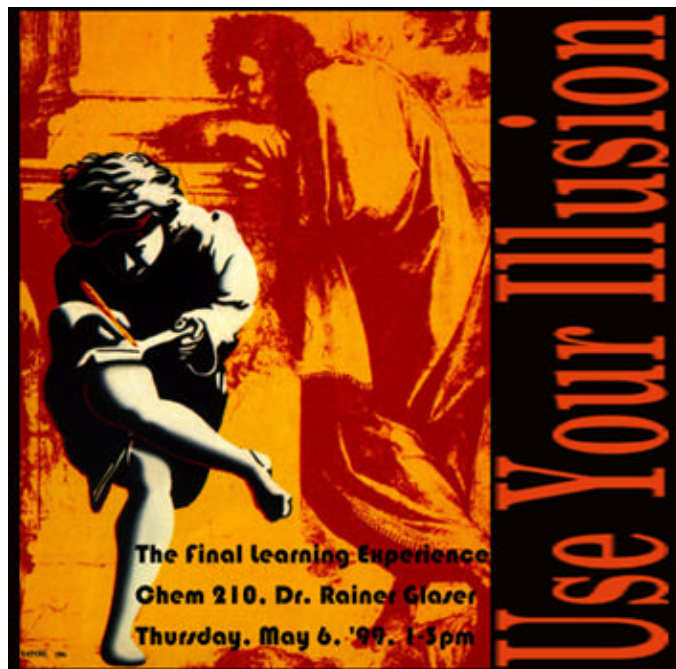


Chem 210, "Org. Chem. I", WS99
Dr. Rainer Glaser

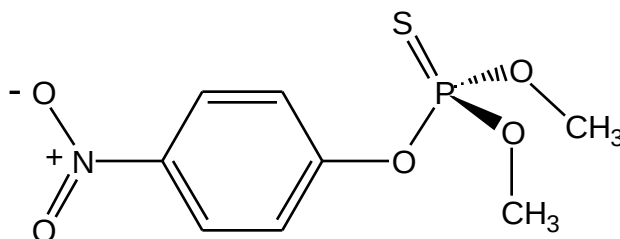


*The Final
Learning Experience
Thursday,
May 6, 1999,
1:00 - 3:00 pm*

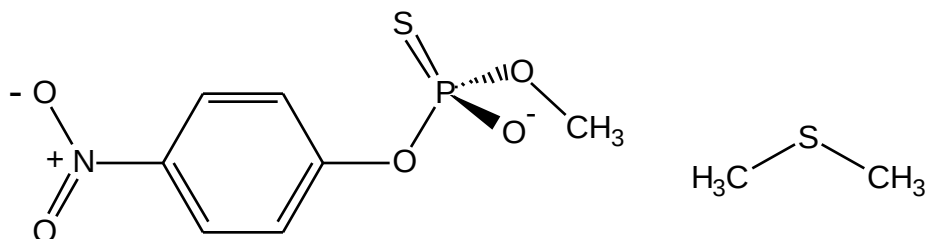
Name:		
Question 1. Nucleophilic Substitution. (News Item #6)	14	
Question 2. Electrophilic Addition.	24	
Question 3. Str. and Syn. of Alcohols. (MC)	16	
Question 4. Syn. of Alcohols.	14	
Question 5. Reactions of Alcohols. (MC)	16	
Question 6. Naltrexone. (News Item #11)	30	
Question 7. Reactions of Alcohols.	14	
Question 8. IR Vibrational Spectroscopy. (MC)	16	
Question 9. NMR Spectroscopy. (MC)	16	
Question 10. Basic ¹ H-NMR Spectra	28	
Question 11. Functional MRI. (News Item #13)	12	
Total	200	
Multiple Choice Percentage Q3, Q5, Q8 and Q9.		

