Year 2, Organic Chemistry, Chapter 27:
A Couple of Suggestions

- If you want to be successful in whatever career you choose, then you need to start by getting the highest grades that you are capable of getting in your ‘A’ Levels – and I am committed to getting you the highest grades that you can get in ‘A’ Level Chemistry.

- There are two elements to getting a good grade in Chemistry viz. (A) understanding what is happening (and that is what this book is about, and all textbooks are about) and (B) learning all the tricks that will get you as many marks as possible – and it this latter point that I will address here.

A) Understanding what is going on

- I would suggest that when you reach the end of each Chapter in whatever textbook is recommended by your Exam Board, then you go through the Chapter and make very short notes on the important points in the Chapter. By doing that, when you get to the exams themselves, you can just look through your notes rather than having to read the whole textbook again.

B) Tricks to score very marks

B1) Reaction Equations

- I will, at later date, talk about exam technique, but here I want to draw your attention to the fact that if you go through the Marking Schemes for past papers from your Exam Board, then you will see that one (or more) marks is/are awarded for providing an appropriate/correct Reaction Equation for every question. It is possible to score a good 20% of the marks just by providing the right Reaction Equations.

- The Exams Boards do this for three reasons: (a) because they know that not all UK students have a good mastery of the written language, (b) because an appropriate/correct Reaction Equation demonstrates an understanding of what is happening, and (c) because they have to take into account the fact that students in other parts of the world could be sitting their exams, and they may not speak English very well – and a Reaction Equation demonstrates a grasp of the reactions involved.

- On page 4 I have written the equations for the reactions of Carboxylic Acids, and as soon as I have done so you will see that (ignoring explanatory comments) in no more than 10 lines (**TEN LINES**) you can sum up everything that you need to know about Carboxylic Acids at ‘A’ Level. If you have understood the Chemistry that underlies the equations, then this is an enormously efficient way of **summarising** the understanding that you have acquired.

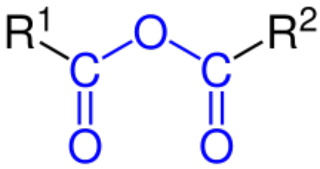
B2) Information Trees

- A second little trick is to construct an Information Tree for every group of Chemicals that you are required to know at 'A' Level. The creation of Information Trees is a very common practice in the scientific world, and I have done this for you (wherever feasible) both last year and this year. Please make sure that you have one for every single substance that you are studying viz. Alcohols/ Halogenoalkanes/Aldehydes/Ketones/etc. You can use my trees, or you can create your own.

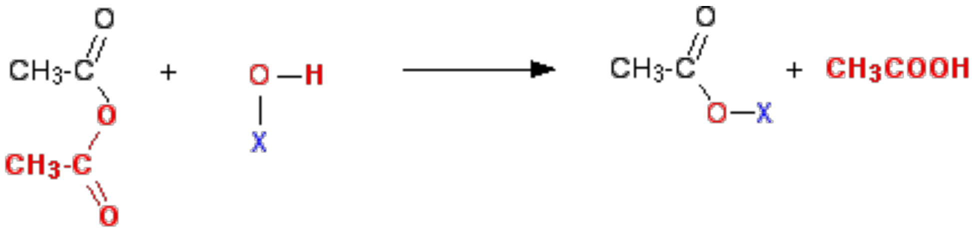
C) The writing of formulae

- Some of the compounds that are dealt with at 'A' Level are rather (and sometimes very) complicated – and I find that writing them the way that they are written officially does not really convey an adequate understanding of what is involved in the molecule. Drawing the skeletal formula of the molecule can be much more explanatory, but this can take up a lot of space.

- For instance, if you were making notes about Acid Anhydrides, the generic formula for Acid Anhydrides is $(RC(O))_2O$ – and quite frankly that conveys nothing at all to me. The skeletal formula (the one below is from Wikipedia, but it is a conventional depiction where R_1 and R_2 can be any legitimate species)[1] conveys much more information



- The molecule on the left below (from Jim Clark's excellent website "chemguide") is called Ethanoic (or Acetic) Anhydride (and the diagram as it is shown depicts the formation of Ethanoic Acid through its hydrolysis by Water).



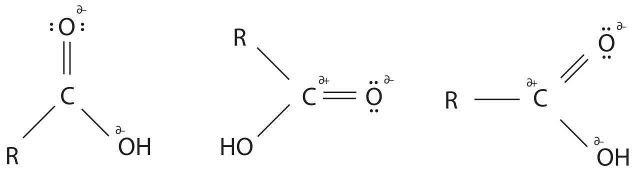
- However, it is not always possible to draw skeletal formulae.

