FUNDAMENTALS OF CHEMISTRY 1B (CHEM1002) - November 2009

2009-N-2

- A: solid B: liquid C: gas

  100 °C and 1 atm

  The air pressure is lower at 6000 m than at sea level. The boundary line between regions B and C shows that lowering the pressure lowers the boiling point. If the temperature is lower, a longer period of time is required to effect the same level of cooking.

  The equilibrium line between the solid and the liquid (represented by the line between regions A and B) slopes to the left. If you begin in the solid region close to this line and you increase the pressure, you will cross the line vertically and go into the liquid region. As the liquid is more stable at higher pressure, it must be more dense than the solid.

2009-N-3

- As more electrons get added to the same electron shell with the increase in atomic number, the effective nuclear charge increases. The electrons therefore get attracted more strongly and the radius decreases.

  As the electrons get held more strongly, there is a gradual change from metallic to non-metallic behaviour. The smaller atoms attract additional electrons more strongly and have a higher electronegativity.

- H^+ (i.e. a proton)

  The weaker the acid, the stronger the conjugate base. $K_a \times K_b = 10^{-14.00}$

acid	base
H_3PO_4	$H_2PO_4^-$
H_2CO_3	HCO_3^-
$H_2PO_4^-$	HPO_4^{2-}

2009-N-4

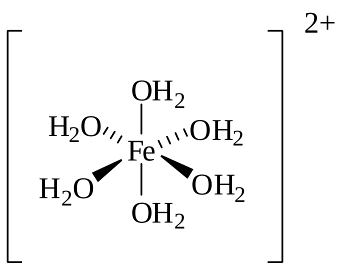
- The endpoint is where the indicator changes colour and the reaction is observed to be completed. The equivalence point is where equal amounts of acid and base have been added. Ideally, the endpoint and equivalence point should be as close to one another as possible.

  Place a known volume (*eg* 25.00 mL) of the weak acid solution in a conical flask and add 2 drops of phenolphthalein indicator.
  Titrate with a known concentration of the strong base from a burette until the end point (first permanent pink colour). Record volume used.
  The equation of the reaction must be known
  eg $H_2A(aq) + 2OH^-(aq) \rightarrow A^{2-}(aq) + H_2O$
  Calculate the moles of OH^- used.
  Hence calculate the moles of weak acid present in 25.00 mL.
  Hence calculate the moles of weak acid present in 1000.00 mL (i.e. its concentration).

2009-N-4 (cont.)

Titrate the weak acid past its equivalence point with a strong base, recording the pH as you go.
Construct a graph of mL base added *vs* pH. This is a titration curve.
Determine the volume of base required to reach equivalence point (where slope of line is vertical).
Divide this value by 2 to give the half equivalence point (where [HA] = [A^-]).
Read the value of the pH at the half equivalence point from the titration curve.
From Henderson-Hasselbalch equation, this is the point where pH = pK_a.

2009-N-5



Fe(II) has 6 *d* electrons arranged in the 5 available *d* orbitals as shown below.

↑↓	↑	↑	↑	↑

Paramagnetism occurs whenever there are unpaired electrons.

Fe^{2+} has a reasonably high charge density and this polarises the Fe–OH_2 bonds. This in turn weakens the O–H bonds and leads to H^+ being released.

$$[Fe(OH_2)_6]^{2+} + H_2O \rightleftharpoons [Fe(OH)(OH_2)_5]^{+} + H_3O^{+}$$

2009-N-6

- 0.3 mg (1 significant figure)

2009-N-7

- pH = 8.22

Therefore pOH = 14.00 – 8.22 = 5.78

Therefore [OH^-] = $10^{-5.78} = 1.7 \times 10^{-6}$

2×10^{-22} M

CO_2 dissolves in water to give acidic solution that reacts with OH^- ions.

$$2OH^-(aq) + CO_2(aq) \rightarrow CO_3^{2-}(aq) + H_2O$$

From Le Chatelier's principle, the decrease in [OH^-] will result in an increase in [Fe^{3+}].

