## Solutions to Section A

1. C

Recall that a strong acid will have a weak conjugate base, and a weak acid will have a strong conjugate base. Therefore, HNO_3 and HCl will produce weak conjugate bases. Weak species do not ionise fully in water, and thus do not break down into their charged ionic forms to the same extent as strong species. CH_3COOH, however, is a weak acid and thus produces a strong conjugate base. This base will ionise greatly in water and will break down into charged ions to a much greater extent than the other species. The presence of charged ions is a key determinant in electrical conductivity, and therefore **the conjugate base of CH_3COOH will have the greatest electrical conductivity.** NaOH is not an acid, and would not form a conjugate base at all.

2. B

After the NaOH has been added, all the NH_3 has been neutralised (NB: the conjugate base NH_4^+ has been boiled off and therefore cannot affect the pH). So the only factor contributing to the pH of the conical flask is the remaining NaOH that was in excess in the initial reaction with ammonia. We can determine the [NaOH] in excess easily, as we do in all back titrations by considering the titre of HCl and its concentration.

$$NaOH_{(aq)} + HCl_{(aq)} \longrightarrow NaCl_{(aq)} + H_2O_{(l)}$$
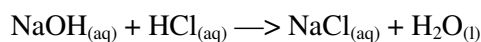
n(HCl) = c x v = 19.36/1000 x 0.097 = 0.0018779 mol = n(NaOH)

Remember than the NaOH is all contained within the fluid of the conical flask, whose total volume is 45ml (the 25ml from the aliquot and the 20ml added from the NaOH).

Thus, we can determine the concentration of NaOH and determine the pH.

c(NaOH) = n/v = 0.0018779/0.045 = 0.0417311M

Using the formula: pH $= 14 + \log[OH^-]$ (NB: only at 25 degrees Celsius)

$= 14 + \log[0.0417311] = 12.62$ (thus B)

3. B

If the burette had been rinse with distilled water, then water droplets would have lowered the concentration of the HCl in the burette. Thus, a greater titre of acid would be required to neutralise all the excess NaOH, making it look as though there was a greater amount of NaOH present. If there was more NaOH in excess, that would indicate that less was used in the reaction with ammonium, suggesting that less ammonium was present. Therefore, the calculated percentage of ammonium would be lower.

4. C

In this titration, acid is slowly being titrated into a basic solution, so the pH begins high and slowly falls. Phenolphthalein indicator changes colour over the range 8.3 to 10, therefore, as the pH falls, the colour would change **too soon**, before pH 7 had been reached and before the reaction had been completed. Thus, it would appear that little acid was required to neutralise the excess NaOH and it would seem as though little excess NaOH remained. Therefore we would assume that a larger amount of NaOH had already been neutralised by the ammonium, and our perceived amount of ammonium would be **higher than the true value**.

5. B

Considering that this is a **hydrated** sample of barium chloride, the remaining percentage by mass of the compound must be water. Therefore the percentage of water in the compound is:

$$100 – 52.34 – 27.07 = 20.59$$

From here, conventional empirical formula calculations can be used.

Species:	Ba	Cl	H_2O
Mass:	52.34	27.07	20.59
M:	137.3	35.5	18
Mol:	0.3812090	0.762535	1.14388
Ratio:	1	2	3

Therefore, $BaCl_2.3H_2O$

6. D

From the half equation, we know that H_2O_2 has lost electrons. Therefore, the other reagent must be accepting electrons. From the acronym OIL RIG we know that **oxidation is loss (of electrons), reduction is gain (of electrons)**. Thus, the other species must be undergoing reduction because it is gaining electrons. Oxidants undergo reduction, therefore the other, **unknown agent is an oxidant, because it gains electrons.**

7. D

Note: the complete identification of an unknown hydrocarbon nearly always requires you to determine the *molar mass*.

From the question, we know that the original alcohol is *completely* converted into carboxylic acid, thus, the number of mol of the carboxylic acid are the same as the number of mol of the alcohol. This can be determined from the concentration and volume of the alcohol solution.

n   = c x v

    = 20.00/1000 x 1.0133 = 0.020266 mol

Now, we know the mass of the carboxylic acid and the number of mols that give this mass, thus we can use a rearrangement of the common formula n = m/M to determine the molar mass.

M   = m/n

    = 1.500/0.020266 = 74.0156 g/mol (approx. 74)

This suggests that the carboxylic acid is propanoic acid, because this species has a molar mass of 74. Therefore, the original alcohol was most likely **propanol**.