- For my own notes therefore, I have developed my own way of writing formulae – and I would suggest that you create your own also. Let me show you how I do it.

[1] I would advise you not to write "R^2" / "R^3" / etc because this looks as though you are talking about "squares" / "cubes" / etc. Use R_1 / R_2 / and so on.

C1) Writing the formulae for Carboxylic Acids and their derivatives

- I remind you that these are the skeletal formulae for the depiction of a Carboxylic Acid



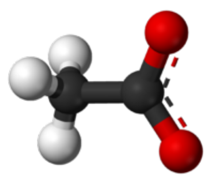
and as you can see this not exactly the easiest way of drawing the Acid.

- My way of writing the formulae for Carboxylic Acids and their derivatives (and I stress that this is *my way*, and that you should develop your own way) is
  R.C=O(OH) where "R" can be any legitimate species
  "C=O" is a Carbon atom double-bonded to an Oxygen atom,
  and the species in brackets will vary according the molecule concerned and it is bonded to the same C atom that is double-bonded to the Oxygen atom. It is in brackets to indicate that it is bonded to the Carbon atom that has the Carbonyl "C=O" species bonded to it.

- This will therefore give
  R.C=O(H) Aldehyde
  R.C=O(Cl) Acyl Chloride/Acid Chloride
  R.C=O(NH_2) Amide
  R.C=O(OR) Ester
  and you can see that the "R.C=O" (the "R" species bonded to a C atom that is double-bonded to an O atom) remains the same for whatever derivative I have looked at.

- There are a couple of other species that I could have included viz.
  R.C=O The Acyl Group (the generic root for all the Carbonyl compounds)
  R.C=O(O^-) Acetate/Acylate/Carboxylate anion

- The Acetate/Acylate/Carboxylate anion **R.C=O**(O^-)



is common to many of the Carbonyl species.

- Other than for the table showing the reaction equations for Carboxylic acids on page 4, let us move on to Organic Synthesis.

‘A’ LEVEL REACTION EQUATIONS FOR CARBOXYLIC ACIDS

(Modestly simplified equations. Create your own equations for **YOUR** Exam Board. **Please use in conjunction with my info tree on Carboxylic Acids.**)

R.COOH = Carboxylic Acid / R.C=O(H) = Aldehyde / R.C=O(R') = Ketone / R.C=O(Cl) = Acyl Chloride / R.C=O(O–O=C.R') = Acid Anhydride / $R.CH_2OH$ = Alcohol.
NB A Nitrile = R.C≡N / An Am**ide** = $R.C{=}O(NH_2)$ / An Am**ine** = $R.NH_2$.
“Reflux” indicates that the reaction takes a long time and therefore needs to be speeded up/or that it requires a considerable amount of energy to take place.
A precipitate is shown as (s).

A) Routes INTO a Carboxylic Acid (the reactions of Carboxylic acids as ordinary acids are not shown here)

Ketones do not oxidise under gentle oxidisation (nor do 3˚ Alcohols)

FROM	REACTION CONDITIONS	REACTION EQUATION (phases/states not always known therefore not included / **non-organic products not always shown**)	Comment
1˚ Alcohol	conc. H2SO4 / $Cr_2O_7^{2-}$	$R.CH_2OH + 2[O] \longrightarrow R.COOH + Water$	Orange to green
2˚ Alcohols oxidise into Ketones but NOT into Carboxylic Acids (other than with aggressive oxidising agents such as MnO_4^-).			
3˚ Alcohols do not oxidise with gentle oxidising agents.			
Aldehydes	conc. H2SO4 / $Cr_2O_7^{2-}$/heat	$R.C{=}O(H) + [O] \longrightarrow R.COOH$	
Aldehydes	Tollen’s ($[Ag(NH_3)_2]^+$)	$R.C{=}O(H) + [Ag(NH_3)_2]^+[NO_3]^- \longrightarrow R.COOH + Ag(s) + NH_3(g)$	Silver ppt
Aldehydes	Fehling’s (Cu^{2+}/tartarate/OH^-/in situ)	$R.C{=}O(H) + Cu^{2+} + OH^- \longrightarrow R.COOH + Cu^{1+}$	Blue to coppery-red
Aldehydes	Benedict’s (Cu^{2+}	$R.C{=}O(H) + Cu^{2+} + OH^- \longrightarrow R.COOH + Cu^{1+}$	Blue to coppery-red
$CH_3.C{=}O(R)$	Iodoform test for Ketones ($+I_2/OH^-$)	$CH3.C{=}O(R) + 3I_2 + 4OH^- \longrightarrow H.COOH + CHI_3(s)$	Hydrolysis
If Cl_2 were used instead of I_2, then Chloroform ($CHCl_3$) would be obtained instead of Iodoform (CHI_3).			
Nitriles	dilute H^+ or dilute OH^-/heat	$RC{\equiv}N + 2H_2O(l) + HCl(aq) \longrightarrow R.COOH + NH_4Cl(g)$ (if NH_3 if OH^- is used)	
Acyl Chloride	+ H_2O/pyridine as solvent	$R.C{=}O(Cl) + H_2O(l) \longrightarrow R.COOH + HCl$	very violent reaction
Acid Anhydride	+ H_2O/pyridine as solvent	$(R.C{=}O)_2.O + H_2O(l) \longrightarrow$ 2 lots of R.COOH	very violent reaction

