PRACTICE EXAM #4 (Ch. 21, 24-25)

Chem1B, General Chemistry II

1.) Predict which nuclides should be stable and which should be radioactive. For those that are radioactive, predict which type of nuclear decay they are most likely to undergo.

a.) $^{7}_{3}Li$ ratio: (7-3) = 4 neutrons/3 protons = 1.33, ratio of neutrons to protons is too high for a "light" element→ **β-emission** (will be: $^{1}_{0}n \rightarrow {}^{1}_{1}p^{+} + {}^{0}_{-1}\beta$)

b.) $^{134}_{53}I$ ratio: (134-53) = 81 neutrons/53 protons = 1.53, ratio of neutrons to protons is too high since Z = 50 wants a 1.4:1 ratio → **β-emission** (will be: $^{1}_{0}n \rightarrow {}^{1}_{1}p^{+} + {}^{0}_{-1}\beta$)

c.) $^{28}_{15}P$ ratio: (28-15) = 13 neutrons/15 protons = 0.867, ratio of neutrons to protons is too low for a "light" element → positron-emission (will be $^{1}_{0}p^{+} \rightarrow {}^{1}_{0}n + {}^{0}_{+1}\beta$)

2.) Predict the products, including their **structure**, from the following reactions. **Balance** the equations where appropriate.

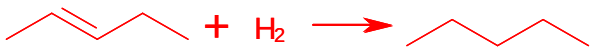
a.) Combustion of heptane → ?

Heptane: alkane, 7 carbons, 7x2 + 2 = 16 hydrogens

C_7H_{16} + **11** $O_2(g) \rightarrow$ **7** $CO_2(g)$ + **8** $H_2O(g)$

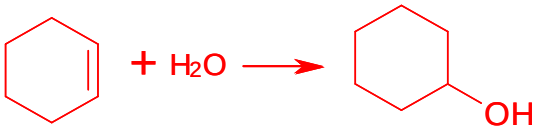
b.) Hydrogenation of 2-pentene → ?

Addition of H_2 around the double bond



c.) Hydration of cyclohexene → ?

Addition of H_2O around the double bond



3.) Calculate the nuclear binding energy for antimony-127 that has an **atomic** mass of 126.906924 amu in (1) **J/mole**, (2) **J/atom**, and (3) **J/nucleon**.

126.906924 amu – (51)(5.485799 × 10^{-4} amu) = 126.906924 amu – 0.027977574 amu

nuclear mass = 126.8789464 amu

(51)(1.007276 amu) + (127-51)(1.008665 amu) = 128.029616 amu, mass of nucleons

Calculate mass defect and convert to kg/mole.

128.029616 amu – 126.8789464 amu = 1.1506695 amu/atom× $\frac{1\text{ kg}}{1000\text{ g}}$ = 1.1506695 × 10^{-3} kg/mol

ΔE = (1.1506695 × 10^{-3} kg/mol)(2.9979 × 10^{8} m/s)^2 = 1.0341532 × 10^{14}

(1) **1.034153 × 10^{14} J/mol**

(2) 1.0341532 × 10^{14} J/mole × $\frac{1\text{ mole}}{6.022 \times 10^{23}\text{ atom}}$ = 1.7172920 × 10^{-10} → **1.717292 × 10^{-10} J/atom**

(3) 1.717292 × 10^{-10} J/atom × $\frac{1\text{ atom}}{127\text{ nucleons}}$ = 1.3521984 × 10^{-12} → **1.35298 × 10^{-12} J/nucleon**

4.) Consider a molecule of tris(ethylenediamine)copper(II) nitrate ion.

a.) Give the appropriate chemical formula for the complex. **$[Cu(en)_3](NO_3)_2$**

b.) What is the **coordination number**, if en is bidentate? **6 (3x2)**

c.) What is the **oxidation state** of the metal? **+2** (en is neutral)

d.) What is the **overall charge** on the complex? **+2** (only metal)

e.) What **geometry** will the above complex adopt? **octahedral**

f.) Depict the crystal-field splitting pattern for the above complex, showing explicitly which d-orbitals move where, and fill it appropriately to show whether it is **paramagnetic** or **diamagnetic** (en is a **strong field** ligand).

octahedral geometry: splits into e_g (d_{z2} ; d_{x2-y2}, higher) and t_{2g} (d_{xz}, d_{yz}, d_{xy}, lower)
Cu^{2+} has 9 d-electrons.

e_g, d_{z2} ; d_{x2-y2}: ↑↓ ↑

t_{2g}, d_{xy}, d_{xz}, d_{yz}: ↑↓ ↑↓ ↑↓

paramagnetic: unpaired electron in the e_g

g.) The above compound absorbs strongly at 595 nm. Calculate the **splitting energy** between the d-orbitals in J/mole.

