Part II Exam Questions Reports 2018/19 *(incomplete)*

Paper 1

Q1

This was a straightforward question which required electron counting of both main group and transition metal fragments; two of the main concepts of the course. Most students did well with many getting full marks. **The average mark was 4.2.**

Those that lost marks simply made counting errors so were unable to provide an accurate prediction of the structure.

Q2

This short answer question proved to be trickier than Q1. Few students obtained full marks **and the average was lower (3.6/5).**

Most students were able to rationalise why a bridging hydrogen is more acidic than a terminal one. Some lost half a mark for failing to provide an explanation for why this is.

The application of Wade's Rules needed in part ii) proved straightforward for most students. Those that lost marks made small slip ups such as including the wrong number of phosphine ligands on the copper, or failing to actually count electrons in order to predict the structures and instead simply drawing a structure without any evidence of electron counting.

The final part of the question was the sting in the tail here. There are a number of ways this metalloborane could be interpreted and, depending on how this is viewed, a number of plausible ways to count electrons for the complex (i.e. is the bonding delocalised w.r.t. the borane or is the borane providing localised electrons for the metal centre). One mark was available for this part of the question and this was awarded for any sensible interpretation. Many students were put off this part of the question completely and didn't comment.

Q3

This was generally answered extremely well and given it was a simple recall and application of the same metal-metal multiple bonding situation as had been described in lectures, showed that candidates had studied the material thoroughly. It was therefore marked very strictly.
The first situation was a triply-bonded tungsten dimer. Most candidates recognised that three groups on each metal would not allow d_{xy} orbitals to be used in M-M bonding. Only the correct form of the MO diagram was given credit. Marks awarded for correct MO diagram and bond order.
The second example had a quadruple bond. Nearly all candidates could identify that the bridging ligands were monoanionic, therefore could work out the oxidation state and number of bonding electrons in the MO diagram.

A mark was awarded for showing the metal d-orbitals forming each bonding interaction.

Q4
The question was generally answered well with clear explanations, although many candidates neglected to give a brief explanation as to why a half-filled subshell is favourable so that their answers lacked some scientific rigour.

Q5
Well answered: with majority of answers disconnecting via a C_2 fragment introduced by epoxide or aldehyde alkylation. The isopropyl group was disconnected via conjugate addition. **Mean = 3.4**

Q6
Very well answered, with most of the answers showing good recall of the use of a activating group, double alkylation and decarboxylation (good recall of mechanisms). **Mean = 3.8**

Q7
Slightly less well answered with a wide spread of scores (surprising given that it is almost identical to a problem sheet example). Two approaches taken: standard lactone disconnection back to a 1,5 -dicarbonyl or initial methyl disconnection leaving a simple lactone. **Mean = 3.2**

Q8
Well answered, with majority of answers using ozonolysis to cleave the alkene ring junction and standard chemistry to remove a C=O (Clemmensen, Wolff-Kishner or Thioacetal).
Mean = 3.4

Q9
This question was answered well on the whole: **the average mark achieved was 13/20.** Students struggled with the aspects which relied on them having learnt certain aspects of the notes (the reaction schemes in part (a i) and illustrating the antibonding orbitals of $[B_6H_6]^{2-}$ in part (a ii), however, students fared better on applying the concepts of the course in the remaining sections of the question.

(a) Most students were able to suggest a synthesis of BH_3(THF) and roughly 65% of students also gave a plausible synthesis for Na$[B_3H_8]$.

Few students were able to give detailed descriptions of the antibonding orbitals of $[B_6H_6]^{2-}$. In fact it was this part of the whole question that caused most problems. The majority of students only obtained one mark out of four for this part. In most cases this was awarded for stating that $[B_6H_6]^{2-}$ overall has 18 bonding MOs for cluster bonding: 7 bonding MOs and so therefore 11 antibonding MOs.

(b) This section of the question was answered very well. Most students scored full marks which shows that the general concepts of the course had been understood, even for these (in some cases) challenging examples.

(c) (i) This section required a detailed analysis of the fragments present in each question. Students lost marks here by not providing enough detail – for example by simply not counting electrons for the contributing fragments.

(ii) Many students found this part challenging. Conceptually I think this was the most difficult part; many did not know how to handle the C_3H_5- fragment and so got a bit lost. Some marks were awarded for sensible counting of electrons, for any complex suggested.