Question 1. Nucleophilic Substitution. (14 points)

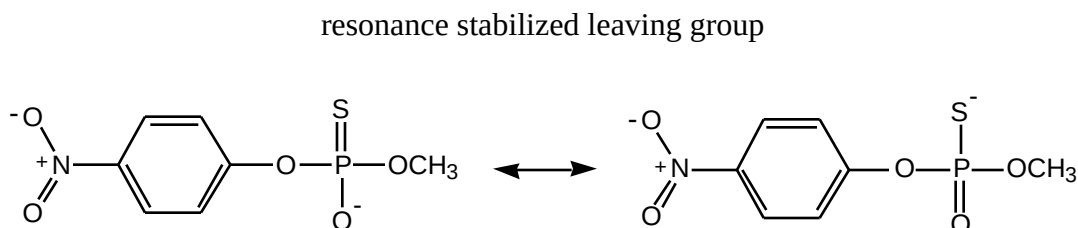
The article “BAN IS SOUGHT ON 5 PESTICIDES TO PROTECT KIDS” (*The Arizona Republic*, Jan. 29, **1998**) talked about environmental activism aimed at banning a group of pesticides. One of these is **methyl parathion** and its structure is shown. This compound is suspected to be toxic because of its high methylating power. Methyl parathion contains two methyl groups. If one of these methyl groups is attacked by a nucleophile, then an S_N2 (S_N1 , S_N2) reaction can occur. This S_N reaction is facilitated by the fact that the nucleofug is a really good leaving group. (2 point)



(a) Consider the reaction of the **methyl sulfide** nucleophile, H_3C-S^- , with methyl parathion. Draw the structure of the product of this reaction and draw the structure of the leaving group as well. (6 p.)

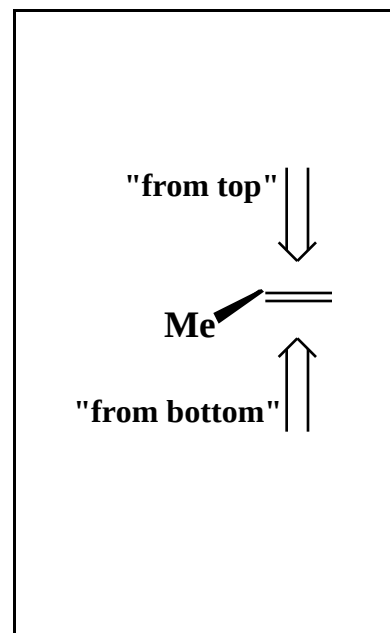


(b) Using resonance theory, explain why the leaving group in the above reaction is a “good” one. (6 p.)



Question 2. Electrophilic Addition of Bromine. (24 points)

Let's look at the addition of Br_2 to propene. This reaction involves the electrophilic addition of a Br^+ to the $\text{C}=\text{C}$ bond of propene and a bridged **bromonium** ion is formed. This intermediate is then attacked by a bromide ion. The Br^- can attack either at the terminal or at the central C-atom but the attack at the **central** (central, terminal) position will be favored since this carbon carries a **larger** (smaller, larger) positive charge in the intermediate because it is **more** (more, less) substituted. In the end, a 1,2-dibromopropane is formed that contains one $-\text{CH}_2\text{Br}$ group and one $\text{CHBr}-$ group. Now we note that the central carbon has become chiral as the result of the bromination. The ratio of *R* and *S* centers is, however, exactly unity and the product is **racemic**. To fully realize this stereochemistry, complete the following chart.



Draw the intermediate formed by attack of Br^+ from "the top"		Draw the intermediate formed by attack of Br^+ from "the bottom"	
Draw the product formed by <i>trans</i> addition of Br^-	R or S: S	Draw the product formed by <i>trans</i> addition of Br^-	R or S: R

Question 3. Structure and Synthesis of Alcohols. (16 points)

E-Q2 What type of orbitals are involved in the C-O bond in alcohols?

- a. **(C)sp³-(O)sp³**
- b. (C)sp²-(O)sp²
- c. (C)sp²-(O)sp³
- d. (C)sp³-(O)sp²
- e. (C)sp³-(O)p³

E-Q3 Identify the tertiary alcohol among the following alcohols.

