_{9/2}$ and $5G_{7/2}$
b) $4H_{7/2}$and $4H_{9/2}$
c) $5H_{11/2}$ and $5H_{9/2}$
d) $5F_{9/2}$and $5F_{7/2}$
e) $4F_{7/2}$and $4F_{5/2}$

Q3) How many different sets of quantum numbers are possible for an electron for which $n = 4$?

a) 32
b) 16
c) 24
d) 28
e) 20

Q4) What is the largest angle between the z-axis and the total angular momentum $\boldsymbol{J}$ for an electron in the d-shell when its intrinsic and orbital angular momenta are parallel ($\vec{L} \parallel \vec{S}$)?

a) 147.7°
b) −59.5°
c) 90.0°
d) −80.3°
e) 99.7°

Q5) An electron in an atom has orbital angular momentum **L**$_1$ with quantum number $l_1 = 2$, and a second electron has orbital angular momentum **L**$_2$ with quantum number $l_2 = 2$. What are the possible quantum numbers for the total angular momentum **J** = **J**$_1$ + **J**$_2$?

a) 0, 1, 2, 3, 4, 5
b) 1, 2, 3, 4, 5, 6
c) 0, 1, 2, 3, 4
d) 1, 2, 3, 4, 5
e) 2, 3, 4, 5, 6

Q6) The fine-structure splitting of the $2P_{3/2}$ and $2P_{1/2}$levels in hydrogen is 4.5×10^{-5} eV. Determine the magnetic field that the $2p$ electron in hydrogen experiences. Assume the magnetic field is parallel to the z axis.

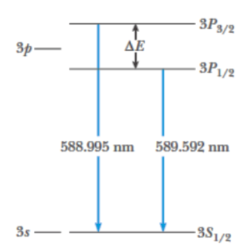
a) 0.39 T
b) 0.45 T
c) 0.32 T
d) 0.24 T
e) 0.19 T

Q7) The angular momentum of the yttrium atom in the ground state is characterized by the quantum number $j = 3/2$. How many lines would you expect to see if you could do a Stern-Gerlach experiment with yttrium atoms?

a) 4
b) 3
c) 2
d) 1
e) 0

Q8) The famed sodium doublet arises from the spin–orbit splitting of the sodium $3P$ level, and consists of the closely spaced pair of spectral lines at wavelengths of 588.995 nm and 589.592 nm. Find ΔE.

a) 2.13×10^{-3} eV
b) 1.23×10^{-3} eV
c) 4.13×10^{-3} eV
d) 1.87×10^{-3} eV
e) 3.21×10^{-3} eV



(Ch13)

Q9) How many neutrons are in a neutron star of radius $R = 12$ km. [$\rho = 2.35 \times 10^{17}$ kg/m^3]

a) 1.07×10^{57} kg
b) 3.5×10^{29} kg
c) 9.7×10^{59} kg
d) 5.3×10^{46} kg
e) 4.8×10^{36} kg

Q10) What is the binding energy per nucleon for $^{64}_{30}\mathrm{Zn}$? [$m = (^{64}_{30}\mathrm{Zne}) = 63.929\,145\ u$]

a) 8.7 MeV/nucleon
b) 8.1 MeV/nucleon
c) 9.1 MeV/nucleon
d) 7.5 MeV/nucleon
e) 8.4 MeV/nucleon

Q11) Use the semi-empirical mass formula to determine the binding energy per nucleon for $^{197}_{79}\mathrm{Au}$? [$m = (^{197}_{79}\mathrm{Au}) = 196.966\,543\ u$].

a) 8.8 MeV/nucleon
b) 7.5 MeV/nucleon
c) 7.3 MeV/nucleon
d) 8.4 MeV/nucleon
e) 7.9 MeV/nucleon