8. B

The key concept here is that **gas chromatography cannot be used when the heat required to vaporize a molecule is greater than the heat required to decompose a molecule**. We generally say that molecules of RMM > 300 are inappropriate for gas chromatography because their large level of intermolecular bonding makes them hard to vaporize. But in some cases there are smaller molecules that decompose. Amino acids are a well known example of this. But, for the sake of completeness, we will evaluate each of the choices:

A: Let's just look at the larger molecule: decanoic acid has a molar mass 172 g/mol. If you didn't want to work out the molecular formula, you could do this quickly by remembering that the 'dec'

means there are 10 carbons and the 'oic acid' means there are two oxygens. Adding up these masses only gets you to 152. The remainder of the molecule is made up of hydrogens. So it's quite clear that decanoic and nonanoic acid can both be used in a gas chromatograph as they have an RMM < 300 and, as they are fatty acids, can be vaporized.

B: This is the correct answer. The formula for these can be found using your data book. The molar masses are less than 300 g/mol. **However, in the case of amino acids: decomposition occurs instead of vaporization.**

C: Monosaccharides will generally have the formula $C_6H_{12}O_6$. This molar mass is 180 g/mol (a useful number to remember). They can be vaporized and used in gas chromatography.

D: The formulas for these are in your data book. Lauric acid has molar mass of 200 g/mol and Myristic acid has molar mass of 228 g/mol. Again, fatty acids can be vaporized.

9. C

A silica plate bears charge. As a general rule, forces due to polarity or charge are far stronger than dispersion forces. Adsorption caused by large size is due to dispersion forces, while the other choices describe forces caused by polarity or charge. If the plate was non-polar, there would be no possibility of attraction due to charge and dispersion forces would be the *most* influential.

10. A

Largest = takes the most time = E

Most concentrated = highest peak = B

11. A

We can do this systemically. First thing to note is the reaction with hydrogen, which **converts the alkene to an alkane (hydrogenation)**. An alkane has formula C_nH_{2n+2}. Hence its molar mass (which will equal the m/e of the molecular ion) is given by the formula $M(C_nH_{2n+2}) = 12n + 2n + 2 = 14n + 2$. So for example C_2H_6 (ethane) will have molar mass of $12 \times 2 + 2 \times 2 + 2 = 30$. In this case:

$M(C_nH_{2n+2}) = 72$ (reading from mass spectrum)

$12n + 2n + 2 = 14n + 2 = 72$

$14n = 70$

$n = 5$

Hence compound D, after hydrogenation, becomes pentane (C_5H_{12}). Prior to hydrogenation it would be pentene (C_5H_{10}).

The most abundant compound is compound B, which has a lower retention time than compound D and hence passes faster through the GC and hence is smaller. Considering compound C is also an alkene, one can rule out pentene (compound D) and butene. As there are only two possible smaller alkenes (propene and ethene) and compound A is smaller than compound B, it follows that compound B is propene. Hence A.

12. D

Using the data book and going through the choices, we can see that A indicates the presence of an O-H (acid) group, B indicates a C=C double bond, C indicates a C=O double bond and D indicates an O-H (alcohol) group. The question stem describes hydrogenation, addition of chlorine and addition of an alcohol functional group. Hence D is the only choice that works.

After addition, the C=C double bond disappears. **The O-H acid group is what occurs on COOH (carboxyl) groups and should not be confused with that on hydroxyl groups**.

13. B

Here you operate with two basic principles. The wavelength you select must be:

a) significantly absorbed by the compound you are testing for

b) not significantly absorbed by compounds present that you are not testing for

Failure to do this can be a major source of error in an experiment. **The only wavelength provided where these conditions are satisfied is 280 nm**: the correct answer.

14. D

$n(C) : n(H) : n(O) = 76/12.0 : 13/1.0 : 11/16.0 = 6.3 : 13 : 0.69$

The ratio indicates that the molecule has very few oxygen atoms compared to carbon or hydrogen atoms. This is in line with fatty acids, **which each consist of a long hydrocarbon chain attached to a carboxyl group.**

The molecule is not a protein or nucleic acid because it lacks nitrogen or phosphorus atoms. Carbohydrates often have the formula $C_x(H_2O)_y$, which means $n(H) : n(O)$ should be roughly equal to $2 : 1$, so the molecule is unlikely to be a carbohydrate.

