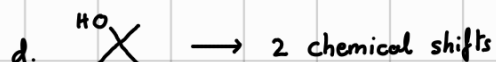
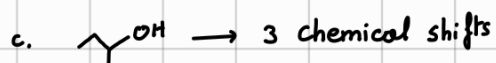
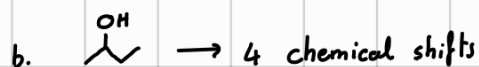
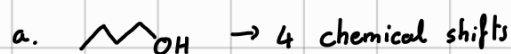


Exercise 1.



Exercise 2

We use the Bloch equation (we solve it)

$$\frac{d}{dt} M_z = -\frac{1}{T_1} (M_z - M_0)$$

$$\Leftrightarrow \frac{dM_z}{M_z} = -\frac{1}{T_1} dt$$

$$\Leftrightarrow \ln(M_z) = -\frac{t}{T_1} + C$$

$$\Leftrightarrow M_z = k e^{-\frac{t}{T_1}}$$

$$\Leftrightarrow M_z = k(t) e^{-\frac{t}{T_1}}$$

$$\Leftrightarrow \frac{dM_z}{dt} = k'(t) e^{-\frac{t}{T_1}} - \frac{k(t) e^{-\frac{t}{T_1}}}{T_1}$$

$$\Leftrightarrow k'(t) e^{-\frac{t}{T_1}} = \frac{M_0}{T_1}$$

$$\Rightarrow k'(t) = \frac{M_0}{T_1} e^{\frac{t}{T_1}} \quad \Leftrightarrow k(t) = M_0 e^{\frac{t}{T_1}} + C_2$$

The general solution is therefore :

$$M_z = M_0 + C_2 e^{-\frac{t}{T_1}}$$

$$\text{at } t=0, M_z(t)=0 \quad \Leftrightarrow C_2 = -M_0$$

$$\Rightarrow M_z = M_0 (1 - e^{-\frac{t}{T_1}})$$

$$\rightarrow \text{Percentage} : \frac{M_z}{M_0} \cdot 100 = (1 - e^{-\frac{t}{T_1}}) \cdot 100 \quad \text{with } T_1 = 1.2 \text{ s}$$

Good work getting this equation!

Knowing the percentage of M_z , it is now possible to calculate the percentage of M_x due to the fact that

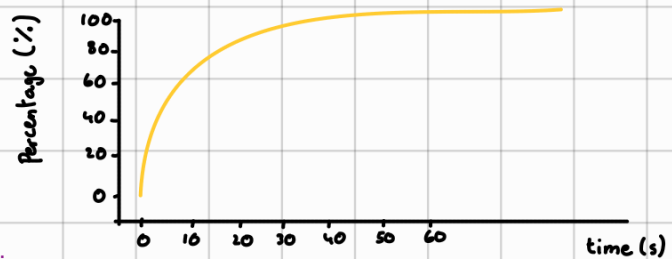
$$\% M_x = 100 - \% M_z$$

This step isn't needed — the 90° pulse transfers all the $M_z \rightarrow M_x$, so $M_x = M_z$ in this case

We therefore get the following results and graph.

- a. 100% 0%
b. 37,8% 63.2%
c. 0,7% 99.3%
d. 0% 100%

e.

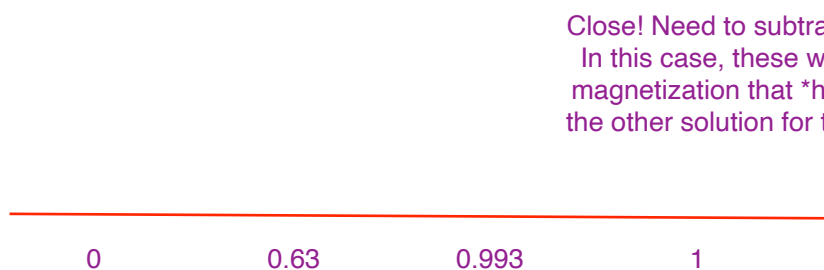


Close! (See above, all the math is correct, these percentages just shouldn't have been subtracted from 100)

Exercise 3

The high chemical shift of protons in aromatic rings arises because the ring current in the aromatic system creates an induced magnetic field that deshields the protons in the ring. This deshielding shifts their resonance to higher values on the NMR spectrum.

Additional info: this is essentially a saturation recovery sequence, similar to the inversion recovery (see Jigsaw 3B)



Close! Need to subtract these values from 1. In this case, these would be the amount of magnetization that *hasn't* relaxed yet. See the other solution for the equation derivation.

Plot is flipped upside-down—should see an increase in intensity over time

effective magnetic field which makes them resonate at a higher frequency due to the Larmor theorem.