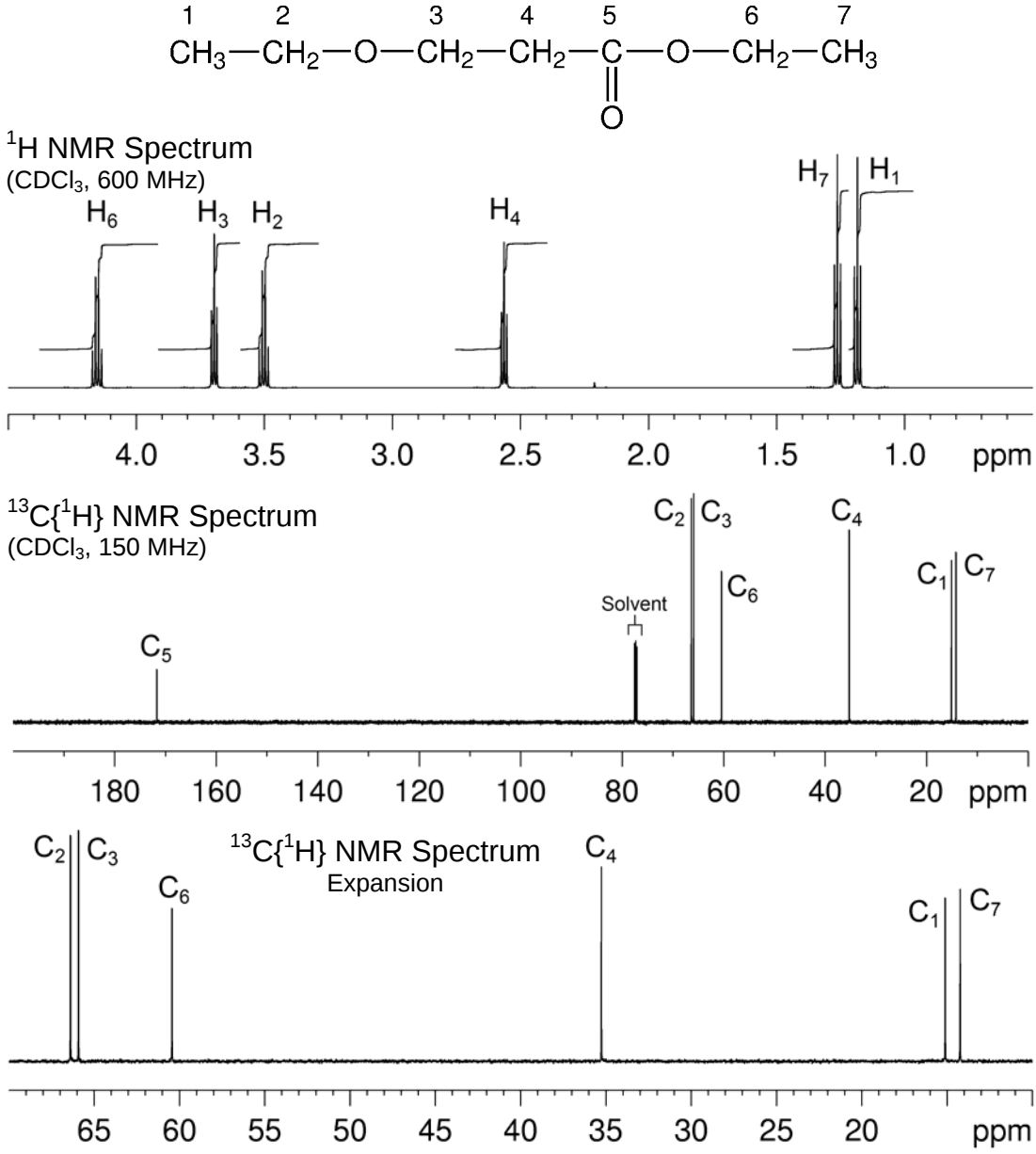
Problem 5

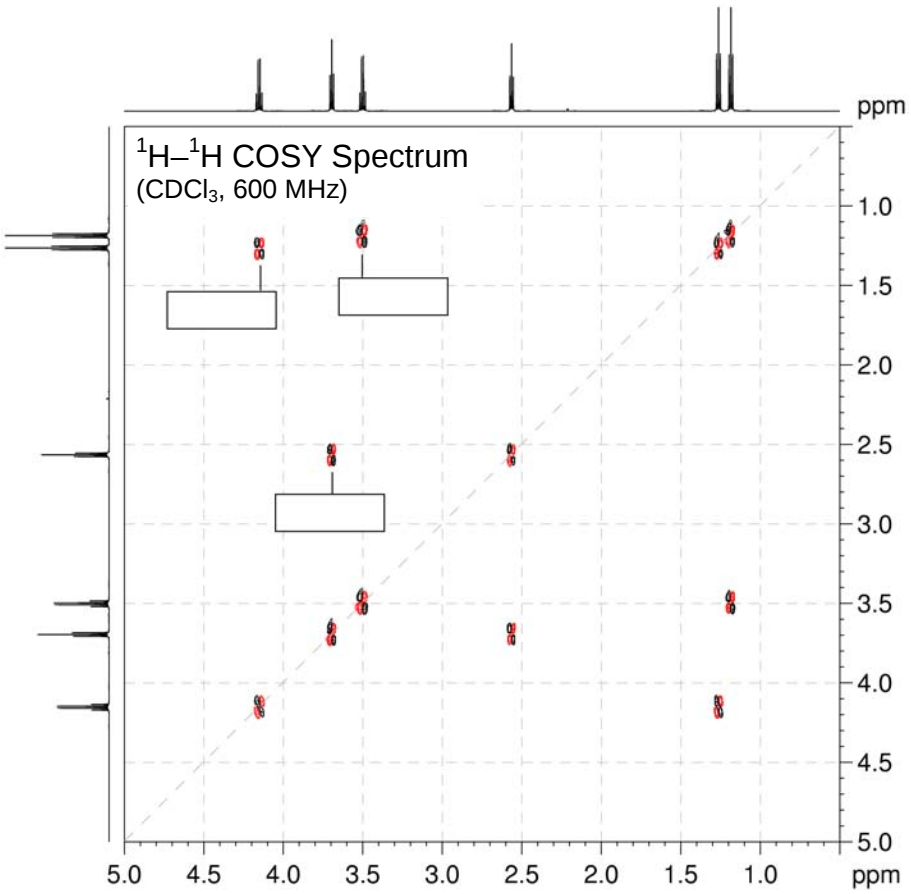
The ^{1}H and $^{13}C\{^{1}H\}$ NMR spectra of ethyl 3-ethoxypropionate ($C_7H_{14}O_3$) recorded in $CDCl_3$ solution at 298 K and 600 MHz are given below.

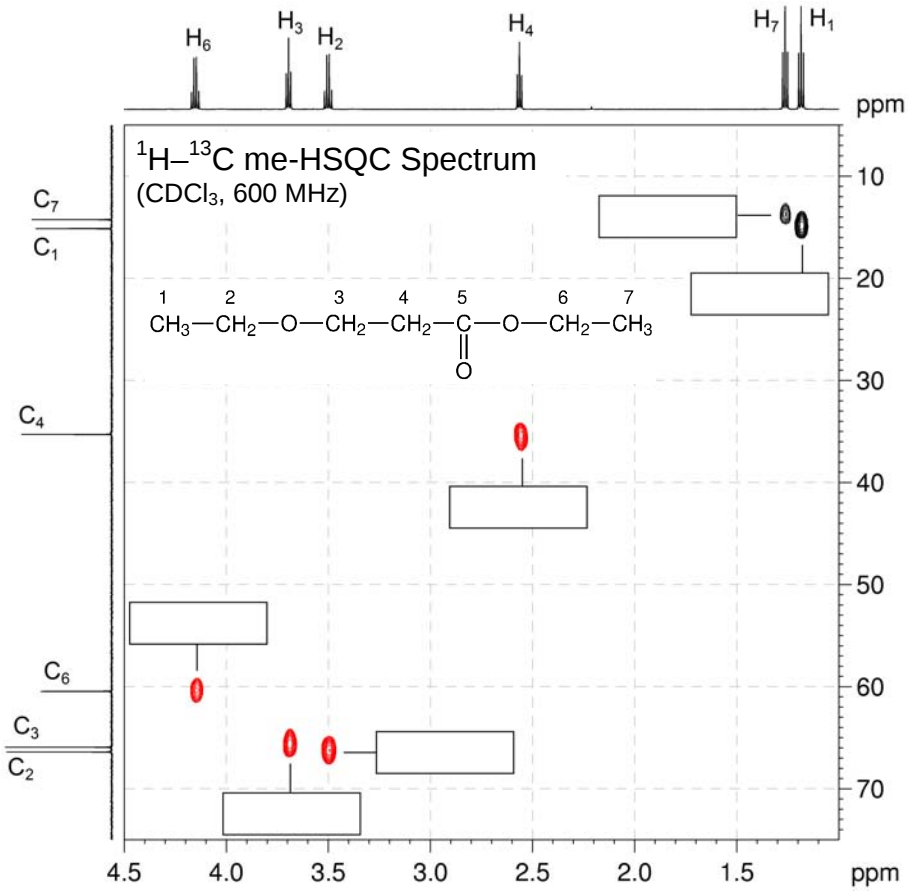
The ^{1}H NMR spectrum has signals at δ 1.18 (H_1), 1.26 (H_7), 2.56 (H_4), 3.50 (H_2), 3.70 (H_3) and 4.15 (H_6) ppm.