15. D

Acidified dichromate ($H^+/Cr_2O_7^{2-}$) is a commonly used oxidant.

16. C

Since Y and Z can condense to form an ester, the answer cannot be A or B. Because Y can be oxidised to Z, the correct remaining option is C, because a (primary) alcohol can be oxidised to a carboxylic acid.

Note: A *primary* alcohol has the hydroxyl group present in the form of $-CH_2OH$. That $-CH_2OH$ can be oxidised to $-COOH$.

17. B

A is incorrect because the question provides that W should have a functional group.

B is correct because pent-1-ene can react with HCl gas in an addition reaction to produce 1-chloropentane. 1-chloropentane (X) can then undergo a substitution reaction to form pentan-1-ol (Y) which is a primary alcohol. Y needs to be a primary alcohol if it is to be oxidised to a carboxylic acid.

C is incorrect because if X is 2-chlorobutane, Y must then be butan-2-ol which is not a primary alcohol.

D is incorrect because C is incorrect.

18. A

Butane (CH_3-CH_2-CH_2-CH_3) is a symmetrical molecule with only two hydrogen environments: one for the CH_3 hydrogens and another for the CH_2 hydrogens. The n+1 rule states that:

If the hydrogens of a particular environment have n <u>neighbouring</u>, <u>non-equivalent</u> hydrogens, the peak from that environment will be split into n+1 component peaks.

Keep in mind that the word 'neighbouring' as it's used above means 'on the adjacent carbon atom'. 'Non-equivalent' means 'not of the same environment'.

The CH_3 hydrogens have 2 neighbouring, non-equivalent hydrogens, so the CH_3 hydrogens will form a triplet (2+1). The CH_2 hydrogens have 3 neighbouring, non-equivalent hydrogens, so the CH_2 hydrogens will form a quartet (3+1).

19. D

Chemical shift is a measure of frequency (relative to the strength of the magnetic field applied by the NMR machine to standardise chemical shifts across different spectrometers). The reference standard mentioned here is of course TMS (tetramethylsilane).

20. D

The primary structure of a protein is simply its amino acid sequence. The secondary structure consists of localised structural motifs such as helices and sheets and is maintained by hydrogen bonding. The tertiary structure is the overall folding of a polypeptide to form a unique 3D structure – pretty much all forms of bonding play a role in producing the tertiary structure: dispersion forces, hydrogen bonding, ionic interactions and even covalent bonding (in the form of disulfide cross-links between cysteine residues).

Solutions to Section B

Question 1

a.

Ionic substances do not exist as *discrete* separate molecules; they are part of ionic lattices. Therefore, they have no molecular formula because they do not exist as molecules. There can have an empirical formula, however, because that is simply the ratio of the different atoms present.

(1 mark for stating existence of ionic lattices, 1 mark for including difference between empirical and molecular formula and relating this to the ionic lattice)

b.

Unlike acid-base reactions, which typically do not undergo a colour change by themselves, redox reactions can often show clearly visible changes in colour at end point. Therefore, acid-base titrations require an indicator so that the end point can be readily detected; however, redox reactions often have end points that are self-evident.

(1 mark for recognizing that redox reactions sometimes show colour changes at the end point, 1 mark for relating this to the use of indicators in acid-base reactions)

c.

i. The oxidation state of chromium in $CrSO_4$ in Cr^{2+} because $Cr^{2+}_{(aq)} + SO_4^{2-}_{(aq)} \longrightarrow CrSO_{4(aq)}$. Remember that all sulphur containing ions discussed at this level have 2- charges (S^{2-}, SO_3^{2-}, SO_4^{2-}). We are told that Cr^{3+} is produced in the question.

Thus, by balancing the charges with electrons:

$$Cr^{2+}_{(aq)} \longrightarrow Cr^{3+}_{(aq)} + e^-$$
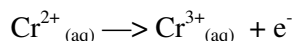
As we can see, the Cr^{2+} has lost an electron and its oxidation number has increased. Hence the reaction that produced $Cr^{3+}_{(aq)}$ is **oxidation**.

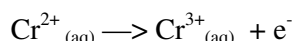**ii.** Electrons obey stoichiometric ratios just like any other species.

