Problem Set 4 Chem 142 Key

1. Write complete balanced nuclear equations for the following processes.
   a) Radium-226 decays by alpha particle emission.

$$^{226}_{88}Ra \longrightarrow ^{222}_{86}Rn + ^{4}_{2}He$$

   b) Scandium-43 is produced by electron capture.

$$^{43}_{22}Ti + ^{0}_{-1}e \longrightarrow ^{43}_{21}Sc$$

   c) Selenium-91 decays into selenium-90.

$$^{91}_{34}Se \longrightarrow ^{90}_{34}Se + ^{1}_{0}n$$

2. Which of the following nuclides are likely to radioactive and which are likely to be stable. Explain your choice and in the case of radioactivity predict the most likely mode of radioactive decay.

(a) Nitrogen-12

$^{12}_{7}N$

$\frac{N}{Z} = \frac{5}{7}$ too low

$^{1}_{1}p \longrightarrow ^{1}_{0}n + ^{0}_{1}e$

positron emission (or) electron capture

(b) Lead-208

$^{208}_{82}Pb$ both N & Z magic #'s

Stable

(c) Thorium-233

$^{233}_{90}Th$ $Z > 83$ radioactive

α - decay

3. The half-life of cobalt-60 is 5.26 years.
   (a) What is the rate constant for the decay of cobalt-60?

$$k = \frac{0.693}{t_{1/2}} = \boxed{0.13175\ yr^{-1}}$$

   (b) How much of a 71.8 g sample of cobalt-60 remains after eighteen (18.00) years?

$$\ln\left(\frac{N_t}{N_0}\right) = -kt$$

$$\ln\left(\frac{N_t}{71.8g}\right) = -(0.13175\ yr^{-1})(18.00\ yr)$$

$$\ln\left(\frac{N_t}{71.8g}\right) = -2.3715$$

$$\frac{N_t}{71.8g} = 0.09334$$

$$\boxed{N_t = 6.70\ g}$$

4. ^{131}I (as $Na^{131}I$) is used to treat hyperthyroid disease. It decays to Xenon by first order kinetics. The half-life of ^{131}I is 8.0 days. If you are given 3 ng of $Na^{131}I$, how many days will it take for 99.99% of it to decay, that is, for there to be only 0.003 ng left? (8 pts)

   $\ln[^{131}I]_{start}/[^{131}I]_{end} = kt$

   $t_{½} = \ln 2/k$

   $k = \ln 2/t_{½} = 0.693/8.0$ days $= 8.66 \times 10^{-2}$ days^{-1}

   $\ln([^{131}I]_{start}/[^{131}I]_{end}) = \ln(3$ ng$/0.003$ ng$) = \ln 1000 = 6.91 = kt= (8.66 \times 10^{-2}$ days$^{-}1)t$

   t = 79.8 days

5. The atomic mass of ^{127}I is 126.9004 g/mol. Calculate the nuclear binding energy of this nucleus (in kJ/mol). The mass of a proton is 1.007825 g/mol and the mass of a neutron is 1.008665 g/mol.

   127-I has 53 protons and 74 neutrons:

   mass = 53(1.007825) + 74(1.008665) = 128.055935

   Δ_{mass} = 126.9004-128.055935 = -1.15535 g or -1.15535×10^{-3} kg

   $E = mc^2 = (-1.15535 \times 10^{-3} kg)(3.00 \times 10^8\ m/s)^2$

   $E = -1.0399815 \times 10^{14}$ J/mol or -1.04×10^{11} kJ/mol

6. Given the information below, answer the following question:

Mass of proton 1.00728 amu | Mass of neutron 1.00866 amu | Mass of electron 5.485799×10^{-4} amu

Mass of ${}_{9}^{19}F$ =18.998403 amu/atom | Velocity of light (c) 2.998×10^{8} m s^{-1}

Mass-energy conversion 1 amu = 931.5 MeV

a) Calculate the mass deficiency of ${}_{9}^{19}F$ in amu/atom.

Theoretical mass = 9 (1.00728) + 10 (1.00866) + 9 (0.0005485799) amu/atom
Theoretical mass = 19.157057 amu/atom
Mass deficiency = Theoretical mass – Actual mass
Mass deficiency = 19.157057 amu/atom – 18.998403 amu/atom = 0.158654 amu/atom

b) Determine the mass deficiency of ${}_{9}^{19}F$ in g $mol^{-1.}$

0.158654 g mol^{-1}

c) Calculate the binding energy (BE) of 919*F* in kJ $mol^{-1.}$

BE = Δmc^2
BE = (0.158654 g/mol) (2.998 x 108 m s^{-1})2(1 kg/103 g)
BE = 1.431 x 1013 kg m2 s–2 mol^{-1}
BE = 1.431 x 1013 J mol^{-1}
BE = 1.431 x 1010 kJ mol^{-1}