2009-N-8

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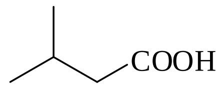
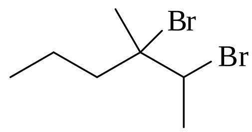
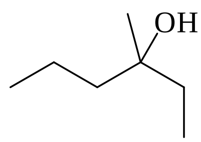
3-methyl-1-butanol

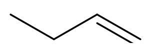


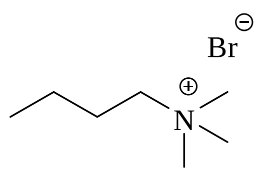


(*Z*)-3-methyl-2-hexene



1-bromobutane





2009-N-9

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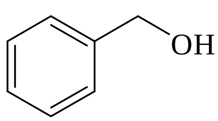
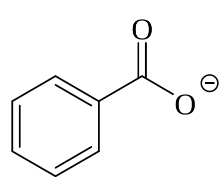
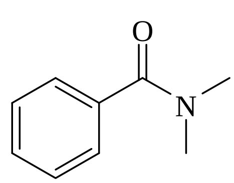
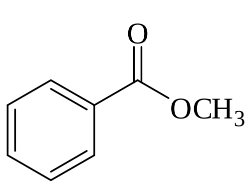
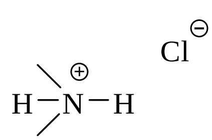




$SOCl_2$



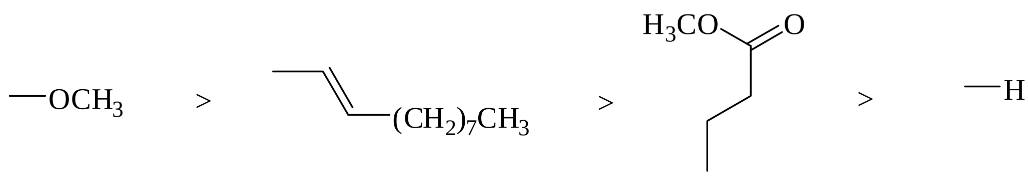




2009-N-10

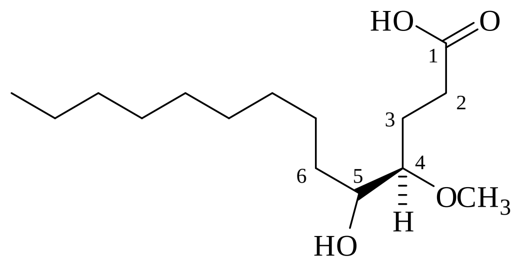
- $C_{16}H_{30}O_3$

  (*Z*)

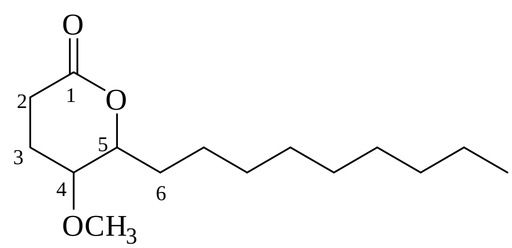
  

  (*R*)

  The 4 M H_2SO_4 catalyses 2 reactions; hydrolysis of the ester to a carboxylic acid and addition of water across the C=C double bond to give the following intermediate.

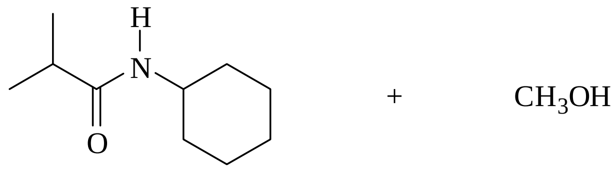
  

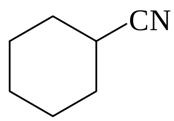
  This intermediate can undergo an intramolecular esterification (the OH on carbon 5 reacts with the carboxylic acid group at carbon 1) to give the cyclic ester (**Y**).

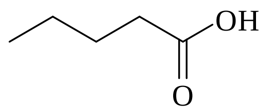
  

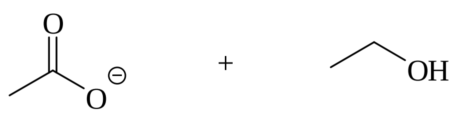
  4 (There are stereogenic centres at C4 and C5.)

2009-N-11

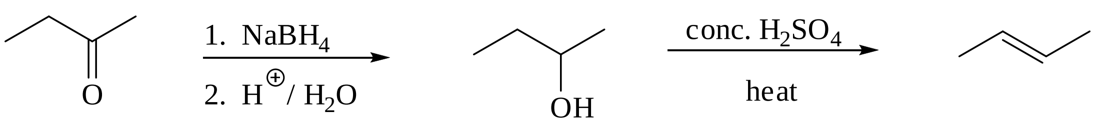
- 







2009-N-12

- 

The starting material absorbs strongly in the 1650-1800 cm^{-1} region.
The intermediate alcohol absorbs strongly in the 3000-3300 cm^{-1} region.
The product does not absorb strongly in either of these regions.

The product is symmetrical and has only 2 resonances. The starting material and the intermediate both have 4 resonances, but the chemical shifts will differ: the carbonyl C in the starting material is at 180-200 ppm while the C–OH carbon is at approx. 50 ppm.