$v(CrSO_4) = $ initial burette reading – final burette reading

          =   50.0   -   17.25   = 32.75ml

$c(CrSO_4) = 0.21824M$

Thus,   n   =   c x v

          $n(CrSO_4) = $ 0.21824 x 32.75/1000 = 0.00714736 mol (1 mark)

Recall the equation:

$$Cr^{2+}_{(aq)} \longrightarrow Cr^{3+}_{(aq)} + e^-$$

(1 mark)

We know the $n(Cr^{2+})$ because it is the same as the $n(CrSO_4)$, thus we can find the $n(e^-)$

$$n(CrSO_4) = n(Cr^{2+}) = n(e^-) = 0.00714736 \text{ mol}$$

Considering significant figures, the final answer is **$n(e^-) = 0.00714$ mol** (1 mark)

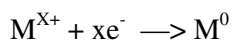**iii.** We know the concentration and volume of MO_Z.

Therefore, $n = c \times v$

          $n(MO_Z) = 0.0756 \times 15.75/1000 = 0.001191456 \text{ mol}$

Considering significant figures, the final answer is **$n(MO_Z) = 0.001191456$ mol**

iv. The amount of electrons released by the Cr^{2+} is the same that M^{X+} accepts.

$$M^{X+} + xe^- \longrightarrow M^0$$

We know $n(MO_Z)$ and we know $n(e^-)$, so the ratio X should be easily deduced. The number of mol of the electrons should be X times the number of mol of M^{X+}, which itself should have the same number of mol as MO_Z.

Therefore, $n(e^-)$ $= X \, n(MO_Z)$

                    $= X \, n(M^{X+})$

                    (1 mark)

Or, mathematically,

          0.00714736 $= X \, 0.001191456$

Thus, X $= 0.00714736/0.001191456 = 5.9988 \longrightarrow$ Approx. 6

(1 mark)

So the value of X is 6, and the original oxidation state must have therefore been **M⁶⁺**. (1 mark)

d.

The substance contains only oxygen and the unknown metal M. Therefore, if we have M^{6+}, we need three O^{2-} ions to create a neutral species. Therefore, the empirical formula must be **MO₃.** (1 mark for answer)

Question 2

a.

$n(CO_2) = m(CO_2) / M(CO_2) = 3.24 / (12.0 + 2 \times 16.0) = 0.0736$ mol

Since all the carbon in Muscalure is in the form of CO_2 after complete combustion,

$n(C$ in Muscalure$) = 0.0736$ mol

$n(H_2O) = m(H_2O) / M(H_2O) = 1.32 / (2 \times 1.0 + 16.0)$

$\qquad = 0.0733$ mol

Since all the hydrogen in Muscalure is in the form of H_2O after combustion,

$n(H$ in Muscalure$) = 2 \times 0.073333$

$\qquad\qquad = 0.147$ mol

If the molecular formula of Muscalure is C_xH_y, then:

$y/x = n(H) / n(C) = 0.147/0.0736 = 2.00$

So $y = 2x$ and the formula is C_xH_{2x}

C_xH_{2x} is the formula either for an alkene with one double bond or for a cyclic alkane.

Since the question provided that Muscalure is non-cyclic, it must then be an alkene.

(2 marks for appropriate working and 1 mark for stating that Muscalure is an alkene)

b.

Since we already have the molecular formula in terms of x, all we need is to determine x. We can do this by constructing an equation for x.

$M(Muscalure) = x \times 12.0 + 2x \times 1.0 = 14.0x$

Since the molar mass of Muscalure is 322.0 g mol⁻¹,

$14.0x = 322.0$

$x = 23$

So the molecular formula of Muscalure is $C_{23}H_{46}$

(2 marks for the correct molecular formula; 1 mark for an incorrect answer with mostly correct working)
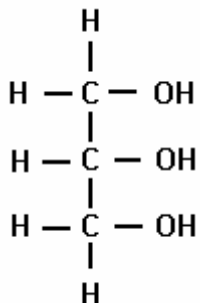
c.