(iii)Most students got full marks for identification of **C** and **D**. Marks were lost by those who again did not count electrons in order to prove the structure types (both closo in this case).

Q10 (a,b) *[5]*

Part (a) was a simple recall of the principles discussed in the lectures. It was surprising the percentage of answers that talked about metal-metal multiple bonding rather than metal-ligand multiple bonding. Of those that did discuss metal-ligand multiple bonding, all talked about having suitable π-donor ligands though not all recognised the importance of having electronegative ligands or high oxidation state metals. Although not discussed in detail in lectures, but mentioned in passing, the reverse situation of low oxidation state metals and π-acceptor ligands could also give rise to metal-ligand multiple bonds. A very few answers mentioned this as well.

Part (b) was an extension of the principles of constructing MO diagrams for M-L multiple bonds which was done in lectures with the M-O-M and O-M-O examples. Only about half of candidates made an attempt to produce an MO diagram for the five-atom O-M-O-M-O system. Marks were awarded for the diagram (including non-bonding d_{xy} orbitals) and electron occupancy. A high proportion could not determine the correct number of electrons available for bonding. Explanations for the shorter terminal bonds were good, comparing the number of bonding, non-bonding and antibonding interactions in the MO diagram.

Those who could not construct the full MO diagram described the central M-O-M unit from lectures and the terminal M-O units. Partial marks were awarded if diagrams and explanations were sensible.

Q10 (c,d: f-block)
Nearly all candidates explained clearly that the metal-ligand bonding is primarily electrostatic/ionic. The emphasis on `sublimation' in the question didn't suggest to all candidates that metal-ligand interactions are strong enough for there to be discrete `molecular' species in the vapour (like the basic zinc acetate they made last year), which made the significance of fluorination difficult to explain. For the more-challenging part (d), the candidates who thought to write a balanced equation leading to a neutral complex with a sensible Ln coordination number did well, while those who neglected this preliminary step

tended to end up with outlandish structures. The majority of candidates did not seem to be under time pressure by the end of the question although a few were clearly in difficulty.

Q11

The mean mark was **13.2/20**
No change in the published marking scheme

There were 48 first class answers but only 12 scoring above 17.
There were **5** third class answers and **2** fails (although these low scores seemed to be due to incomplete answers rather than lack of knowledge).

(a) Well answered following the expected disconnections leading to the suggested starting material. Good recall of reductive amination and methods for regioselective alkylation of unsymmetrical ketones (although many answers omitted the use of TMS-enol ethers in the S_N1 alkylation sequence).

(b) Good retrosynthesis but the soft d^1 reagent (nitromethane) given as a suggested starting material seemed to have caused confusion. Good syntheses of the substituted cyclohexanone from 1,5-dicarbonyl showing good understanding of the underlying chemistry.

Q12

The mean mark was **13.4/20**
No change in the published marking scheme

There were 56 first class answers with 10 scripts scoring 18 or above – these were excellent answers. There were 6 third class answers but no indication of running out of time on this question.

(a) Well answered. Good retrosynthetic analysis leading to alkyne addition to an enone constructed from an aldol condensation.

(b) Well answered and caused far fewer problems than anticipated !! Good retrosynthetic analysis leading to the two Diels-Alder reactions. Good recall of regio and stereoselectivity.

General comment (Qs 11 and 12)

Both questions well answered with few of the “classic” errors that have been so common in previous years. Indicates a good basic understanding of the A2 Core course.

Paper “A

Q13

The main challenge of this question was with the algebra in part (a) and with the units in both parts. A classic error was to think that the ratio of two frequencies was the same as the ratio of the two corresponding wavelengths. Generally the spread of marks was as expected

Numerical answers: $s = 2.30 \times 10^{7}$ m s^{-1} and $T = 5.65 \times 10^{5}$ K

Q14

As usual with questions of this kind, many people confused the splitting of the energy levels with the splitting in the spectrum. There was also the inevitable muddle over units and the required conversion to cm^{-1}. Oddly, a significant number of people derived (or tried to derive) the given expression for the electric field interaction energy: this was certainly not required. As ever, a well-drawn and annotated diagram was by far the best way to answer this question.

Numerical answers: 7 lines, splitting 4.48×10^{-4} cm $^{-1}$

Q15

This turned out to be very straightforward and so offered some ‘easy marks’ for many people. Many achieved 5/5

Q16

This produced rather a bimodal distribution. Those who knew how to do it got 5/5, but a significant number floundered around with units and ended up computing a quantum yield, a dimensionless ratio, which was anything but.