- a. Cyclohexanol
- b. Phenol
- c. **2-Methyl-2-propanol**
- d. Hydroquinone
- e. Benzyl alcohol

E-Q6 In what types of positions will you find the hydroxyl groups in the most stable structure of *cis*-cyclohexene glycol?

- a. Both axial
- b. Both equatorial
- c. **One axial and one equatorial**

E-Q9 Which alcohol is the least miscible with water?

- a. Methanol
- b. Ethanol
- c. Propanol
- d. Butanol
- e. **Pentanol**

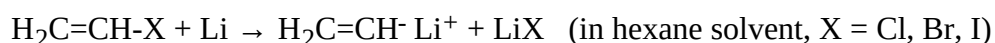
Question 4. Synthesis of Alcohols with Organometallics. (14 points)

(a) Provide syntheses for ethylmagnesium bromide and vinyl lithium. In each case, draw the structures of the starting materials and the product and specify the solvent. (3 points each)

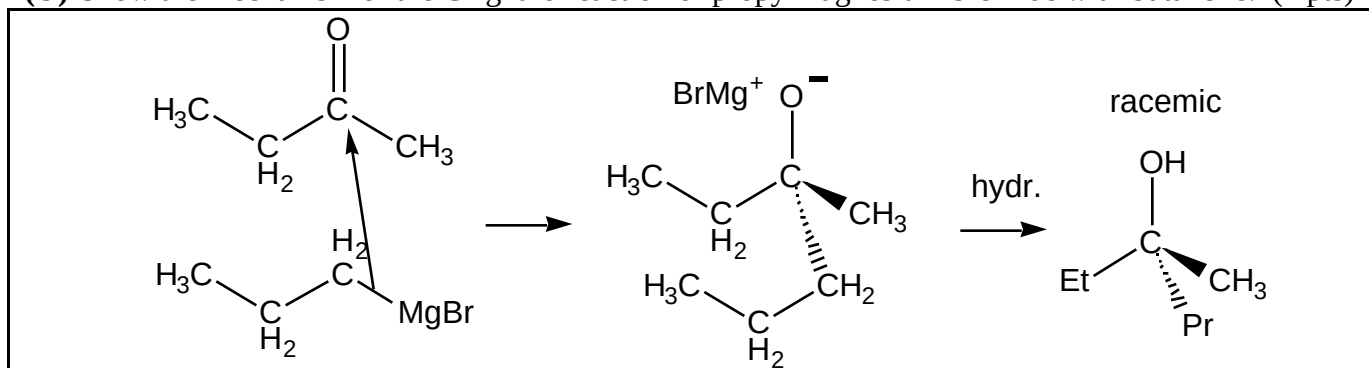
Ethylmagnesium bromide:



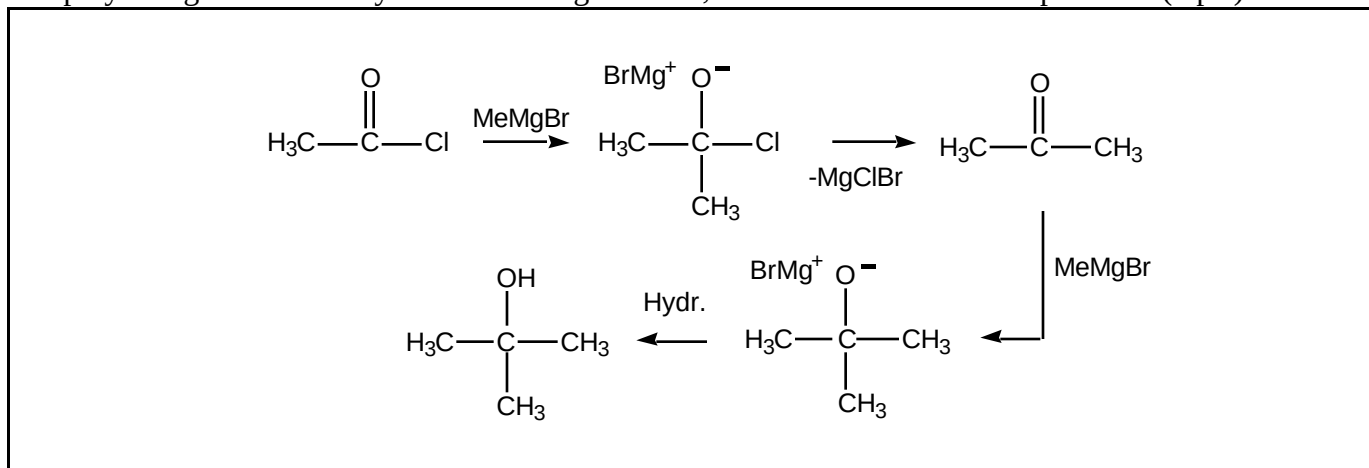
Vinyl lithium:



(b) Show the mechanism of the Grignard reaction of propylmagnesium bromide with butanone. (4 pts)



(c) Suggest a synthesis of *tert.*-butanol that starts with a carboxylic acid derivative of your choice and employs Grignard chemistry. Draw starting material, all intermediates and the product. (4 pts)



Question 5. Reactions of Alcohols. (16 points)

E-Q1 Which one of the following statements does **not** describe an oxidation?

- a. Loss of hydrogen gas
- b. Addition of atomic oxygen
- c. Addition of molecular oxygen
- d. Addition of a halogen atom or molecule
- e. Addition of a hydride ion**

E-Q22 Consider the Fischer esterification of methanol with formic acid by way of mineral acid catalysis. Which statement does **not** apply?

- a. This is an equilibrium reaction.
- b. The ester formed is methyl formate.
- c. Esterification releases water.
- d. The reaction is acid catalyzed.
- e. Adding more acid catalyst shifts the equilibrium toward more ester formation.**

E-Q23 What is nitroglycerine? Glycerine is 1,2,3-propanetriol.

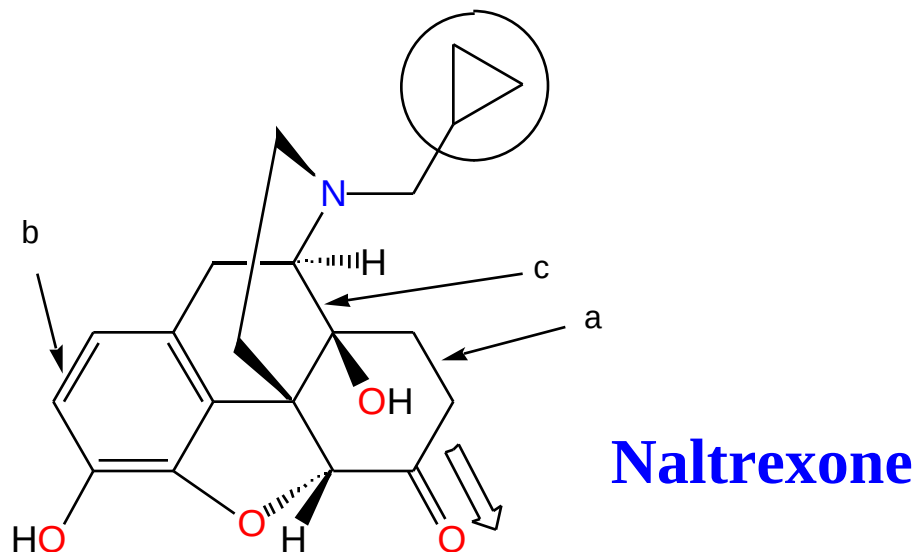
- a. The mononitrate of glycerine, ester at C1.
- b. The mononitrate of glycerine, ester at C2.
- c. The dinitrate of glycerine, esters at C1 and C2.
- d. The dinitrate of glycerine, esters at C1 and C3.
- e. The trinitrate of glycerine.**

E-Q24 Phosphoric acid can form mono-, di- and triesters. Diesters of phosphoric acid are part of the backbone of RNA and DNA. Identify the molecular formula of the dimethyl ester of phosphoric acid.