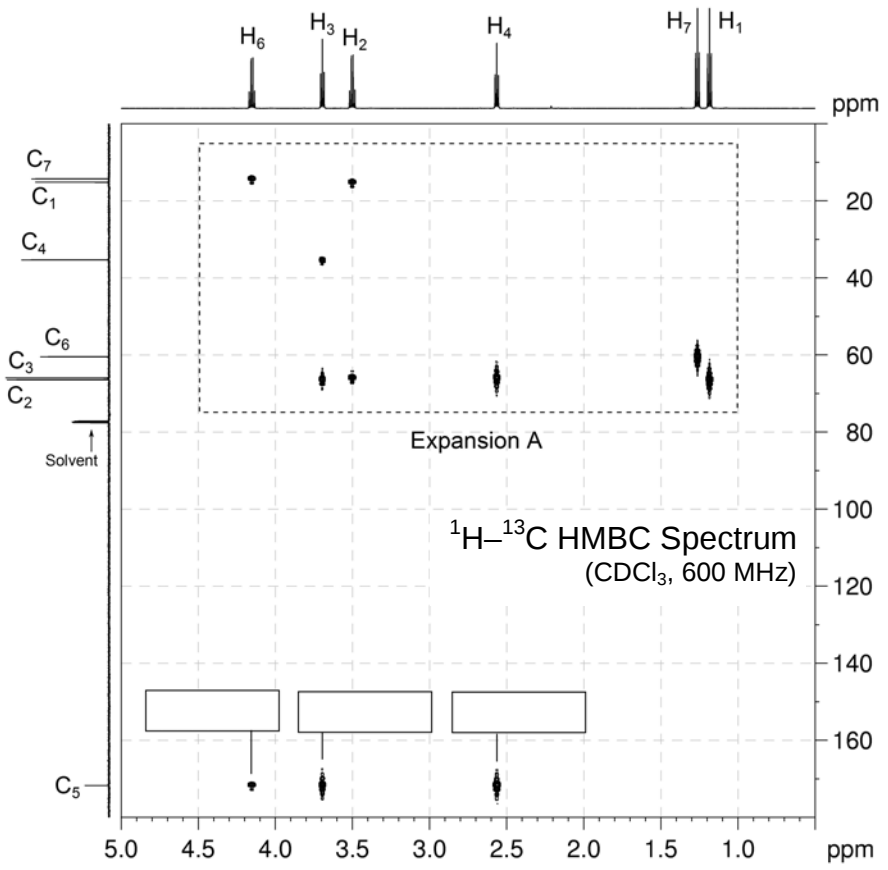
The $^{13}C\{^{1}H\}$ NMR spectrum has signals at δ 14.2 (C_7), 15.1 (C_1), 35.3 (C_4), 60.4 (C_6), 65.9 (C_3), 66.4 (C_2) and 171.7 (C_5) ppm.

