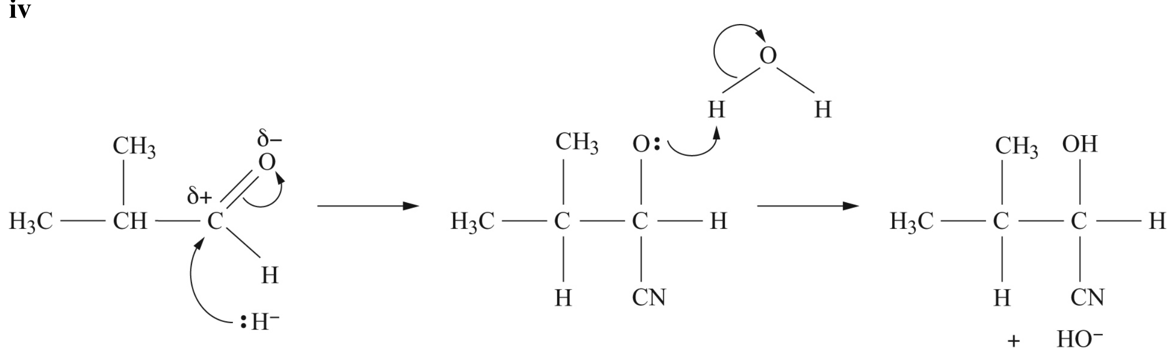
Chapter 18: Carbonyl compounds

Homework marking scheme

1 **a** **i** $CH_3CH(CH_3)COOH$ [1]
2-methylpropanoic acid [1]
ii any one from acidified potassium dichromate, ammoniacal silver nitrate solution /Tollen's reagent or Fehling's solution [1]
iii $CH_3CH(CH_3)CHO + [O] \rightarrow CH_3CH(CH_3)COOH$ [1]

b **i** $CH_3CH(CH_3)CH_2OH$ [1]
2-methylpropan-1-ol [1]
ii sodium borohydride [1]
in water [1]
iii $CH_3CH(CH_3)CHO + 2[H] \rightarrow CH_3CH(CH_3)CH_2OH$ [1]
iv



dipoles on aldehyde [2]
lone pair donated by negative hydrogen ion [1]
curly arrow from lone pair or negative charge on O [1]
curly arrow from O–H bond onto oxygen. [1]

c **i** $CH_3CH(CH_3)CH_2OH + CH_3CH(CH_3)COOH \rightarrow$
$CH_3CH(CH_3)COOCH_2(CH_3)CHCH_3 + H_2O$
reactants [1]
products. [1]

ii number of moles of acid $= \frac{4.4}{88} = 0.05$ mol [1]

iii number of moles of alcohol $= \frac{2.96}{74} = 0.04$ mol [1]

iv number of moles of ester $= \frac{4.03}{144} = 0.028$ mol [1]

v The limiting factor is the number of moles of alcohol = 0.04 mol [1]

percentage yield $= \frac{\text{actual yield}}{\text{theoretical yield}} \times 100\%$ [1]

$= \frac{0.028}{0.04} \times 100\% = 70\%$ [1]

d use the combined gas equation, $PV = nRT$, so $n = \dfrac{PV}{RT}$ [1]

$n = \dfrac{1\times10^5 \times 82.3\times10^{-6}}{8.314\times400}$ [1]

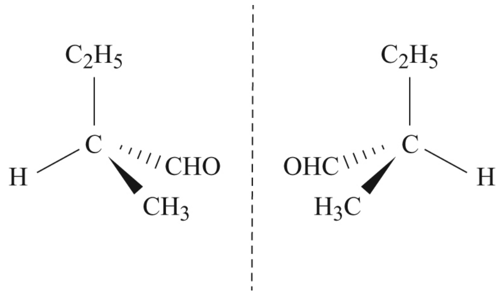
$= 2.47 \times 10^{-3}$ mol [1]

mass $= n \times M_r = 2.47 \times 10^{-3} \times 72 = 0.178$ g [1]