Q12) The half-life of ^{40}K is 1.3×10^9 years. What is the activity of 1.5 kg of a potassium sample that naturally contains 0.012 percent of ^{40}K nuclei? [M = 39.1 g/mole]

a) 1.3 μCi
b) 2.6 μCi
c) 3.9 μCi
d) 0.85 μCi
e) 3.1 μCi

Q13) Find the kinetic energy of the alpha particle emitted in the following decay $^{211}At \rightarrow {}^{207}Bi + \alpha$.
[m(At) = 210.987496 u, m(Bi) = 206.978471 u, m(He) = 4.002603 u]

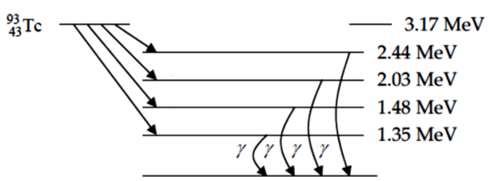
a) 5.87 MeV
b) 5.98 MeV
c) 3.00 MeV
d) 4.56 MeV
e) 5.21 MeV

Q14) In the beta decay of $^{24}_{11}Na$ to $^{24}_{12}Mg$, an electron is observed with a kinetic energy of 3.15 MeV. What is the energy of the accompanying neutrino? [m(^{24}Na)= 23.990963 u and m(^{24}Mg)=23.985042 u]

a) 2.37 MeV
b) 5.52 MeV
c) 0
d) 3.77 MeV
e) 4.18 MeV

Q15) The beta decay of $^{93}_{43}Tc$ to $^{93}_{42}Mo$ is starting from the ground state of the parent nucleus to specific energy levels in the daughter nucleus as illustrated in the figure. For which of these levels are beta decay allowed? [m($^{93}_{43}$Tc) = 92.910 250 u, m($^{93}_{42}$Mo)=92.906 809 u]

a) 1.35, 1.48 and 2.03 MeV
b) 1.35, 1.48, 2.03, and 2.44 MeV
c) 1.35, 1.48, 2.03, 2.44, and 3.17 MeV
d) 1.35 and 1.48 MeV
e) 1.35 MeV



Q16) A 30.0-g of carbon has been found in a historic vessel and it shows a ^{14}C ($T_{1/2}$=5730 yr) activity of 200 decays/min. How old is the vessel? [Abundance ratio $^{14}C/^{12}C = 1.3\text{x}10^{-12}$]

a) 6700 yr
b) 5730 yr
c) 6290 yr
d) 7350 yr
e) 4580 yr

Ch (3 – 5)

Q17) Which one of these processes involves a decrease in the kinetic energy of an electron?

(a) Bremsstrahlung
(b) Photoelectric effect
(c) Compton scattering
(d) X-ray diffraction
(e) Blackbody Radiation

Q18) A hydrogen atom initially in its ground state $(n = 1)$ absorbs a photon and ends up in the state for which $n = 3$. What is the energy of the absorbed photon?

a) 12.1 eV
b) 13.6 eV
c) 1.51 eV
d) 6.35 eV
e) 8.47 eV

Q19) Calculate the de Broglie wavelength for a neutron moving with a kinetic energy of 2.0 MeV.

a) 20 fm
b) 14 fm
c) 25 fm
d) 30 fm
e) 35 fm

Ch (6 – 8)

Q20) The Schrödinger equation is

1) a second-order differential equation.
2) an equation based on conservation of energy.
3) an equation whose solution gives the wave function that describes a particle.
4) an equation plays the role of Newton’s laws in classical mechanics.

How many of the above statements are **wrong**?

a) Zero
b) One
c) Two
d) Three
e) All four

Q21) Applying the tunneling phenomena for α decay, estimate the half-life for the radioactive element thorium in the decay process ${}^{232}_{90}\text{Th} \rightarrow {}^{228}_{88}\text{Ra} + \alpha$. Assume the energy of the ejected alpha is 4.05 MeV and the nuclear size is about 9.0 fm.

a) 1.7×10^{10} yr
b) 2.6×10^{11} yr
c) 3.5×10^{12} yr
d) 6.4×10^{9} yr
e) 9.0×10^{8} yr