- a. $\text{O}=\text{P}(\text{OH})_3$
- b. $\text{O}=\text{P}(\text{OH})_2(\text{OMe})$
- c. $\text{O}=\text{P}(\text{OH})(\text{OMe})_2$**
- d. $\text{O}=\text{P}(\text{OMe})_3$

Question 6. Naltrexone. (30 points)

The use of naltrexone in treating alcoholics was the subject of the article "*NALTREXONE IS ALTERNATIVE TO ALCOHOLISM. WHY IS IT SO LITTLE USED?*" by Thomas Ropp (*The Arizona Republic*, February 19, **1998**). Naltrexone curtails the craving for alcohol as it blocks the opioid receptors in the brain. Aside from the mode of action of naltrexone, the article also described how antabuse affects the usual metabolism of alcohol.



Chemistry starts with observation and the skills to recognize and to name what has been recognized. So, please exercise your “**skills to observe, recognize & name**”: (a) Naltrexone contains one "cyclopropyl" group. Find it and circle it. (b) The amino group is _____ (primary, secondary, **tertiary**). (c) The ether O-atom carries 2 electron lone pairs. (d) The "double bond equivalent" (DBE), defined as the sum of rings and unsaturations in a molecule, of naltrexone is 10. (e) The configuration of the chiral C-atom carrying the aliphatic alcohol function is S (*R* or *S* ; this item counts twice). (f) The aliphatic alcohol is _____ (primary, secondary, **tertiary**). (g) Naltrexone _____ (**contains**, does not contain) an "enolizable hydrogen." (h) For the C=O bond, indicate the bond dipole moment by drawing (in the above structure) an arrow from the positively charged end to the negatively charged end. (i) Naltrexone contains 5 heteroatoms that can serve as H-bonding acceptors and 2 functional groups that can serve as H-bonding donors. (j) The C-C single bond indicated by the arrow "a" is about 1.54 Å long while the C=C bond indicated by the arrow "b" is about 1.40 Å long (1 Å = 100 pm). (k) The amino and the hydroxyl groups that are attached to the bond indicated by the arrow "c" are _____ (*cis*, *trans*, ***gauche***). (l) The C-C single bond "a" is formed by overlap between two _____ (sp, sp², **sp³**) hybrid orbitals. (30 points)

Question 7. Oxidations and Reductions of Alcohols. (14 points)

(a) For alcohol $\text{H}_3\text{C}-\text{CH}_2-\text{CH}_2-\text{CH}_2-\text{OH}$, **1**, complete the following functional group transformations.

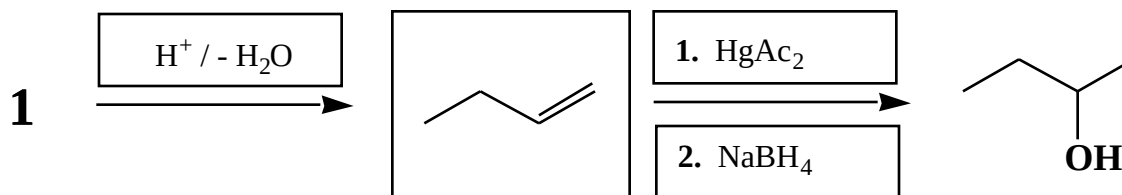
Alcohol **1** is oxidized to the corresponding **aldehyde**: (2 points)

Use PCC. Need to give the structure of PCC or at least the full name.

Alcohol **1** is oxidized to the corresponding **carboxylic acid**: (2 points)

Use any of the chromium trioxide reagents.