Q21

This should have been a straightforward question as it is straight from the notes. However, it was poorly answered. People were confused about what the spectrum actually was, referring to the O branch as ‘anti-Stokes’ scattering, muddling up the O and S branches, thinking they were P and R branches and much else besides. In the derivations requested in (b) many people forgot to include the wavenumber of the laser line or confused the signs of the terms: there was a lot of muddle in something which should have been straightforward. As a result as lot of people failed to get the assignment in (c) and this then led to problems in (d), and sometimes in (e). Partial credit was given for correct methods even if the results were wrong. The answers to (f) were on the whole garbled.

Numerical answers: a is S_1, b is S_0, c is O_2 and d is O_3; B_1 is 0.871(2) cm^{-1}; B_e is 0.889 cm^{-1} and R_e is 141 pm.

Q22

Part (a) on term symbols was generally done reasonably well, although people were generally not that careful about explaining how the value of Λ was found.

Part (b) was less well done, with much muddled thinking being evident in all parts. Much of this stemmed from not taking into account that the spectrum is in emission – resulting in lots of upside-down diagrams and arguments. A few clear diagrams would have helped enormously in many cases, as opposed to the flood of barley legible formulae which many offered. (b) (iv) was an absolutely standard piece of work, but some got in a total muddle by not remembering that the given transitions had an electronic contribution as well as a vibrational one. Overall, disappointing.

Paper 2B

Q25

This question required a direct recall of facts from the lecture and most candidates scored very well, with an average mark of 4.0/5 and several candidates giving a flawless answer. A recurrent (minor) mistake was to write down definitions of the kinetic or potential energy operators for a specific, e.g. 1D system, rather than for a "general wavefunction" as required by the question.

Q26

This question required a recall of facts from the lecture and their application in a slightly different way. Overall results were satisfactory (3.3/5 average mark); however, quite often, inaccurate, sloppy, and/or incorrectly labelled drawings were produced. For future examinations (and beyond), candidates could be advised to practice sketching functions, diagrams, etc. by hand, such that they can quickly and efficiently convey their message.

Q27

This question applied a concept taught in the lecture. Most candidates used the "box method" for determining the ground-state configuration, and around half of them easily achieved a full mark (average 4.0/5).

Q28

This question required the transfer of concepts from the lecture to an unknown system. Most candidates appeared to be familiar with the general idea but unfortunately only very few gave a fully correct answer (average mark 2.7/5). In several cases, the candidates did not recognise (or state) the basic assumptions of Hückel theory, such as the fact that all neighbouring p_z orbitals are taken to interact in the same way. Some candidates provided, without comment, the full matrix equation in which the coefficients appear as well: the latter are independent from the "alpha" and "beta" integrals.

Part II B2 – Concepts in Physical Chemistry - Symmetry and Bonding

Short Answer Questions

The average mark over the four questions is 2.9.

Question 29

Most students could successfully identify the point group of cubane. Many had difficulty forming and reducing the representation spanned by the carbon 2s orbitals. For students that did successfully answer the question, a mark was lost if there was no indication about how they reduced the representation. **The average mark was 2.31.**

Question 30

Most students successfully answered this question. Mostly marks were lost for misidentifying As2I4. **The average mark was 3.78,** which is higher than desired. However, given the question said *state* no extra marks were given for showing how the candidate determined the point group.

Question 31

Answers to this question were variable. Many students did not apply every symmetry operation; instead only applying one per class. This approach was awarded the marks for the correct method. **The average mark was 2.75.**

Question 32

Answers to this question were mixed. For part a), candidates successfully identified the unique operations; however, they often didn't show why they are unique. For part b, candidates identified they needed to relate the two symmetry operations but often didn't use $R_2 = S^{-1}R_1S$.