A triglyceride is formed by a condensation reaction involving three fatty acid molecules and glycerol. So the equation for a hypothetical reaction with erucic acid is:

3 erucic acid + glycerol → $C_{69}H_{128}O_6$ + 3 H_2O

It may be clear now that to find the molecular formula of erucic acid, we can use the principle of conservation of mass. But first, we need to determine the molecular formula of glycerol. You should be able to draw the structure of glycerol:

$$
\begin{array}{c}
\text{H} \\
| \\
\text{H} - \text{C} - \text{OH} \\
| \\
\text{H} - \text{C} - \text{OH} \\
| \\
\text{H} - \text{C} - \text{OH} \\
| \\
\text{H}
\end{array}
$$

Just count the atoms and you get $C_3H_8O_3$

Now we're ready to calculate the formula of erucic acid:

$C_{69}H_{128}O_6$ + 3 H_2O - $C_3H_8O_3$ = $C_{66}H_{126}O_6$
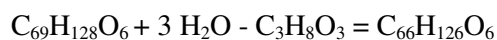
This accounts for the atoms of three erucic acid molecules, so the molecular formula of each molecule must be $C_{22}H_{42}O_2$

(3 marks for the correct answer; 1 or 2 marks for an incorrect answer with some correct working)

d.

You should be familiar with the fact that there are saturated and unsaturated fatty acids, depending on whether there are carbon-carbon double bonds.

One way to find the number of double bonds in is to mentally convert the carboxylic acid into a hydrocarbon:

$$
\text{R} - \text{C}
\begin{array}{c}
\diagup\!\!\!\!\diagup \text{O} \\
\diagdown \text{O} - \text{H}
\end{array}
\longrightarrow \quad \text{R} - \text{H}
$$
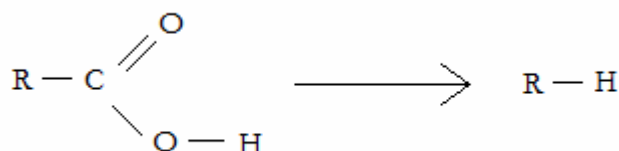
The reason for doing this is that you can readily determine whether RH is saturated or unsaturated.

If RCOOH is $C_{22}H_{42}O_2$, then RH is $C_{22}H_{42}O_2$ – COO = $C_{21}H_{42}$

Since RH is of the form C_xH_{2x}, it is an alkene with one double bond.

So erucic acid has one carbon-carbon double bond.

(1 mark for the correct answer, 1 mark for evidence of working)

Question 3

An initial fair reaction to this question may have been: why is there so much to read? That same reaction was felt by thousands of chemistry students in the 2009 chemistry mid-year examination. In such cases it is important to register as much of the information as possible. Underlining or highlighting key parts is a good strategy to dealing with such questions.

a.

i. The stationary phase facilitates adsorption of compounds being run on the TLC plate. As the compound travels up the plate, it will form temporary intermolecular bonds with the stationary phase that will slow down the compound's progress. As time progresses, the more adsorption, the less the compound travels. In this case the stationary phase is the polar molecule cellulose. Hence the result is that polar molecules will travel on average less up the plate compared to non-polar molecules due to the possibilities of hydrogen or dipole-dipole bonding.

(1 mark for noting stationary phase's role in adsorption, 1 mark for relating this to the experiment)

Note: some students may not see it necessary to state the basic facts about what the stationary phase does. However, in a two mark question, it is a good safe strategy to state the obvious, as this statement might be allocated a mark.

ii. The mobile phase both carries the components of the sample up the stationary phase and impacts on the distance these components travels. This is because if a component is heavily attracted to the mobile phase it will more easily undergo desoprtion off the stationary phase and hence travel further up the plate. In this case the mobile phase is non-polar, which means non-polar compounds will more readily desorb and travel further up the plate.

(1 mark for noting mobile phase's role in desorption, 1 mark for relating this to the experiment)

iii. Normally, thin layer chromatography reveals only coloured compounds, and many other components may go undetected. Ninhydrin helps colour some (but not all) of the remaining components in order to extract more information from the experiment. (1 mark)

b.

If the mobile phase began at a level higher than the spot then instead of rising up the stationary phase with the mobile phase, the sample would dissolve into the mobile phase and spread throughout it. This would cause the experiment to fail. (1 mark)

Note: every practical instruction is given for a reason. It is a useful form of practice to think about what that reason is.

c.

The results suggest it is possible that 1-pentamine is a component of liquid X, or at the very least do not rule out the possibility of 1-pentamine being present in liquid X. This is because spot C in the results has the same R_f as 1-pentamine (0.40). The component(s) of spot C traveled approximately two fifths of the distance that the solvent front traveled. As R_f = distance traveled by component divided by distance traveled by solvent front, this means that spot B has an R_f of 0.40.

