Trial Exam

2011 Unit 3 VCE Solutions

1.	●	B	C	D	**16.**	A	B	●	D
2.	A	B	C	●	**17.**	A	B	C	●
3.	●	B	C	D	**18.**	A	●	C	D
4.	●	B	C	D	**19.**	A	B	●	D
5.	A	B	C	●	**20.**	●	B	C	D
6.	A	B	●	D	**21.**	A	●	C	D
7.	A	●	C	D	**22.**	A	●	C	D
8.	A	B	C	●	**23.**	A	B	●	D
9.	●	B	C	D	**24.**	A	B	●	D
10.	●	B	C	D	**25.**	●	B	C	D
11.	A	B	●	D					
12.	A	B	C	●					
13.	A	●	C	D					
14.	A	●	C	D					
15.	●	B	C	D					

Circle the correct response to each question on the answer sheet.

SECTION B –Short answer questions

Question 1

The amount of vitamin C in a brand of orange juice can be determined by titration with a standard iodine solution. Iodine reacts with vitamin C according to the equation below.

$$C_6H_8O_6\,(aq) + I_2(aq) \Rightarrow C_6H_6O_6\,(aq) + 2H^+(aq) + 2I^-(aq)$$

A 25.00 mL sample of juice is placed in a 250 mL volumetric flask and made to the mark with distilled water. 20.00 mL aliquots are then placed in a conical flask and titrated against a 1.45 X 10^{-3} mol/L I_2 solution. Four titrations are carried out and the results recorded in the table below.

	1	2	3	4
Titre	18.95	19.05	18.99	17.01

a) Write a balanced half equation for the oxidation of vitamin C.

$C_6H_8O_6(aq) \rightarrow C_6H_6O_6(aq) + 2H^+(aq) + 2e^-$

b) What is the average titre?

17.01 is non-concordant $\Rightarrow$ ave titre = (18.95 + 19.05 + 18.99)/3 = 19.00 mL

c) Calculate the amount, in mol, of vitamin C present in the 20.00 mL aliquot.

$n(vit.\ C) = n(I_2) = 0.00145 \times 0.019 = 2.76 \times 10^{-5}$ mol

d) Calculate the amount, in mol, of vitamin C in the original orange 25.00 mL sample.

$n(25\ mL) = n(volumetric\ flask) = (2.76 \times 10^{-5}) \times (250/20) = 3.45 \times 10^{-4}$ mol

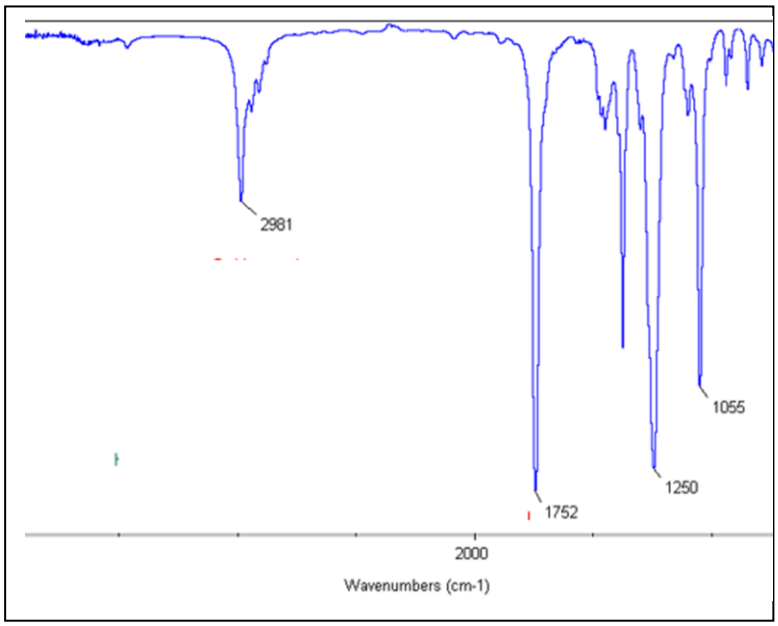
e) Calculate the concentration, in grams/Litre, of vitamin C in the original juice, to the right number of significant figures.

