(c) (i) For each signal. (1) for identification and (1) for reason. [6]

δ 11 7· H of –OH or -COOH; one H: ✓
because it exchanges with D_2O/labile proton
or singlet because it has no ✓
H atoms on an adjacent atom
or data table 11.0 – 11.7

δ 2 4 2H of $-CH_2-$ ✓
quartet because it has 3 H atoms on the adjacent carbon
(n+1) = 4 lines ✓
or data table 2.0 – 2.9 CHC=0

δ 1 1. 3H of CH_3- ✓
triplet because it has 2 H atoms on the adjacent carbon
(n+1) = 3 lines ✓
or data table 0.7 – 1 6 CH_3–R

(ii) It is due to OH and the proton can **exchange/swap/substitute** [1]
(1) with the D in D_2O. ✓
or D replaces H
NOT just reacts with water

Total = 17

6 (a) (i) propanone ✓ [1]
accept acetone or propan-2-one

(ii) propanal ✓ [1]
accept propanaldehyde but **not** ethanal

(b) (i) *reagent(s):* e.g. 2,4-dinitrophenylhydrazine ✓ [2]
in words or formula

observation: e.g. orange / red / yellow precipitate / crystals ✓

no mark for observation if no reagent given

(ii) *reagent(s):* e.g. ammoniacal $AgNO_3$ ✓ or Ag_2O or Ag^+ or Tollens [3]
observation for D: No change ✓
observation for E: silver (mirror) ✓ grey ppte

or similarly for another **chemical** test that works e.g. acid dichromate, Fehlings or CHI_3 test

(c) (i) Marked cross at $\nu \sim 1700$ ✓ [2]
D has carbonyl group or ketone or C=O ✓

(ii) e g Reduction $CH_3COCH_3 \rightarrow CH_3CHOHCH_3$ (1) [2]
(or product is an alcohol)

new (broad) peak at ~3230 – 3550 cm^{-1} (1)
loss of peak at ~ 1700 cm^{-1} (1)

any two good points ✓ ✓

Qu.	Expected answers:	Marks
6 (a) (i)	C_7H_8O ✓	[1]
(ii)	M_r = 108 so m/e of molecular ion = 108 / ecf from (i) ✓	[1]
(iii)	%C = (84.0)/(108) x 100% = **77.8%** ✓ %H = (8.0)/(108) x 100% = **7.4%** ✓ / ecf from (i) or (ii)	[2]
(b)	*K* has OH group ✓ *K* has peak at 3230 - 3550 cm^{-1} ✓ (ignore reference to any other bonds) *L* does not have OH group / peak at 3230 - 3550 cm^{-1} ✓	[3]
(c) (i)	peak at δ = 7.3ppm / with area 5, is due to the benzene ring (protons) ✓ peak at δ = 4.5ppm / with area 2, is due to the $-CH_2-$ (protons) ✓ peak at δ = 3.2ppm / with area 1, is due to the OH (proton) ✓	[3]
(ii)	peak at δ = 3.2ppm / with area 1 disappears / ecf from *(i)* ✓	[1]
(iii)	expect peak at δ = 7.1-7.7 ppm ✓ 5 protons responsible / area = 5 ✓ expect peak at δ = 3.3-4.3ppm ✓ 3 protons responsible / area = 3 ✓	[4]
		[Total: 15]

3 (a) ester ✓
(primary) amine ✓ [2]

(b) (i) $C_8H_9NO_2$ ✓ [1]

(ii) M_r of **A** = 151 (or ecf from **(i)** ✓

moles **A** = 0 100g/151 = 0.000662
conc **A** = 0 000662/0 330dm^3
= **0.002 /0.0020** (ecf from a wrong M_r) ✓ [2]

(c) (i) **peaks identified**
peak **X** – benzene ring protons ✓
peak **Y** – CH_2 protons ✓
peak **Z** – CH_3 protons ✓
3 identification marks

reasoning from δ value . . for each, either.
- quotes the relevant functional group in the Data Sheet (eg –O-CH_2-R) /or
- quotes the relevant Data Sheet range (eg 3 3–4 3) / or
- from first principles using the expected deshielding to assign the peaks
✓✓✓

reasoning from the splitting pattern .
Y peak is a quadruplet/1 3 3.1 etc
this is due to 3 neighbours / adjacent to a CH_3 ✓
Z peak is a triplet / 1 2·1 etc
this is due to 2 neighbours /adjacent to a CH_2 ✓