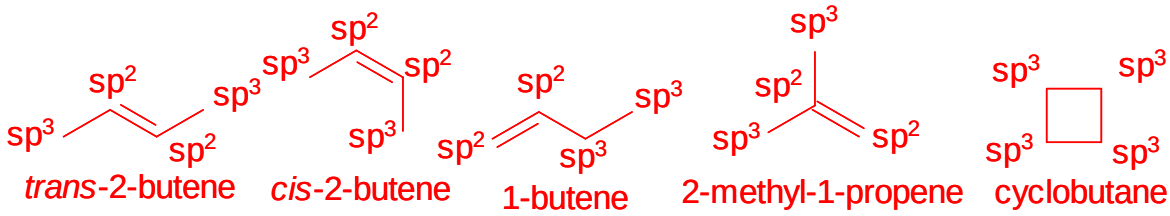
$$E = \left(6.626 \times 10^{-34}\ \text{J*s}\right)\left(\frac{3.00 \times 10^{8}\ \text{m/s}}{5.95 \times 10^{-7}\ \text{m}}\right) = 3.340 \times 10^{-19}\ \text{J/atom}$$

$$\frac{3.340\times10^{-19}\text{J}}{1\ \text{atom}} \times \frac{6.022 \times 10^{23}\ \text{atoms}}{1\ \text{mole}} = 2.011 \times 10^{5} \rightarrow \mathbf{2.01 \times 10^{5}\ J/mole}$$

h.) What **color** will the compound appear to be?

Absorbs 595 nm, so will appear as the complement →

5.) Consider 2-butene. Draw its structure and the structures of all **five** of its isomers with the formula C_4H_8. Indicate whether each isomer is **constitutional** or **cis-trans** in comparison to 2-butene. Also indicate the **hybridization** at each individual carbon atom.

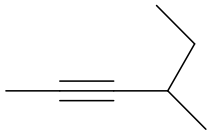


6.) Explain **why** alkanes exhibit conformational but not cis-trans isomerization but not cis-trans whereas alkenes exhibit cis-trans but not conformational.

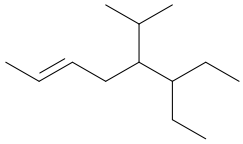
Alkanes have free rotation around each bond due to having only s-overlap from the single bonds. All four hybrids are equally spread apart.

Alkenes and alkynes do not have free rotation due to the p-overlap and their remaining sp^2 hybrids are 120 degrees from each other.

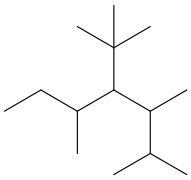
7.) Derive the correct IUPAC names for the following compounds. (21 pts)



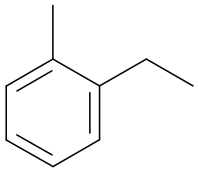
(A)



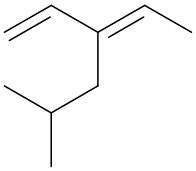
(B)



(C)



(D)



(E)

(A) **4-methyl-2-hexyne**

(B) **6-ethyl-5-isopropyl-2-octene**

(C) **4-*tert*-butyl-2,3,5-trimethylheptane**

(D) **1-ethyl-2-methylbenzene or o-ethylmethylbenzene**

(E) **3-*sec*-butyl-1,3-pentadiene**

8.) The percent natural abundance of potassium-40 is 0.0117%. The radioactive decay of these atoms occurs 89% by β-emission and the rest by other decay modes. The half-life of potassium-40 is 1.25×10^9 years. Calculate the number of electrons produced per second by the potassium-40 present in a 1.00 g sample of the mineral microcline, $KAlSi_3O_8$. Assume that there are 365 days in a year.

$$1.25 \times 10^9 \text{ years} \times \frac{365 \text{ days}}{1 \text{ year}} \times \frac{24 \text{ hours}}{1 \text{ days}} \times \frac{60 \text{ minutes}}{1 \text{ hour}} \times \frac{60 \text{ seconds}}{1 \text{ minute}} = 3.9\underline{4}2 \times 10^{16} \text{ seconds}$$

$$3.94 \times 10^{16} \text{ seconds} = \frac{\ln(2)}{k} \rightarrow k = 1.7\underline{5}8 \times 10^{-17} \text{ sec}^{-1}\text{, number of decays per atom per second}$$

Molar mass of microline: 281.05 g/mol

$$1.00 \text{ g microline} \times \frac{1 \text{ mole microline}}{281.05 \text{ g microline}} \times \frac{1 \text{ mole K}}{1 \text{ mole microline}} \times \frac{0.0117 \text{ moles } ^{40}\text{K}}{100 \text{ mole K}} \times \frac{6.022 \times 10^{23} \text{ atoms}}{1 \text{ mole } ^{40}\text{K}}$$

$$= 2.5\underline{0}6 \times 10^{17} \text{ atoms K-40}$$

$$(1.7\underline{5}8 \times 10^{-17} \text{ sec}^{-1})(2.5\underline{0}6 \times 10^{17} \text{ atoms}) = 4.4\underline{1}0 \rightarrow \textbf{4.41 electrons produced per second}$$