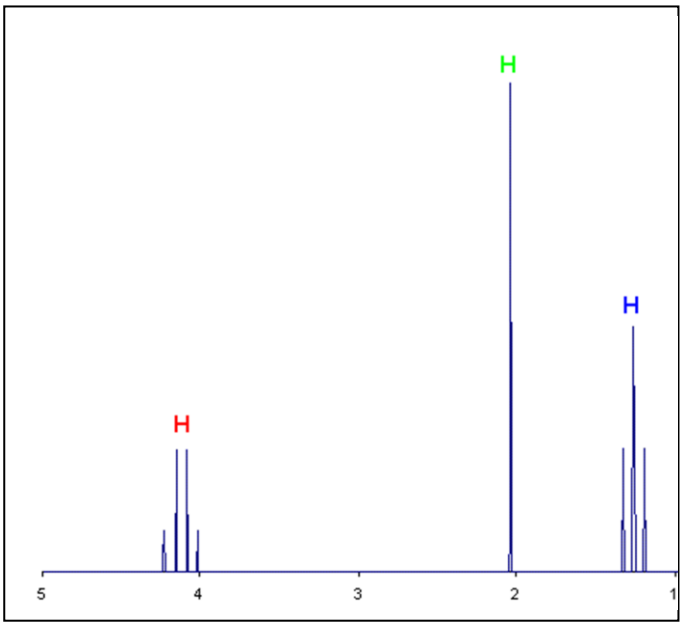
$mass(vit.\ C) = (3.45 \times 10^{-4}) \times [(6 \times 12) + (8 \times 1) + (6 \times 16)] = 0.0607$ g

g/Litre =0.0607/0.025 = 2.43 g/L

Question 2

A molecule with the formula $C_4H_8O_2$ is analysed using IR spectroscopy and ^1H NMR spectroscopy as shown below.

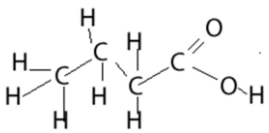




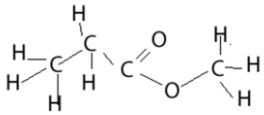
Analysts suspect the presence of three isomers. Isomer "A" reacts with Na_2CO_3 to produce carbon dioxide while isomer "B" and "C" are synthesised when a primary alcohol and a carboxylic acid react.

a) Draw the structural formulae of the three isomers, showing all bonds.

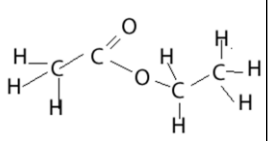
Isomer A



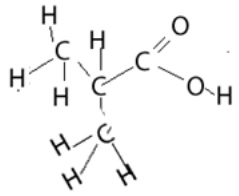
Isomer B

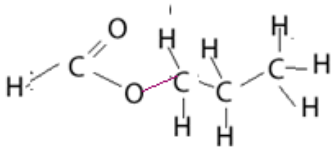


Isomer C



Other possible isomers exist and include 2-methyl propanoic acid and propyl methanoate





b) i) Consider the IR spectrum of this molecule. What bond is indicated at wavenumber 1752? ***C=O bond***

ii) The IR spectrum can be used to exclude which isomer ?

Since there is no acidic O-H bond present we can discount the carboxylic acid.

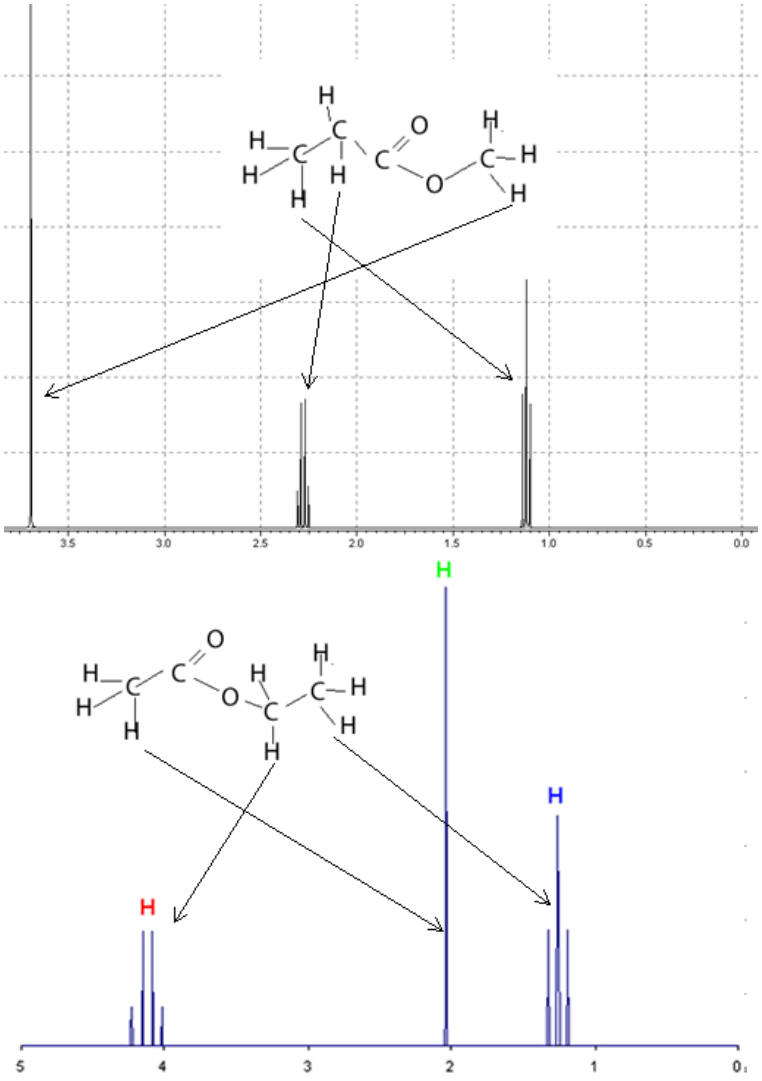
c) i) Which alkyl group gave rise to the triplet in the ^{1}H NMR spectrum?