Q33

This question built upon the "particle in a box" concept, which is central to the lecture, and transferred it in the direction of a practical research question (the study of nanoparticles, which are sometimes approximated as a 3D "box"). The overall results were satisfactory, and it is clear that most candidates had a good working understanding of the associated concepts (e.g., the boundary conditions) and were generally well prepared. In some cases, candidates lost part marks due to what appears to have been carelessness (e.g. in writing the Hamiltonian), unfortunately. The answers to the final part of the question (f), requiring the candidates to think about a practical laboratory situation, were mostly good, although sometimes too vague ("the potential outside the box might not be infinite": yes, but why?). **The average mark was 13.5/20, with the two highest-scoring candidates achieving 17.5/20.**

Q34

This question encompassed different concepts concerning atomic and molecular orbitals. Most candidates appeared to be familiar with these concepts and the average results are good (**average 14.0/20; several first-class answers**). Occasional problems included the use of an incorrect normalisation condition for the radial function (part (c)) or issues with the calculations. The drawings of MO schemes (including that for CO) were mostly correct but sometimes not properly labelled or very hastily drawn (as were the RDFs) – it is understood that the questions are answered under time constraints, but especially then, some practice could be useful for future examinations.

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Question 35

Answers across the entire questions were well done. Most marks were lost due to a lack of detail in their answers. **The average mark was 13.4 (67 %).**

Part a i) + Part a ii)

Students answered these questions well; however, marks were lost for not indicating how the representations were reduced.

Part a iii)

Most students produced a good molecular orbital diagram for the anion. Generally, marks were lost for missing small details such as the energy axis and atomic orbital labels.

Part a iv)

Some candidates had issues calculating the number of electron but otherwise this was well answered.

Part a v)

Many students could produce an answer to this question; however, often the occupancy of the molecular orbitals wasn't included.

Part b i)

Most students successfully identified the point group of the molecule.

Part b ii)

Most students identified that the p orbitals of carbon and nitrogen had the same irreducible representations as those of the fluorines in part a). However, explanation of this fact was lacking in most cases.

Part b iii)

Students provided good molecular orbital diagrams for this question. Again, marks were lost due to missing details such as the energy axis and connectors showing which atomic orbitals are interacting.

Question 36

Across the entire question, this was answered well. Generally, marks were lost for a lack of detail in their answers. Most candidates supplied an answer suggesting the timings were good. **The average mark was 13.3 (67 %).**

Part a)

Students were expected to be familiar with the molecular orbital diagram for octahedral complexes and be able to reproduce it. Marks were lost for small errors in the ordering of the Molecular Orbitals as well as missing the energy axis and connectors indicating which atomic orbitals were being mixed.

Part b)

Most students were able to determine the point group of the distorted complex.

Part c)

Most students could form and reduce the representations for the ligand orbitals. Marks were lost due to a lack of detail on how the representations were reduced.

Part d)

Most students could draw the symmetry orbitals. Errors occurred when the student had previously incorrectly assigned the point group of the distorted complex.

Part e)

Marks were awarded for a reasonable arrangement of molecular orbitals. Marks were lost for a lack of detail in the diagram with simple errors such as the incorrect number of orbitals, no energy axis or connectors costing candidates marks.

Part f)

Students were able to answer this question well regardless of their success in the earlier parts. Marks were awarded for determining if the complex distorts. Additional marks were awarded for some indication of how this was determined.

Paper 3

Q39

The mean mark was **17/25**
No change in the published marking scheme

There were 33 first class answers with only 2 scripts scoring 22 (the highest mark) – these were excellent answers. There was only 1 third class score and indication of candidates running out of time on this question.

(a) Very poorly answered with the majority of answers failing to provide a reasonable mechanism for the Eschenmoser fragmentation (in lecture notes and Core practical !!).

(b) Reaction **C** was poorly answered – generation of carbene/carbenoid and insertion into alkene. Reaction **D** was very well explained with almost answers giving good mechanisms for the Hoffmann degradation and identifying the acyl nitrene intermediate.

(c) Well answered with the majority of answers displaying good understanding of pericyclic reactions and the Woodward-Hoffmann rules. A small number of candidates failed to recognise the two electrocyclic ring closures.

Q40

This was the first year in which actual spectra were displayed in the examination, and in which candidate were asked to assign 2D spectra. It was intended to be easy, in order not to put people off from answering it. It was much too easy. The assignments were almost always correct, with only one candidate seriously confused and two slightly muddled presentations, together with another couple who got it right, but didn't do what the question asked: placing the numbers on the peaks in the spectra. This gave almost everyone who tackled the question 21/25. The question about the low coupling constant and the assignment to a pyranose ring ought to have been given a higher proportion of the marks, in order to spread them out.