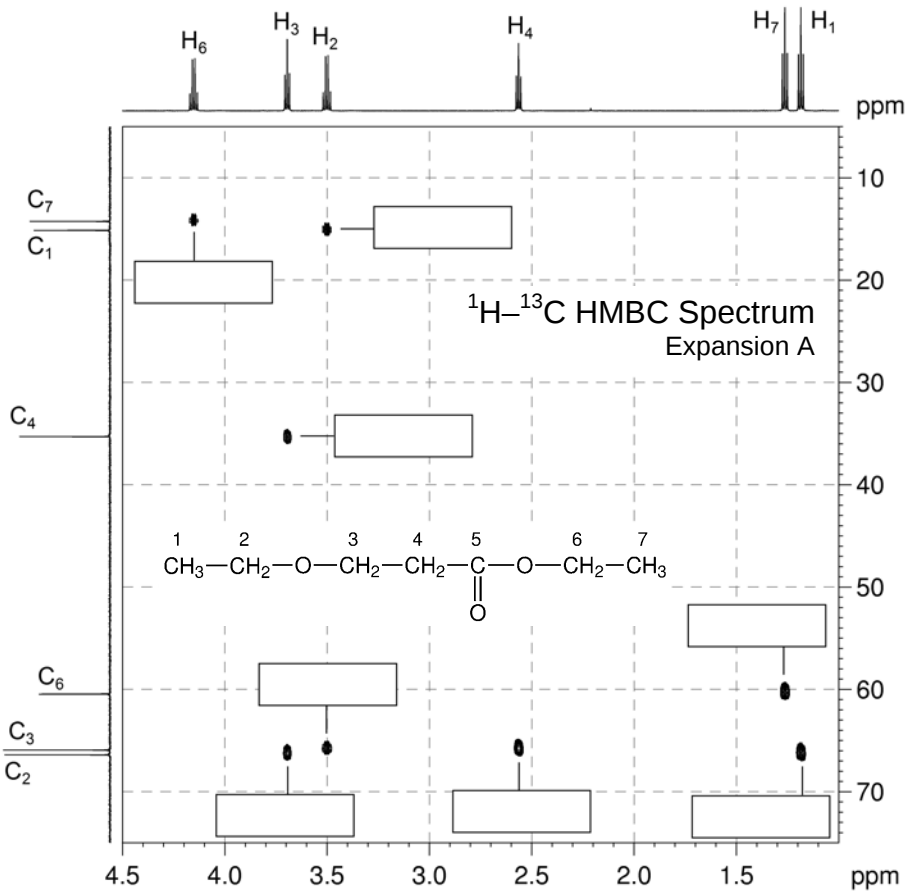
Also given on the following pages are the ^{1}H–^{1}H COSY, ^{1}H–^{13}C me-HSQC and ^{1}H–^{13}C HMBC spectra. For each 2D spectrum, indicate which correlation gives rise to each cross-peak by placing an appropriate label in the box provided (*e.g.* $H_1 \rightarrow H_2$, $H_1 \rightarrow C_1$).




^{1}H–^{1}H COSY Spectrum
(CDCl$_3$, 600 MHz)
ppm
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 ppm


H$_6$
H$_3$
H$_2$
H$_4$
H$_7$
H$_1$
ppm
^{1}H–^{13}C me-HSQC Spectrum
(CDCl$_3$, 600 MHz)
1 2 3 4 5 6 7
CH$_3$—CH$_2$—O—CH$_2$—CH$_2$—C(=O)—O—CH$_2$—CH$_3$
C$_7$
C$_1$
C$_4$
C$_6$
C$_3$
C$_2$
10
20
30
40
50
60
70
4.5 4.0 3.5 3.0 2.5 2.0 1.5 ppm


H6
H3
H2
H4
H7
H1
ppm
C7
C1
C4
C6
C3
C2
Solvent
Expansion A
1H–13C HMBC Spectrum
(CDCl3, 600 MHz)
C5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
ppm
20
40
60
80
100
120
140
160


H6
H3
H2
H4
H7
H1
ppm
C7
C1
1H–13C HMBC Spectrum
Expansion A
C4
1 2 3 4 5 6 7
CH3—CH2—O—CH2—CH2—C—O—CH2—CH3
O
C6
C3
C2
4.5
4.0
3.5
3.0
2.5
2.0
1.5
ppm
10
20
30
40
50
60
70