The CH_2 group gave rise to the triplet

ii) Which alkyl group gave rise to the quartet in the ^{1}H NMR spectrum?

The CH_3 group gave rise to the quartet.

d) Using your knowledge of *chemical shift, nuclear shielding* and the ^{1}H NMR spectrum above identify the isomer present. Give a reason



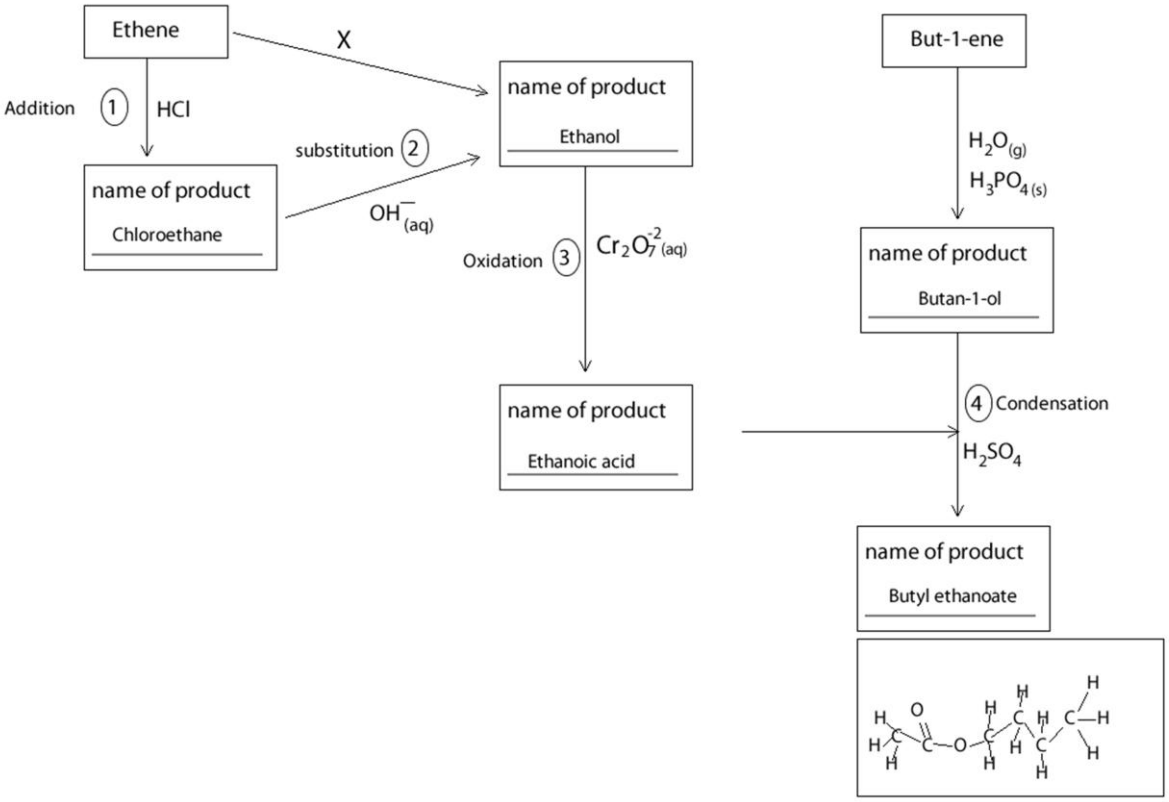
Hydrogen atoms near electronegative atoms such as oxygen experience a reduced nuclear shielding. Their splitting pattern is chemically shifted to the left of the spectrum.

Consider the methyl (CH_3) group next to the oxygen in methyl propanoate (top diagram). It is next to an oxygen and its splitting pattern (singlet) is shifted well over to the left.