Q43

45 students attempted Q43, which was the stratospheric chemistry question to accompany the B4 course.
In part a students were asked to discuss the importance of the concept of families for understanding stratospheric chemistry, with reference to Ox and NOx. This was a fairly fundamental question that was well answered with only a few examples failing to score well – typically by neglecting to discuss how the concept fails. The average mark for this part of the question was 72 %.
In part b students were asked to calculate the time scale for equilibrium (tau) between O and O3 and needed to calculate J1 – the photolysis frequency of O3. This was well answered

with most students doing a very good job of calculating the column of O2 needed to calc J1 and then calculating tau as 1/(J1 + k2[O2][M]) – however some students made errors in missing out the k2 term in tau or instead assuming [M] under typical surface conditions. The average mark was around 76 % for this part.
In part c (i) students were required to calculate the [NOx] and so [NO] and [NO2]. Most students saw that the key calculation was from putting NOx into steady state and then finding a [O1D]. The average mark for this part of the question was 79 %.
In part c (ii) students were asked to compare the rate of Ox loss from NOx with the rate of Ox loss from the Chapman chemistry. This was generally poorly answered with many answers making simple mistakes such as forgetting to include a factor of two for the Chapman Ox loss. The average mark for this part of the question was 56 %.
Finally, in part c (iii) very few students managed to obtain full marks and several candidate did not attempt the question (average mark 40 %). Very few answers discussed why Ox loss by NOx is larger than Ox loss by the Chapman chemistry. However, there were some text book answers which did a great job at linking back to key figures from the notes.

The average mark for Q43 was 17.2/25.

Q44
39 students attempted Q44, which was the tropospheric chemistry question to accompany the B4 course.

In part a students were asked to discuss the importance of VOCs, HOx and NOx in the production of O3 in the troposphere. This was a very straight forward question and the average mark for this part of the paper was 83% with students making only minor mistakes/errors and/or not discussing the conditions that lead to VOC-limited and NOx-limited production (i.e not fully answering the question but putting down lots of other details).
In part b(i) students were given a lot of information detailing the photolysis and oxidation of acetone in the troposphere. Students were first required to show that the oxidation of HCHO (a molecule formed from acetone) leads to the production of 2 HOx molecules. This was well answered and few if any problems arose. The average mark was around 80%.

In part b (ii) students were required to use the acetone oxidation reactions outlined in the paper to calculate how many HOx and O3 molecules are produced as acetone is oxidised into 3 CO2 molecules. This was a poorly answered question, with an average mark of 53 % (but a range from 100% to 0). Where students went wrong included: not explaining answers (just putting numbers down), forgetting that acetone breaks into two fragments and so only calculating O3 and HOx formed from CH3O2 oxidation, failing to see that oxidation of CO to CO2 acts as a source of O3. However, there were some excellent answers to this question highlighting a real understanding of the course.

In part b (iii) students were asked to calculate and compare the production of HOx from acetone at 10 km with the production of HOx from O3. Generally speaking the question was answered reasonably well (average mark of 67 %), with the calculation of HOx production from O3 being fairly trivial for most students. There were several common errors made in calculating the production of HOx from acetone, including: assuming that 2 HOx molecules are produced from acetone, in spite of in part b (ii) saying that 6 HOx were produced, as well as missing sources of intermediates in s.state calculations (i.e. for CH3O2 a term from CH3C(O)O2 was often missed).

Finally, in part b (iv) very few students managed to obtain full marks and several candidate did not attempt the question (average mark 45 %). Common missing points included the fact that in the BL [H2O] is highest as temperatures are highest and that because the acetone lifetime is 29 days (from J1) but transport time scales are 1-2 years from Trop-to-Strat there will be essentially zero acetone in the stratosphere. Hence oxidation of CH4 and H2O are the main sources of HOx in the strat.
The average mark for Q44 was 16.03/25.