(1 mark for expressing the possibility of 1-octamine being present and/or the fact that the results don't rule out this possibility. This mark is not awarded if it is simply stated that spot C is 1-octamine, as this is not necessarily the case)

(1 mark for explanation/calculation on how this outcome was reached)

d.

2 of (1 mark each):

- Better resolution than in TLC, allowing molecules similar in structure and size to be more easily differentiated

- Molecules can be more easily measured for concentration, considering a chromatogram produced in HPLC has peaks that have size proportional to concentration

- Can detect some compounds that are colourless and do not react with ninhydrin

- Molecules can be more easily re-directed into another instrument, like a mass spectrometer, if necessary

e.

Chemical markers are known chemicals that are used as identifiers in fuels. When an unidentified sample is found and HPLC is run, a large peak at a retention time specific to a particular chemical marker indicates that the unidentified sample is derived from a specific known fuel. (1 mark)

f.

1 mark for correct graph (below)

1 mark for correct answer: yes it does exceed the limits

g.

The current procedure is insufficient simply because at such high concentrations the absorbance is too close to 1. Increasing the concentration at these levels will cause minimal change in absorbance as absorbance cannot increase beyond 1. To solve this issue, the solution should simply be diluted by a factor of 10, and this factor taken into account in future calculations.

(1 mark for stating the problem, 1 mark for stating the solution)

Note: any reasonable factor greater than 3 but smaller than 30 would be appropriate

Question 4

a.

Since both A and B consist of hydrogen, carbon and oxygen atoms, you should be on the lookout for oxygen-containing functional groups like hydroxyl, carboxyl, ether and carbonyl (C = O) groups. If you can work out that unknown functional group, it will give you an excellent lead-in to figure out the rest of the structure.

Let's look at A first. In its NMR spectrum, the small, lone peak at 11.5 ppm should be especially conspicuous. Consult your data book to conclude that the 11.5 ppm peak is due to the acidic hydrogen from a carboxyl group. Since the 3 peaks on the ^{13}C NMR spectrum indicate 3 carbon environments, you can already draw the 'skeleton' of A:

If you simply flesh out that structure with hydrogens, you get the structure A:

If you think you've determined an unknown structure, it's always good practice to check if all the information confirms your structure without any contradictions. The molecular mass of propanoic acid is $12.0 \times 3 + 1.0 \times 6 + 16.0 \times 2 = 74.0$ amu, which agrees with the mass spectrum since the peak from the parent molecular ion is at m/z = 74.0. There is a tiny peak at m/z = 75.0, which may cause some doubts, but that peak is actually due to ions with two ^{12}C atoms and one ^{13}C atom. This effect is more pronounced in molecules with more carbon atoms.

If you try to get information out of the chemical shifts in the NMR spectrum at 1.1 ppm and 2.4 ppm, you most likely won't succeed. The proton NMR chemical shift table in your data book is very rough and often not specific enough to be useful.

However, the multiplicity of the peaks can be used to confirm that A is propanoic acid. We have a quartet and a triplet, which supports the idea of adjacent CH_3 and CH_2 groups.

If you were rather open-minded, you might have also considered the structures below, which also have a carboxyl group and 3 carbons:
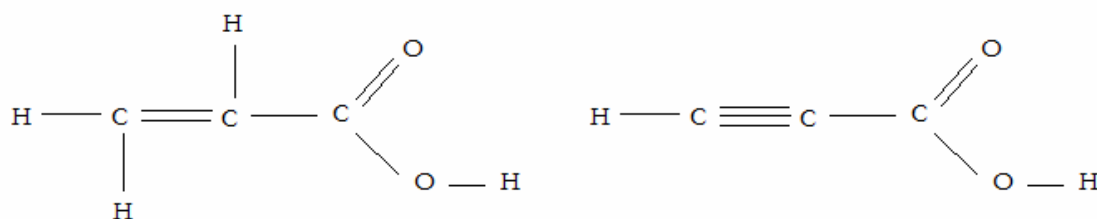
You would then have eliminated these structures because the parent molecular ion in the mass spectrum and the peak splitting in the NMR spectrum do not agree with these structures. The not-so-scientific way of eliminating these structures may be to assume (with a bit of risk) that your VCE exam simply won't give you something that hard!

(1 mark for correctly drawing the structure of A, 1 mark for correctly naming A as propanoic acid, if structure of A is incorrect than award 1 mark for some sound reasoning)

b.

