Solutions

Each answer shows the steps, then the **result**.

2.1

- the ratio of the numbers of protons in each environment

2.2

- a triplet ($n = 2$ neighbours
- $2 + 1 = 3$ lines)

2.3

- A deuterated solvent contains no ^{1}H, so it adds no signals of its own to the spectrum; the reference is tetramethylsilane, TMS

2.4

- The –OH peak disappears; the labile hydrogen is exchanged for deuterium, which does not appear in a ^{1}H spectrum

2.5

- A quartet; the adjacent CH_3 has three protons, and $n + 1 = 4$

3.1 C

- Two equivalent neighbours give $2 + 1 = 3$ lines — a triplet

3.2 B

- D_2O exchange removes the O–H / N–H peak

3.3

(a)

- the CH_3 is a triplet (its 2 CH_2 neighbours give $2 + 1 = 3$); the CH_2 is a quartet (its 3 CH_3 neighbours give $3 + 1 = 4$)

(b)

- $CH_3 : CH_2 : OH = 3 : 2 : 1$

3.4

- the triplet (area 3) is a CH_3 with 2 neighbours, and the quartet (area 2) is a CH_2 with 3 neighbours; so the groups are CH_3 and CH_2 next to each other, i.e. an ethyl group; each splits the other by the $n + 1$ rule

3.5

(a)

- X has three chemical environments for its protons — one for each signal

(b)

- The areas are in the ratio of the numbers of protons in each environment; $2+3+3=8$ hydrogen atoms, which matches $C_4H_8O_2$

(c)

- The quartet at $\delta\,4.1$ has three neighbours, so it is a CH_2 next to a CH_3; the triplet at $\delta\,1.3$ has two neighbours, so it is that CH_3 next to the CH_2; the singlet at $\delta\,2.0$ has no neighbours, so its CH_3 is attached to a carbon carrying no hydrogens, the $C=O$

(d)

- The $\delta\,4.1$ shift shows the CH_2 is attached to oxygen; so X is $CH_3COOCH_2CH_3$, ethyl ethanoate

(e)

- A carboxylic acid –OH; the labile proton exchanges rapidly with deuterium from the D_2O, and deuterium gives no signal in a proton NMR spectrum, so the peak vanishes