ANY 3 out of **5** reasoning marks [6]

(ii) peak at 1700cm^{-1} and/or at 1280cm^{-1} marked ✓ [1]

[Total: 12]

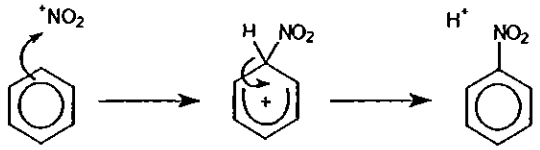
4 (a) (i) reagents conc $H_2SO_4 + HNO_3$ ✓

electrophile NO_2^+ ✓

$H_2SO_4 + HNO_3 \longrightarrow HSO_4^- + H_2O + NO_2^+$ /

$2H_2SO_4 + HNO_3 \longrightarrow 2HSO_4^- + H_3O^+ + NO_2^+$ ✓

mechanism



curly arrow from benzene π-bond to electrophile ✓
correct intermediate (ecf on electrophile formula) ✓
curly arrow from C-H bond to π-bond and H^+ formed ✓

overall equation

$C_6H_6 + HNO_3 \longrightarrow C_6H_5NO_2 + H_2O$ ✓

ANY 6 out of 7 **[6]**

(ii) NO_2^+ accepts an electron pair ✓
H is replaced / substituted by NO_2 ✓ **[2]**

(b) two peaks ✓
peak at/between 2 3-2 7 ✓
peak at/between 7 1-7 7 ✓ **[3]**

[Total: 11]

(b) 1 doublet and 1 quadruplet / 1 3 3 1 and 1.1 ✓
correct reason for at least one peak ✓
(eg 1,3 3,1 due to 3 neighbours / next to CH_3 / use of n+1 rule)

[2]

(c) (i) $C_7H_{12}O$ ✓

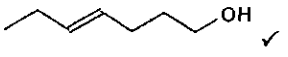
[1]

(ii)

✓

[1]

(iii)



✓

✓

[2]

[Total: 13]

2 (a) (i) $CH_3CHClCH_3$ ✓ allow any formula that is unambiguously 2-chloropropane **[1]**

(ii) $CH_3CHClCH_3 + C_6H_6 \longrightarrow C_6H_5CH(CH_3)_2 + HCl$ ✓ **[1]**

(iii) halogen carrier ✓ **[1]**

(b) (i) peaks identified
peak **X** – CH_3 (protons) ✓
peak **Y** – CH (proton) ✓
peak **Z** – benzene ring (protons) ✓

3 identification marks

reasoning from δ value ... for each, either:
- quotes a δ value for the peak **and** refers explicitly to the Data Sheet /or
- quotes the relevant functional group in the Data Sheet (eg R-CH_3 for X) /or
- quotes exactly the relevant Data Sheet range, ie (0.7–1.6 for X)
  (2.3 – 2.7 for Y)
  (7.1 – 7.7 for Z) ✓✓✓

3 reasoning marks

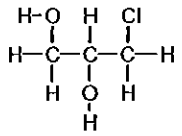
ignore any attempts to reason from the splitting here, but look out for credit to parts (ii) and (iii) if not given below **[6]**

(ii) 1 proton / CH/ 'n' = 1 (using the n+1 rule) ✓

on the neighbouring/adjacent carbon ✓ **[2]**

(iii) the CH_3 protons are all equivalent/in the same (chemical) environment / there are six protons adjacent to the CH ✓ **[1]**

[Total: 12]

3 (a) (i) 

the correct compound .... ✓

shown as a correctly displayed formula ✓

[2]

(ii) yes, because there are four different groups around the central carbon ✓
(or ecf on the structure given in (i)) AW

allow asymmetric / non-superimposable on its mirror image

[1]

(b) infra-red/i.r. (spectroscopy) ✓
peak/absorption at 3230 - 3550 (cm^{-1}) ✓

n.m.r. (spectroscopy) ✓
peak at 3.5–5.5 (ppm) ... ✓
... which disappears in D_2O ✓

Quality of Written Communication
mark for good organisation / a logical response and technical terms, using at least **two** of the following words:
infra-red, nuclear magnetic resonance, spectroscopy, wavenumber, cm^{-1}, chemical shift, ppm) ✓

[6]