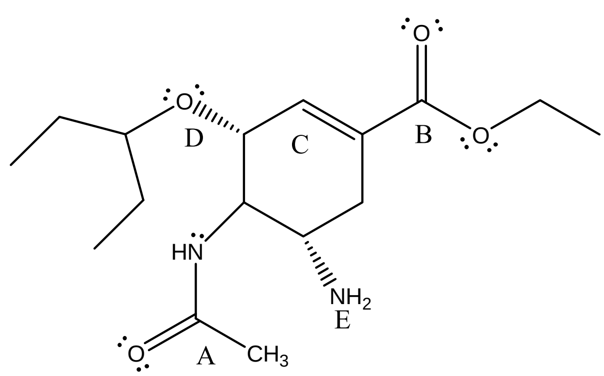
d) Calculate the binding energy of ${}_{9}^{19}F$ in MeV/atom

Since 1 amu = 931.5 MeV,
(0.158654 amu/atom)(931.5 MeV/amu) = 147.8 MeV/atom

e) Calculate the binding energy of ${}_{9}^{19}F$ per nucleon in MeV/nucleon.

19 nucleons: (147.8 MeV/atom)(1 atom/19 nucleons) = 7.778 MeV/nucleon

7. One component of oseltamivir phosphate, otherwise known as Tamiflu®, is pictured at right. This is one of the drugs that the World Health Organization has identified as an effective treatment for the H5N1 strain of influenza A, which is more commonly referred to as "bird flu". (10 pts)



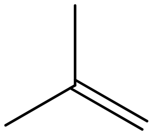
Choices to consider: alkane, alkene, alkyne, aromatic hydrocarbon, alcohol, ether, carboxylic acid, aldehyde, ketone, ester, amine, amide, amino acid.

Identify the functional groups indicated by the letters

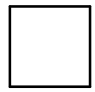
A. ____Amide_______ B. _____Ester______ C. _____Alkene__

D. ___Ether_____ E. _____Amine____

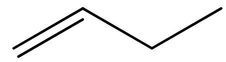
8. Draw the 4 isomers in line notation of C_4H_8 including geometric isomers and name them



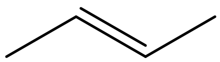
2-methyl-1-propene



Cyclobutane

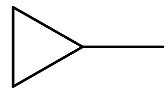


1-butene



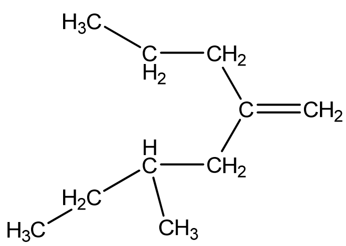
Trans-2-butene

Cis-2-butene

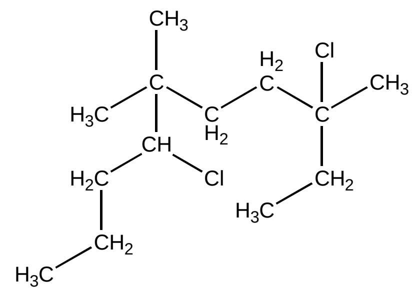


Methylcyclopropane

9. Name the following compounds (6 pts)



Name___4-methyl-2-propyl-1-hexene____



Name__3,7-dichloro-3,6,6trimethyldecane__

10. From each of the following pairs, choose the nuclide that is radioactive. (One is known to be radioactive, the other stable.)

a) $^{80}_{34}Se$ or $^{81}_{34}Se$

$^{81}_{34}Se$ Even-odd nucleus less stable than even-even nucleus.

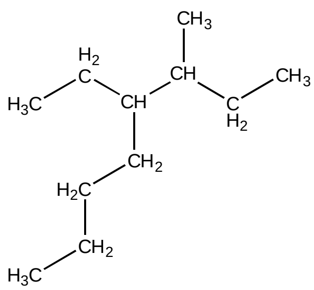
b) $^{209}_{83}Bi$ or $^{210}_{83}Bi$

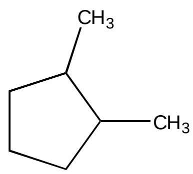
$^{210}_{83}Bi$ Odd-odd nucleus is unstable.

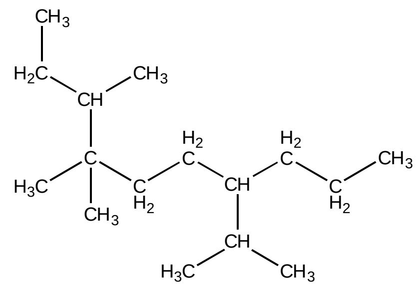
11. Briefly explain why "magic numbers" are important for understanding nuclear structures, i.e., define "magic number".