Q46
6attempts; mean17.7/25; min12.5; max22; standarddeviation4.0; median18.
This question on the regular solution model was answered well, but was perhaps less popular than one might have expected. I am not sure why students were reluctant to answer it,as at least the first few parts were very similar to lectures and one of the exercises. In part(a), many students computed the entropy of the system given, but did not explain why this was the entropy of mixing. In part(b),only a few candidates noticed that they were double-counting interactions,and some candidates seemed to get into a muddle by not being clear what the proportion of neighbours of each type is, and what the proportion of each type of particle is in the mixture. Inpart(c), some candidates were a little confused about phase separation and how this is reflected in the Helmholtz energy of mixing, even though they would have seen something very similar in supervisions. Part (d) was remarkably well done, but part(e), which was intended to be very easy, was answered correctly by only 2 candidates, with most others completely misunderstanding what it was about.
Q47
3attempts; mean19/25.
I presume theapparent length of the question may have scared off candidates–but the question was actually really rather straightforward. In part(a), only one candidate spotted that there is an additional entropy for the isotropic phase relative to a structureless ideal gas. The word ‘structureless’ was included in the hint to try to make it more obvious what the underlying idea behind this part was, but alas it seems not to have been very successful at relaying this. The rest of the question was reasonably well answered.

Q48

Only 9 scripts received, which is slightly disappointing given the numbers attending the lectures, but the quality was very high. 8 received marks over 20.

Parts (a) and (b), that were largely bookwork or material directly covered in the lectures.
Marks were deducted for lack of clarity, or where it gaps in the derivation existed.

Parts (c) on the "problems" where very well answered in general, with only the occasional slip in deriving characters or direct products.

Paper 4

Q51

The question was attempted by 20 students, and the mean mark was 16/25. The top score was 22/25 and the bottom score was 11.5/25. The marks were very spread out, with a very slight bunching near the top end of the marks.
In all answers to the question, every part of the question was attempted. Parts (a) and (b) were elementary questions about the electrochemical set-up. Most students performed well in this section, with no one scoring below 50%. Part (c) tested the understanding of how an electrocatalyst can be analysed using cyclic voltammogram. This required peak assignments, the prediction of the change in the shape of the voltammogram during electrocatalysis, how this shape is used to calculate the catalytic rate constant catalysis, and a visual understanding of what is happening at the interface. This part of the question gave rise to a big spread of marks and was able to discriminate between the level of understanding amongst the students- particularly the question relating to the drawing of the processes occurring at the interface (no one scored 100% in this part). The first part of (d) tested the students' understanding of mass transfer and how this applied to immobilised catalyst. It was in general well answered, though many students did not make the link that the substrates/products still undergo diffusion (despite having stated it in an earlier answer) even if the catalyst was immobilised. The second part of (d) asked the student to come up with an experiment for measuring the concentration of the catalyst that is immobilised on the electrode. Here, the students needed to give one of two correct answers, both of which are simple techniques that require good explanations of the parameters they choose to calculate the final concentration of the catalyst to score full marks. Every student was able to describe at least one of the two approaches; however, the level of understanding of the techniques (based on the descriptions given) varied drastically. This part also gave rise to a big spread in marks with very few obtaining full marks.

Q53 (Inorganic NMR)

The focus of the question was on the explanation and application of concepts from the lecture course, particularly relating to chemical shifts and T1 relaxation time constants, in a system that had some components that were the same as those in the lectures but other aspects that differed -- it required some thought about the interaction of an organic molecule with an inorganic surface. Generally the question was done well with clear explanations of the different factors important for chemical shifts and T1 values, although these were not always discussed for all five of the C atoms of pentene/yne. The formula for `alumina ($Al_2O_3$)' was given in the question but in the minds of a significant subset of candidates this was translated to `aluminium metal' which led to some unusual analyses.

Q54

There were 37 scripts and the range of marks varied from 9 to 24 out of 25 with an average of 15.4. It was felt that this was close enough to the target of 16.25 for a remark not to be necessary. Section a) was generally answered well, as expected as this covered basic material from the lectures where the students had all had considerable practice with in the supervisions. As usual, many students made the mistake of thinking Cys side chains were as polar as Ser side chains and could form good H-bonds. Despite the fact that they were told in lectures this did not happen. The best students got this correct. Many students also thought the protein, p53 had disulphide bridges. p53 was covered in the lectures as a nuclear protein that bound DNA so they should have been aware it is in a reducing environment. Section b) was generally answered okay but many students assumed fraction native = [N]/[D] and calculated this instead of f(N). Again, the best scripts calculated f(N). This part was a simple extension of calculations they were very familiar with. The answers to part c) were very mixed. The question involved using two standard equations and rearranging them into a form where they could substitute parameters and calculate the answer. This wasn't covered directly in lectures or supervisions and some candidates found it extremely difficult. Many answers showed that whilst the candidate had understood the basic principle they struggled to do the basic maths needed. Part d) was generally well answered and most candidates had a reasonable understanding of the data and how to interpret it. However, the biggest different in the marks reflected not the mechanism but how the data given was used as evidence for that particular mechanism. This was done extremely well in some cases, but in other scripts there was very few links made with the data. As usual, the best scripts were near perfect and showed an excellent understanding of the material in the course whilst the lowest scoring scripts were either incomplete or showed considerable confusion or an ability to remember equations and facts but not the ability to use these to answer the questions.