Notice the difference in the NMR spectra of both isomers.

In the NMR spectrum of ethyl ethanoate the splitting pattern (quartet) of the CH_2 next to the oxygen is shifted far to the left.

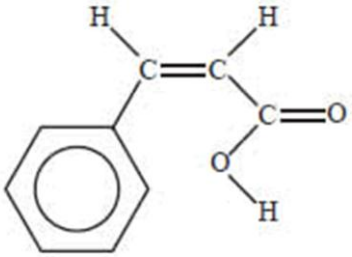
Question 3



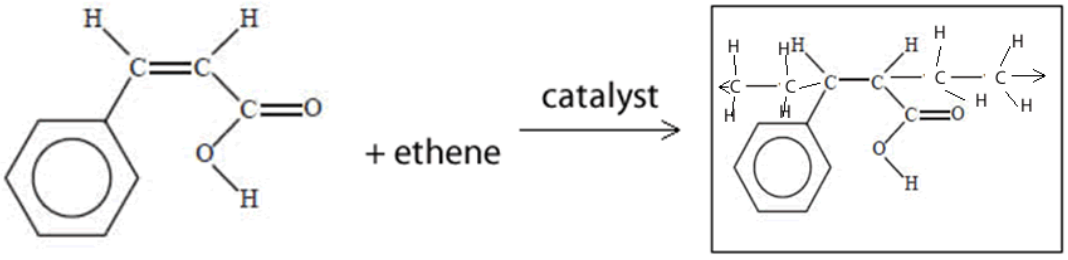
a) Fill the boxes on the diagram above.

b) Using the words , condensation, addition, oxidation, reduction, or substitution label the numbered reactions.
Answers in the diagram above.

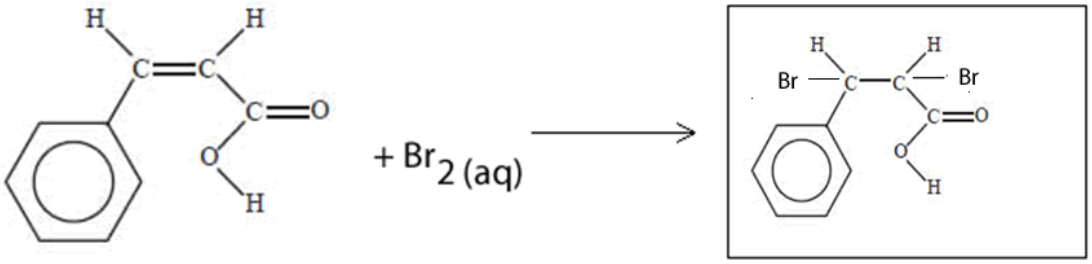
c) Cinnamic acid is an organic acid that contributes to the flavour of cinnamon. Its structure is shown below. Draw structural formulae for the organic products and chemical formulae for all other products formed in the following reactions.



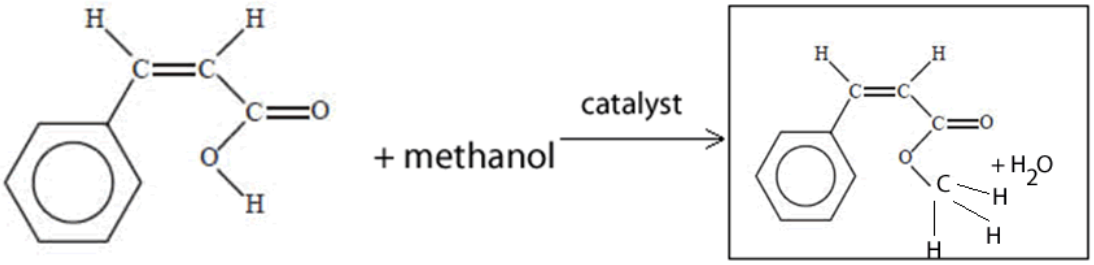
i)



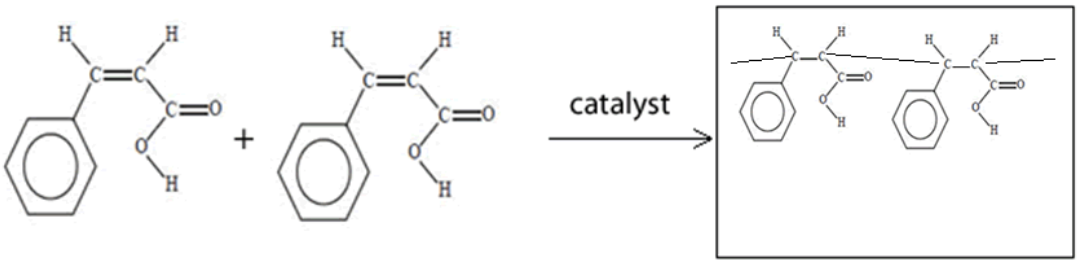
ii)



iii)



iv)



d) Ethanol is a carbon neutral source of energy. It is formed naturally from glucose, a product of photosynthesis, during which carbon is reduced from an oxidation state of +4 to 0.

i) What is meant by the term carbon neutral?