Q22) If an electron has an orbital angular momentum of 4.714×10^{-34} J.s, what is the orbital quantum number (ℓ) for this state of the electron?

a) 4
b) 5
c) 6
d) 3
e) 2

Ch14

Q23) ^{61}Cu isotope is to be produced by alpha particle ($q = 2e$) nuclear reactions on a target of ^{59}Co;

$${}^{4}_{2}\text{He} + {}^{59}_{27}\text{Co} \rightarrow {}^{61}_{29}\text{Cu} + 2n\,.$$

A foil of cobalt ($\rho = 8.9$ g/cm^3), measuring 1.5 cm × 1.5 cm in area and 2.5μm in thickness, is placed in a 12-μA beam of alpha particles; the beam uniformly covers the target. For the selected alpha energy, the reaction has a cross section of 0.640 b. At what rate is the ^{61}Cu produced?

a) 5.4×10^{8} s^{-1}
b) 1.1×10^{9} s^{-1}
c) 2.7×10^{8} s^{-1}
d) 7.6×10^{8} s^{-1}
e) 3.4×10^{9} s^{-1}

Q24) How many statement(s) is related to fusion reactors.

i. Nuclei produced in the reaction are usually highly radioactive.
ii. Energy release can be as large as several MeV per reacting nucleon.
iii. It is usually necessary to overcome a Coulomb barrier for the reaction to occur.
iv. Usually induced by the capture of a neutron.
v. Reacting nuclei come from commonly available chemical elements.
vi. Electrical power could be generated by boiling water using heat obtained from kinetic energy of nuclei produced in the reaction.

a) Four
b) Three
c) Two
d) Five
e) one

Q25) Calculate the threshold kinetic energy for the reaction ${}^{3}_{1}\mathrm{H}(p, \mathrm{D}){}^{2}_{1}\mathrm{H}$.
[m(^{3}H) = 3.016049 u, m(^{2}H) = 2.014102 u]

a) 5.38 MeV
b) 16.1 MeV
c) 9.05 MeV
d) 2.74 MeV
e) 12.5 MeV

Q26) The density of lead is 11.35 g/cm^3, and its atomic weight is 207.2. Assume that 2.000 cm of lead reduces a beam of 1-MeV gamma rays to 28.65% of its initial intensity. What is the effective cross section of a lead atom for a 1-MeV photon?

a) 19 b
b) 38 b
c) 24 b
d) 31 b
e) 15 b

Q27) Find the total energy released in the fission of 1.00 kg of uranium that has been enriched to 10.0% in the isotope ^{235}U. Assume the fission occurs only through ^{235}U + n → ^{93}Rb + ^{141}Cs + 2n.
[m(^{235}U)=235.043930 u, m(^{93}Rb) = 92.922042 u and m(^{141}Cs) = 140.920046 u].

a) 7.4 x 10^{12} J
b) 3.8 x 10^{12} J
c) 1.9 x 10^{12} J
d) 9.8 x 10^{12} J
e) 6.5 x 10^{12} J

Q28) Assuming an average energy release of 200 MeV per fission, calculate the number of fissions per second needed for a 500 MW reactor.

a) 1.56×10^{19} fission/s
b) 2.34×10^{13} fission/s
c) 6.53×10^{21} fission/s
d) 3.44×10^{19} fission/s
e) 8.97×10^{20} fission/s

Q29) Estimate the net power output of a fusion reactor that burns ten 50:50 3-mg D–T pellets every second. Assume that 30% of the fuel ignites and that a 5 1014 W laser pulse lasting 10 ns is needed to initiate burning. The released energy after D-T fusion is 17.6 MeV.

a) 3000 MW
b) 2500 MW
c) 2000 MW
d) 3500 MW
e) 4000 MW

Q30) One of the advantages of the nuclear reactors is:

a) Unlimited fuel
b) Expensive construction costs
c) Energy input vs energy output
d) More greenhouse gases
e) Radioactive waste