Alcohol **1** is turned into a secondary alcohol via an **oxymmercuration** reaction: (6 points)



(b) Now consider the deuterated alcohol **2**, $\text{CH}_3\text{CH}_2\text{CH}_2\text{CHDOH}$, which is optically active and has the R configuration at the chiral C atom. On treatment with thionylchloride, Cl_2SO , **2** gives 1-chlorobutane, **3**. Give a perspective drawing of **3**. What is the configuration of alkylchloride **3**? (4 points)



Retention of configuration

Question 8. Infrared Vibrational Spectroscopy. (16 points)

E-Q5 What is the definition of "wavenumber"?

- a. Same as wavelength
- b. Wavelength x light speed
- c. Wavelength / light speed
- d. $1 / \text{wavelength}$**
- e. Light speed / wave length

E-Q6 Which statement best describes in a qualitative fashion the dependencies of the vibrational frequency on the bond strength and the atomic mass of the vibrating system? The frequency increases with ...

- a. an increase in bond strength and an increase in the mass of the vibrating system.
- b. a decrease in bond strength and an increase in the mass of the vibrating system.
- c. an increase in bond strength and a decrease in the mass of the vibrating system.**
- d. a decrease in bond strength and a decrease in the mass of the vibrating system.
- e. an increase in bond strength and does not depend on the mass at all.

E-Q8 Which area of the IR spectrum is called the "fingerprint region"? [Wavenumbers are given.]

- a. 3,000 - 2,000
- b. 3,000 - 1,000
- c. 2,000 - 1,000
- d. 2,000 - 400
- e. 1,400 - 400**

E-Q13 In which region would you look for C=O stretching modes?

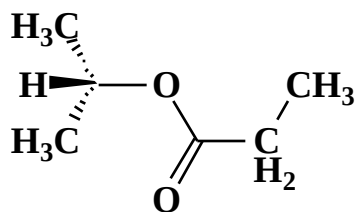
- a. 3300 - 2700
- b. 2300 - 2000
- c. 2300 - 2200
- d. 1800 - 1600**
- e. 1700 - 1600

Question 9. Nuclear Magnetic Resonance Spectroscopy. (16 points)

- E-Q3 Which statement about “shielding” is correct? The more shielded a nucleus, ...
- a. the **higher** is the effective magnetic field at the nucleus and the **higher** is the level splitting.
 - b. the **higher** is the effective magnetic field at the nucleus and the **lower** is the level splitting.
 - c. the **lower** is the effective magnetic field at the nucleus and the **higher** is the level splitting.
 - d. **the lower is the effective magnetic field at the nucleus and the lower is the level splitting.**
- E-Q5 With the chemical shift defined as the ratio between “distance downfield from the standard in [Hz]” and “operating frequency of the spectrometer in [MHz]”, what will be the units of the chemical shift?
- a. Hz (Hertz)
 - b. KHz (Kilohertz)
 - c. MHz (Megahertz)
 - d. **ppm (parts per million)**
 - e. unitless
- E-Q7 The H-atom in terminal acetylenes is greatly affected by anisotropic effects. While the sp-hybridized C-atom is the most electronegative, the H-signal appears much less deshielded than one might expect based on charges alone. In which region do terminal acetylenes absorb?
- a. 0 - 1.5 ppm
 - b. **1.5 - 3 ppm**
 - c. 3 - 4.5 ppm
 - d. 4.5 - 6 ppm
 - e. 6 - 7.5 ppm
- E-Q10 How many kinds of chemically and magnetically nonequivalent hydrogen nuclei are there in chlorocyclobutane?
- a. 1
 - b. 2
 - c. **5**
 - d. 6
 - e. 7

Question 10. ^1H -NMR Spectroscopy. (28 pts)

Consider the NMR spectrum of the ester.