Once again, it's best to start by determining the oxygen-containing functional group. In the IR spectrum, the broad peak at 3350 cm^{-1} indicates an alcoholic O – H according to your data book. In the proton NMR spectrum, the peak at 2.3 ppm stands out as the only one that is a singlet. It is also rather broad, which is the usual case for alcoholic hydrogens. Since we now have two indications of an alcoholic hydroxyl group, it's safe to conclude that B is an alcohol. Alternatively, the 'cheap' way of concluding that B is an alcohol is to look at part c. of this question, which tells you that A and B can react with each other. Within the world of VCE chemistry, carboxylic acids can react with alcohols or amines to form esters or amides respectively. Since we know that B does not contain nitrogen, B must then be an alcohol.

In the mass spectrum, the parent molecular ion is at m/z = 60.0, so the molecular mass of B is 60.0 amu. Although we know that B is an alcohol, we are not so sure that there is only one hydroxyl group – there could be two or more alcoholic hydrogens in the same environment due to structural symmetry. Let's think about what would happen if there were two hydroxyl groups. The two O – H groups would make up 34.0 amu, leaving only 26.0 amu for the other atoms in the molecule. 26.0 amu could only include a maximum of two carbons (24.0 amu) and even in that case, only two C – H hydrogens (2.0 amu) would be allowed. We can see that it doesn't seem practical for there to be two hydroxyl groups in a 60.0 amu molecule. So there is only one hydroxyl group.

Having one hydroxyl group (17.0 amu) leaves 43.0 amu for carbons and C – H hydrogens. That 43.0 amu could comprise three carbons (36.0 amu) and seven hydrogens (7.0 amu). If that were the case, the molecular formula would be C_3H_7OH, which looks like propanol – bingo!

There are two isomers of propanol: propan-1-ol and propan-2-ol.
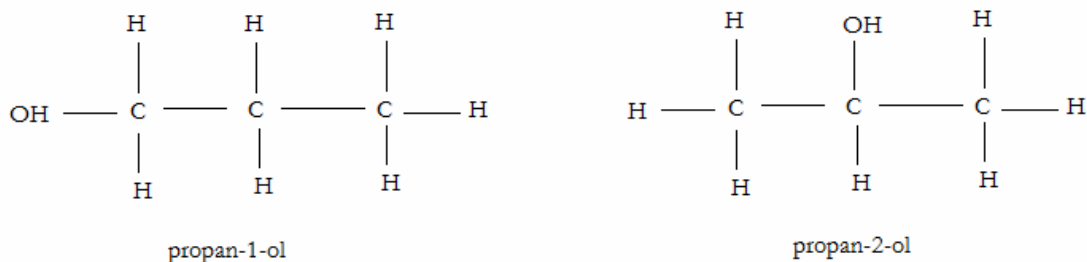

First, let's see if the data matches propan-1-ol. Propan-1-ol has 4 hydrogen environments, which agrees with the 4 peaks on the proton NMR spectrum. Applying the n + 1 rule, we ought to see two triplets (one from the CH_3 and another from the CH_2 next to the hydroxyl group) as well as a multiplet (from the CH_2 in the middle). This is indeed what we have in the spectrum, so we can be confident that B is propan-1-ol. In contrast, propan-2-ol has 3 hydrogen environments which should result in 3 proton NMR peaks. That there are actually 4 peaks in the spectrum already eliminates propan-2-ol.

(1 mark for correctly drawing the structure of B, 1 mark for correctly naming B as propan-1-ol, if structure of B is incorrect than award 1 mark for some sound reasoning)

c.

Esterification:

$CH_3CH_2COOH + CH_3CH_2 CH_2OH \rightarrow CH_3CH_2COOCH_2CH_2CH_3 + H_2O$
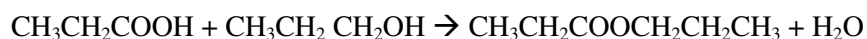
(1 mark for the correct equation)

Question 5

a.