Q55

There were 39 scripts in total and the marks ranged from 8 to 22 out of 25 with an average of 14.9. Although this is slightly below the target of 16.25, it was felt that this question was not answered so well and therefore the slightly lower average mark reflected this. Section a) was generally answered well as expected as it was very basic material that the students had considerable knowledge of given the supervision questions. Question b) was also very straight forward and largely based on material they had covered in lectures and supervisions. However, many students did not read the question clearly and answered only on folding not on stability. Therefore, there were quite a few scripts where the maximum amount of marks that could be awarded was 4 not 8. Enough candidates did answer the full question that I considered it wasn't worded badly and was more a question of students answering the question they expected to see not the one that had been set. Part c) was not answered so well and required a knowledge of what typical errors in these parameters were in order to work out what was a significant difference and what wasn't. They were all told clearly in the lectures what typical errors were although this was not written in the lecture handout. Part d) was challenging and they had not come across the effects of TFE in either lectures or supervisions. They needed to think hard about what might be going on and use the data they had calculated and were given to direct their thinking. Many candidates chose to largely ignore the data and gave a plausible but incorrect answer that was not completely consistent with the data. Even so, they did show a level of understanding of the energetics of protein folding. In contrast, a handful of candidates clearly thought it through and suggested effects in the denatured state. As with Qu. 54, the best scripts showed an excellent understanding of the material in the course whilst the lowest scoring scripts were either incomplete, showed considerable confusion or an ability to remember equations and facts but not the ability to use these to answer the questions.

Q56

(a) The question requires a series of repeated Still-Gennari and an HWE reaction. The opportunities to draw the wrong double bond isomers and wrong methyl group positions were fully explored. Most people gave a good account of the Still Gennari, the HWE and DIBAL, and yet the number of answers with correct structures for both A and B was rather low. A number of people gave essentially correct mechanisms and the right structure for B, but did not indicate what they expected for the structure of A. The question demonstrated that the importance of these reactions had been appreciated.

(b) Ozonolysis followed by aldol was spotted by most people, although a surprising proportion wrote nothing at all for this section. Must explain selectivity between double bonds, role of Ph_3P, enolate(enamine) formation, five versus seven ring formation, E1cb. Stereochemistry retained from starting material.

(c) A lot of good answers; most people spotted that seven-rings are unfavourable and a five-ring alternative is preferable.

(d) Good answers explaining the selectivity of the radical reactions clearly and the reasons for the regio and stereoselectivity.

Q60

12attempts; mean18.6/25; min8.75; max22.75; standarddeviation4.1; median19.4.

In part(a)(i),many candidates did not ‘show’ how they were computing the commutator. Terms arising from the product rule seemed to disappear as if by magic. It would be prudent for candidates to provide appropriate comments and intermediate steps in ‘show’ questions like this, particularly where the answer is given, as it is otherwise very difficult to know whether they understood what they were doing or they reverse-engineered the answer. In part (a)(ii), a few candidates used results for ladder operators or energy eigen values which were not given in the question to make very short work of the proof they were expected to complete–but those results, which they seemed to have memorised (with varying levels of success), come essentially from this kind of derivation, so they did not really ‘show’ the result holds. A number of candidates mistakenly thought that because $\hat{N}|0\rangle = 0$, this somehow meant that $\hat{N}$ was itself an annihilation operator and that $N_k = 0$ forall k, which clearly contradicted what they obtained at the start of this part of the question. In part(b), many candidates did not explain why $\langle m|n\rangle = 0$ if $m \neq n$. A few candidates only considered the ground-state wave function. In part(c), one or two candidates missed out the minus sign in the wave function given, and obtained a destabilising second-order energy for the ground state, without noticing that anything was amiss. Part(d) presented an unusual problem that most students will probably not have thought about before, but it was tackled impressively well by most of those who attempted it. Overall this was a very pleasing performance by a strong cohort.