(a) How many **types of protons** are present in the ester and in what **ratio**. (6 points)

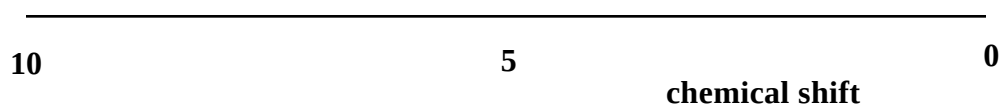
4 types: 6 (2 Me in propyl) : 1 (tertiary) : 2 (methylene) : 3 (methyl in ethyl)

(b) Estimate the **chemical shifts** in ppm (correct sequence of signals expected, reasonable estimates are expected). Write the chemical shifts next to the appropriate H in the above structure. (8 points)

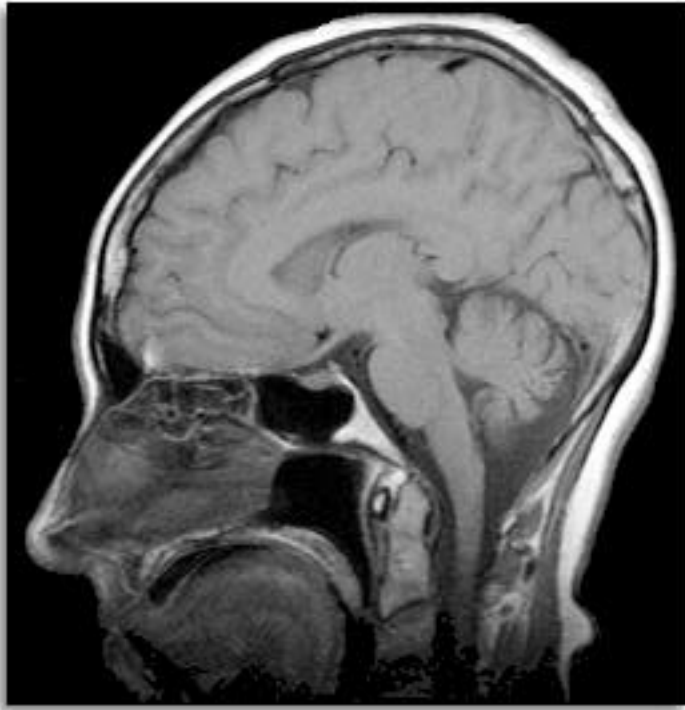
(c) Determine the **splitting pattern** for each signal. Give the multiplicity (singlet, doublet, and so on) and the relative ratios of the lines in each multiplet (e.g. 1:1 for a doublet). (8 points)

Me in Pr: d (1:1); tert. H: septet (1:6:15:20:15:6:1); H in CH_2 : q (1:3:3:1); Me in Et: t (1:2:1).

(d) Now we are ready to draw the spectrum. Do it. Pay attention to chemical shift, multiplicity, and don't forget to reflect the number of absorbing hydrogens correctly in the intensities. Include the signal for the reference material tetramethylsilane (abbreviated TMS). (6 points)



Question 11. Nuclear Magnetic Resonance and Magnetic Resonance Imaging. (12 p.)



*This is your
brain on
"Nuclear
Magnetic
Resonance"*

The article "*BILINGUALISM COMES IN DIFFERENT WAYS*" by Dolores Kong (*Boston Globe*, July 10, 1997) talked about the technique of "functional magnetic resonance imaging," fMRI for short, and how the method can be employed to see "the brain at work." In your own words, explain how fMRI works. Briefly state (a) how simple chemical NMR works and then explain (b) in what way MRI scanning differs from chemical NMR. Finally (c) explain the meaning of "functional" in fMRI. What is observed in fMRI and what kinds of things can be studied with fMRI. [6 points for (a), 3 points each for (b) and (c)].

(a) The principle of NMR

over

The principle of NMR continued

Nuclear spin

Nuclear magnetic moment

Magnetic field

Parallel or antiparallel alignment, Zeeman splitting

Radiowave

Shielding and chemical shift

(b) Magnetic Resonance Imaging

spatial resolution

observe H in water

strong field with gradient

(c) Functional MRI

time resolved

monitor H in water

monitor blood flow

assume that blood flow parallels activity