2 **a** $CH_3CH_2CH_2CH_2CHO$, pentanal [1]
$CH_3CH_2CH(CH_3)CHO$, 2-methylbutanal [1]
$CH_3CH(CH_3)CH_2CHO$, 3-methylbutanal [1]
$(CH_3)_2C(CH_3)CHO$, 2,2-dimethylpropanal [1]
$CH_3COCH_2CH_2CH_3$, pentan-2-one [1]
$CH_3CH_2COCH_2CH_3$, pentan-3-one [1]
$CH_3COCH(CH_3)CH_3$, 3-methylbutan-2-one [1]

b pentan-2-one [1]
3-methylbutan-2-one [1]
both compounds contain the $CH_3–C=O$ group [1]

c 2-methylbutanal [1]
[2]



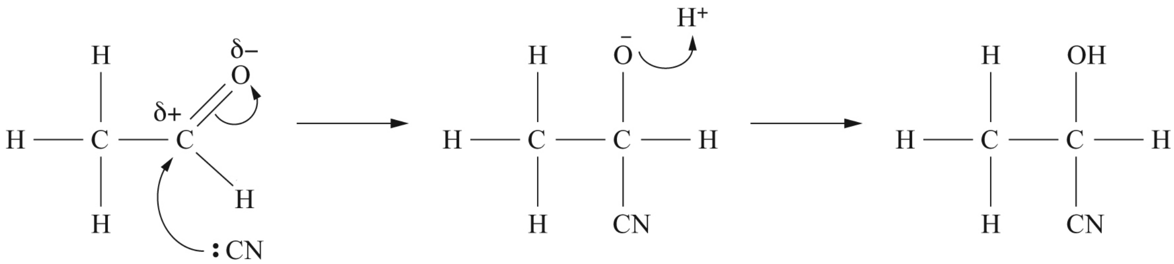
It contains a chiral carbon. [1]

d **i** Warm the substance with Tollen's reagent/ammoniacal silver nitrate solution. [1]
If a silver mirror is formed then the substance is the aldehyde
(if not, then it is the ketone). [1]
or Heat with Fehling's solution, brick-red precipitate formed shows aldehyde present
(if not, then it is the ketone).

ii Add the unknown compound to a solution of 2,4-dinitrophenylhydrazine [1]
filter the (orange) precipitate formed [1]
recrystallise and filter again [1]
dry (the residue) [1]
determine melting point and compare with literature value. [1]

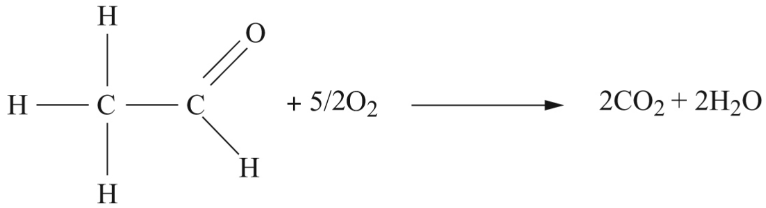
3 **a** **Warm** the compounds with alkaline solution of iodine. [1]
The propanal will not give yellow precipitate of triiodomethane (iodoform) because it does not contain the $CH_3–C=O$ group, unlike ethanal and propan-2-one. [1]
Warm the other two compounds with Tollens reagent. [1]
If silver mirror obtained [1]
then the compound is ethanal, if not, then propanone. [1]
or Heat with Fehling's solution; if brick red precipitate formed then the compound is ethanal. If not, then propanone.

b



dipoles on starting material [1]
curly arrows on starting material [1]
intermediate ion [1]
curly arrow on intermediate ion from lone pair on oxygen to H^+ [1]
correct product [1]

c **i**



bonds broken are 4 × C–H, 1 × C–C, 1 × C=O, 2.5 × O=O [1]
total change in energy = 4 × 410 + 1 × 350 + 1 × 740 + 2.5 × 496 = +3970 kJ mol^{-1} [1]
bonds made are 4 × C=O + 4 × O–H [1]
total change in energy = –4 × 805 – 4 × 460 = –5060 kJ mol^{-1} [1]
overall energy change = +3970 – 5060 = –1090 kJ mol^{-1} [1]

ii The values for the bond energy used are **average** values. [1]
They do not account for the different environments inside molecules; hence the discrepancy. [1]