A) Routes OUT OF a Carboxylic Acid

TO	REACTION CONDITIONS	REACTION EQUATION (phases/states not always known therefore not included / non-organic products not always shown)
1˚ Alcohol	Reduce with $NaBH_4$ or $LiALH_4$	$R.COOH + 4H^+ + 4e^- \longrightarrow R.CH_2OH$
Ester	+ Alcohol (conc. H2SO4 as a catalyst/heat)	$R.COOH + R'.CH_2OH \longrightarrow R.C{=}O(O.R')$ The R' comes from the Alcohol
Amide	+ R'.NHH/heat	$R.COOH + R'.NHH \longrightarrow R.C{=}O(R'NHH)$
Acyl Chloride	PCl_5 / OH^-	$R.COOH + PCl_5(s) \longrightarrow R.C{=}O(Cl) + POCl_3(l) + HCl(g)$
Acid Anhydride	H^+ / heat	$2(R.COOH) \longrightarrow R.C{=}O\text{-}O\text{-}O{=}C.R + water$

That is it chaps. The last two years have sped by very quickly. I have watched you develop from children into adults in two short years. Some of you have made that transition extremely well, but some of you still need to make that transition.

When I went to University I was ill-prepared for the mental transition that everybody needs to make to move from an environment where you are **taught** to an environment where you **learn** and teach yourself, but I hope that I have encouraged you sufficiently to develop in yourself the skills to make that transition better than I did. In the end, when I was at University I went to bed as a child one night and woke up the next morning as an adult (i.e. someone who is responsible for her/his own actions) – and after that everything became easier (*not easy, just easier*).

If you want to make it easier for yourself, then go back and read the Introduction to this book where I told you two years ago how to study, and if you want to have a happy and successful life then read the bits that I started the Introduction with concerning **happiness** and **success**.

Happiness comes from inside you. **It is all about fulfilling your own potential.** You can be the happiest person in the world being a road-sweeper if that is what you are cut out to be, and you can be the unhappiest person in the world being a doctor/dentist/whatever because you have not done what you were capable of doing.

My last word on happiness and success is heavily influenced by my own life-experiences. On the third day of my very first term at University I met a girl who turned out to be the nicest human being that I ever met in my whole life[2]. Four days later I asked her to marry me, and we then spent 50 deliriously happy years together until she died of cancer 10 months short of our 50th anniversary. I personally would say that the touchstone of happiness is to find someone whom you absolutely adore and who absolutely adores you, and then spend your whole lives loving each other. Sadly one of you will die first and leave the other bereft – but, my God, in the intervening years you will have had the most fantastic life that any human being could possibly have.

Good luck. I wish each and every one of you a Happy and a Successful life.

[2] To show you how nice she was, let me tell you two things about her:
i) Even though we were English and Roman Catholics she brought up six Afghan Muslim refugees after we (the British) invaded and destroyed Afghanistan. When the Russians invaded and occupied Afghanistan, 2 million brave Afghan men and boys acted as our 'cat's-paw' and were either killed or wounded resisting the Russians, but as soon as Osama Bin Laden *(a Saudi-Arabian)* fell out with the Americans and committed the atrocity of the Twin Towers in New York, instead of sending in their Special Services to kill Osama Bin Laden, the Americans in a vicious act of revenge **invaded and destroyed the whole of Afghanistan**! Can you believe that!
ii) For her 40th birthday I said to her "I am going to take you on Concorde to New York/we will spend the weekend there/and get Concorde back to London" to which she replied "Would you mind if we didn't do that?", so I said "No, no, of course not. I tell you what. Let's get the Orient Express down to Venice and stay in Harry's bar for the weekend, and then get the Orient Express back", and she said "Would you mind if we didn't do that?" and I said "No. no of course not. What would **YOU** like to do?" and she replied " If I made us some sandwiches and a flask of coffee, would you take me to London Zoo?" – and that is how we spent her 40th birthday. We had a fantastic time just holding hands and looking at all the animals. Money meant nothing to her. Love was the only thing that mattered to her.