Nuclei with a "magic number" of neutrons or protons have additional stability relative to ther nuclei.

12. Write the IUPAC name for each of the following compounds:



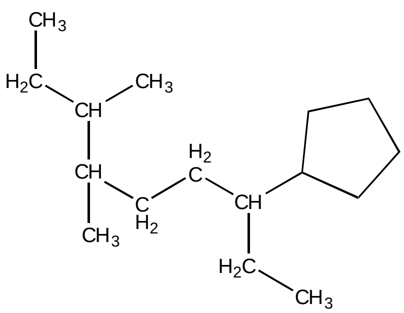


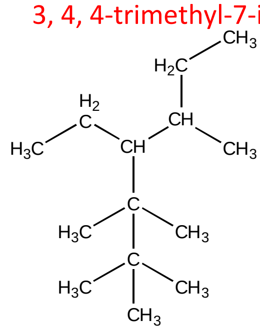


3-methyl-4-ethyl octane

1, 2-dimethyl cyclopentane

3, 4, 4-trimethyl-7-isopropyl decane

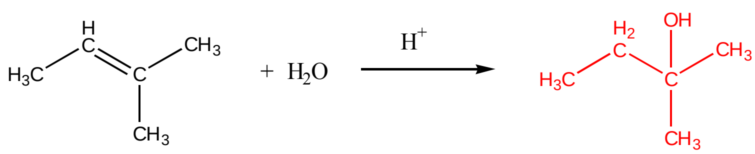


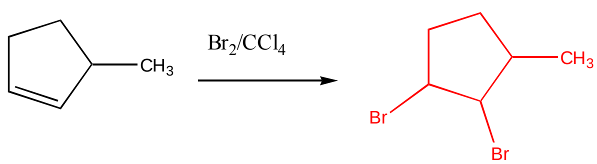


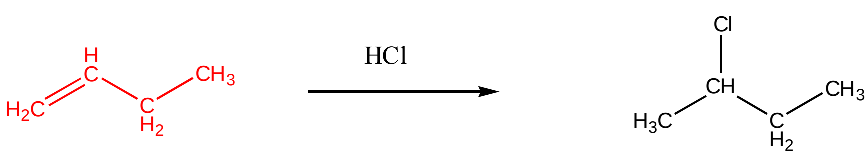
3, 4-dimethyl-7-cyclopentyl nonane

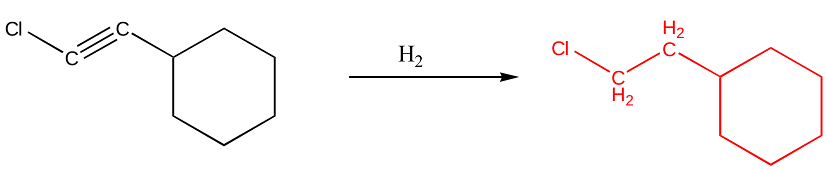
2, 2, 3, 3, 5-pentamethyl-4-ethyl heptanes

Complete the following reactions:



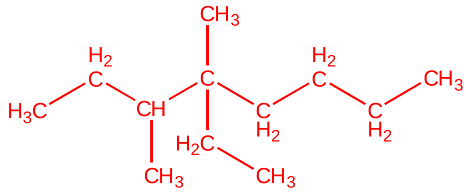




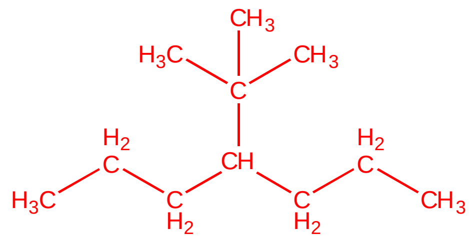


13. Write the full and condensed structural formulas for the following substances:

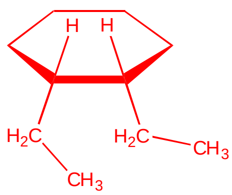
3, 4-dimethyl-4-ethyl octane



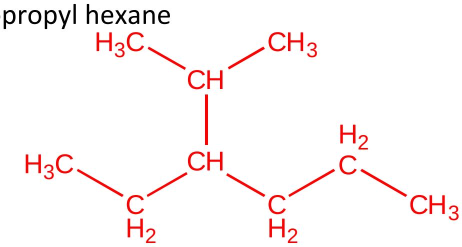
4-t-butyl heptane



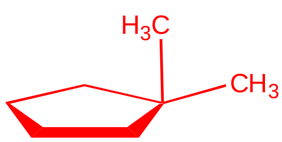
cis-1, 3-diethyl cyclohexane



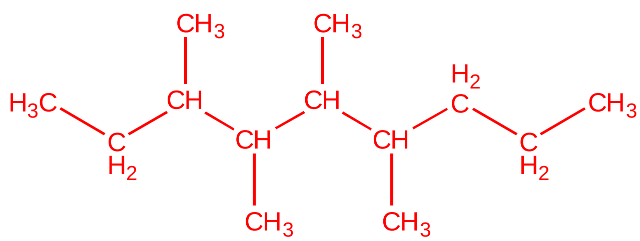
3-isopropyl hexane



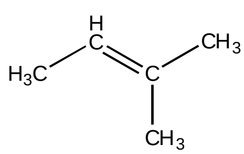
1, 1-dimethyl cyclopentane



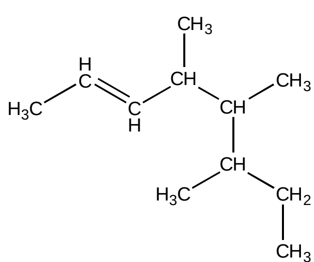
3, 4, 5, 6- tetramethyl nonane



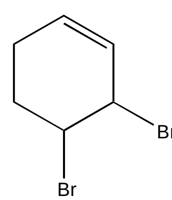
Write the IUPAC name for each of the following compounds.



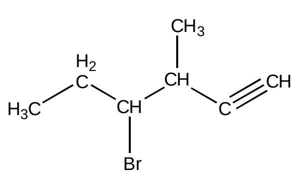
2-methyl-2-butene



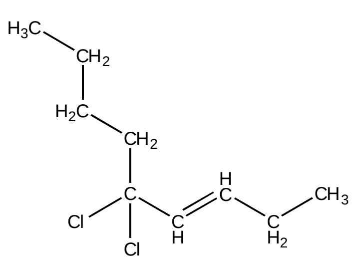
4, 5, 6-trimethyl-2-octene



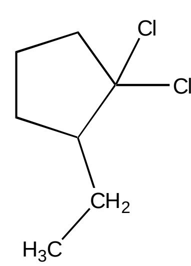
3, 4-dibromo-1-cyclohexene



4-bromo-3-methyl-1-hexyne



5, 5-dichloro-3-nonene



1, 1-dichloro-2-ethyl cyclopentane

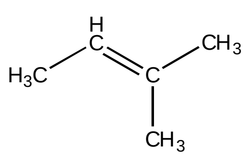
CHM 112 WORKSHEET FOR ALKENES, ALKYNES AND HALOCARBONS

Spring 2002

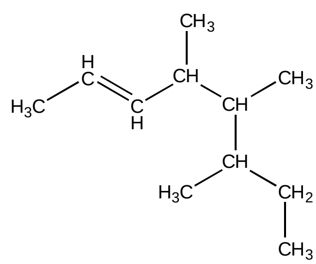
1. Explain, based on the appropriate IMFs, why the melting points and boiling points of alkenes and alkynes are so low.
Since the bonding in these molecules is non-polar covalent, the forces between molecules are weak dispersion forces and the crystals they form are molecular crystals with weak interactions between lattice points. Weaker forces require less energy to overcome. Therefore, the melting points and boiling points are lower.

2. Explain why double and triple carbon-carbon bonds are planar while a single C-C bond is not.
For single bonds, carbon forms sp^3 hybrid orbitals that arrange themselves 109.5^o away in three-dimensional space. Carbon in a double bond forms sp^2 hybrid orbital and these are arranged at 120^o on a plane while carbon in a triple bond undergoes sp hybridization and the resulting orbitals are180^o apart, in a line.

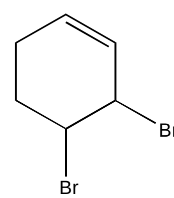
3. Write the IUPAC name for each of the following compounds.



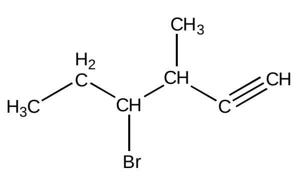
2-methyl-2-butene



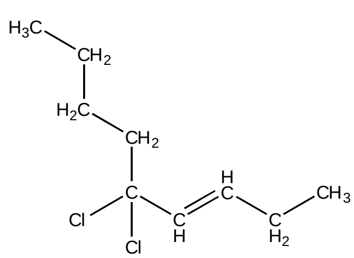
4, 5, 6-trimethyl-2-octene



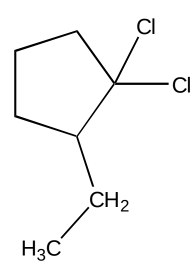
3, 4-dibromo-1-cyclohexene



4-bromo-3-methyl-1-hexyne



5, 5-dichloro-3-nonene



1, 1-dichloro-2-ethyl cyclopentane