The burning of this fuel produces zero net carbon dioxide in the atmosphere.

ii) Give three balanced equations of reactions that show ethanol as being carbon neutral

a) Production of glucose through photosynthesis

$6CO_2(g) + 6H_2O(l) \Rightarrow C_6H_{12}O_6(aq) + 6O_2(g)$

b) Production of ethanol in fermentation

$C_6H_{12}O_6(aq) \Rightarrow 2C_2H_6O(aq) + 2CO_2(g)$

c) Complete combustion of liquid ethanol

$C_2H_6O(l) + 3O_2(g) \Rightarrow 2CO_2(g) + 3H_2O(g)$

d) How many CO_2 molecules are consumed per glucose molecule? ***6***

e) How many CO_2 molecules are produced per glucose molecule in the formation and burning of ethanol?

2 in the conversion of glucose to 2 molecules of ethanol and 2 for the combustion each molecule of ethanol for total of 6.

Question 4

0.415 g of a pure acid, $H_2X(s)$, is added to exactly 100 mL of 0.105 M NaOH(aq). A reaction occurs according to the equation

$H_2X(s) + 2NaOH(aq) \rightarrow Na_2X(aq) + 2H_2O(l)$

The NaOH is in excess. This excess NaOH requires 25.21 mL of 0.197 M HCl(aq) for neutralisation. Calculate

This question appeared in the 2008 VCE exam Unit 3

i. the amount, in mol, of NaOH that is added to the acid H_2X initially.

$n = C \times V = 0.1 \times 0.105 = 0.105$ mol

ii. the amount, in mol, of NaOH that reacts with the acid H_2X

$NaOH(aq) + HCl(aq) \Rightarrow NaCl(aq) + H_2O(l)$ HCl and NaOH react in a 1:1 ratio.

Mol of excess NaOH = 0.197 X 0.02521 = 0.00497 mol
Mol of NaOH reacted = 0.105 – 0.00497 = 0.00553 mol

iii. The molar mass, in g/mol, of the acid H_2X.
Knowing the mol of NaOH we can find the mol of H_2X.
mol H_2X = ½ mol of NaOH
=> n(H_2X) = ½ X 0.0053 = 0.002765 mol
Now the molar mass = mass/mol = 0.415/0.002765 = 150 g/mol

Question 5

Potassium permanganate ($KMnO_4$) is a strong oxidant. In a certain reaction 1.67 grams of chromium(II) sulphate reacted exactly with 37.60 mL of 0.247 M $KMnO_4$. During this reaction the Cr^{2+} ions were oxidised to Cr^{3+}.

a) To what oxidation state was Mn^{7+} converted to?

The number of electrons given up by the reductant, $Cr^{3+}$is equal to the number of electron taken up by the oxidant Mn^{7+}.

The oxidation reaction is as follows.
$Cr^{3+}(aq) + e => Cr^{2+}(aq)$

Mol of electrons = mol of Cr^{3+} ions. = 1.67/60 = 0.0278

Now the mol of Mn^{7+} ions = C X V = 0.247 X 0.03760 = 0.00929 mol
So the ratio of Mn^{7+} : electrons
= 0.00929 : 0.0278
= 1: 3

So for every one mol of Mn^{7+} we need three mol of electrons.
$Mn^{7+}(aq) + 3e => Mn^{4+}(aq)$

b) MnO_4^- is used as an oxidant to convert propan-1-ol, in solution, to propanoic acid and in the process forming Mn^{2+} ions.
   i) Give the oxidation half equation for this reaction.
   $H_2O(l) + C_3H_8O (aq) => C_3H_6O_2 (aq) + 4H^+(aq) + 4e$
   ii) Give the reduction half equation for this reaction.
   $5e + 8H^+(aq) + MnO_4^-(aq) => Mn^{2+} (aq) + 4H_2O(l)$
   iii) Give the balanced overall equation for this reaction

$12H^+(aq) + 5C_3H_8O (aq) + 4MnO_4^- (aq) => 4Mn^{2+}(aq) + 11H_2O(l) + 5C_3H_6O_2 (aq)$