'Deoxyribotrinucleotide' – what a mouthful! But it just means a trinucleotide with deoxyribose (as opposed to ribose) sugar rings. All chains of nucleotides – from dinucleotides to polynucleotides – have a 5' end and a 3' end. The 5' end is where the terminal phosphate group is attached to the 5' carbon of the sugar ring. The 3' end is where the terminal hydroxyl group is connected to the 3' carbon. So without further ado, here is the required structure, based on information from your data book:
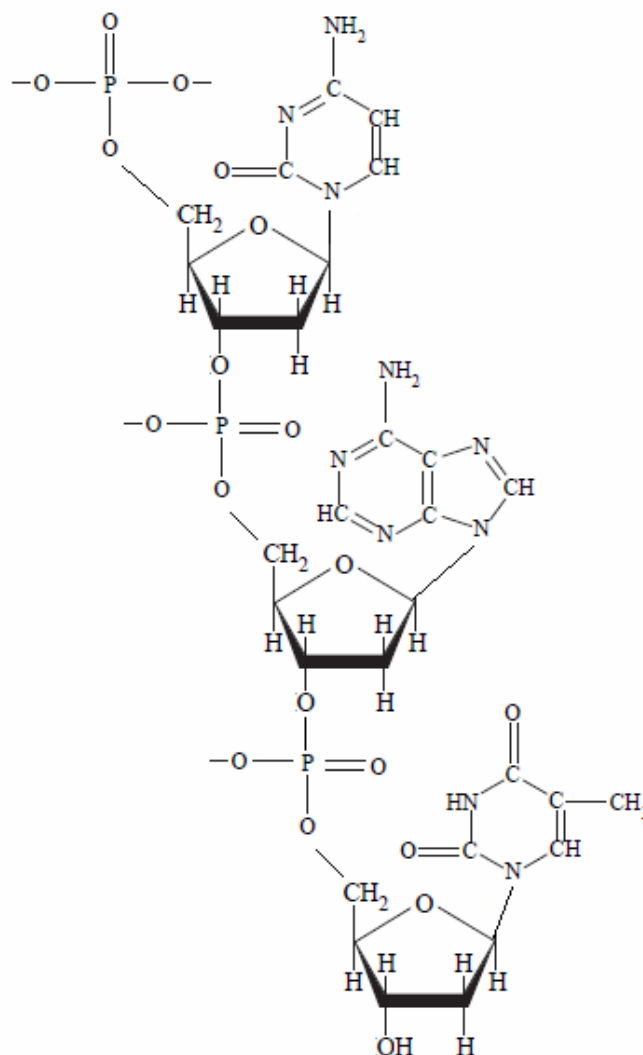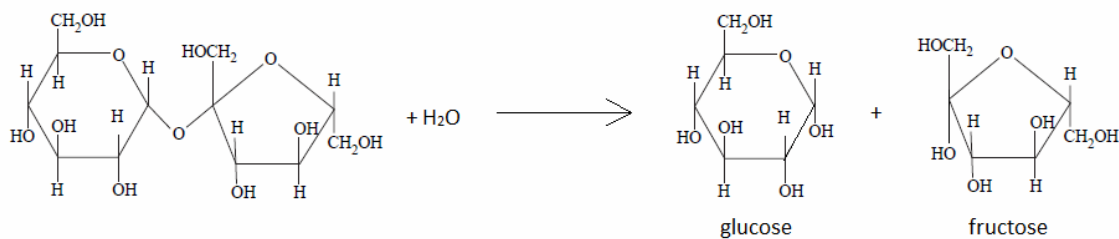
(3 marks for the correct answer; 1 or 2 marks for an incorrect answer that's similar to the correct answer)

b.

Histones are positively charged (1 mark). This helps the negatively charged DNA to bind to histones (1 mark). DNA is negatively charged due to the phosphate groups.

Question 6

a.

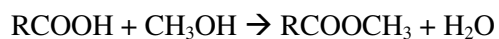(2 marks for the correct equation and 1 mark for correctly naming the monosaccharides)

b.

The three polymers of glucose you need to know for VCE chemistry are glycogen, starch and cellulose. Glycogen is used for energy storage in animals, while starch has the same function in plants. Cellulose is a structural material used in plants (more specifically, it forms the cell wall of plant cells). Structurally, glycogen has chains that branch relatively frequently, while starch is composed of two types of polymers, one with unbranched chains (amylose) and the other with branched chains (amylopectin). Cellulose is unbranched.

(1 mark for naming glycogen, starch and cellulose, 1 mark for describing their functional differences and 1 mark for describing their structural differences)

c.

A biodiesel is typically generated by an esterification reaction between fatty acids (derived from a triglyceride) and methanol (or sometimes ethanol). So if RCOOH is a fatty acid, a typical reaction would be:

$RCOOH + CH_3OH \rightarrow RCOOCH_3 + H_2O$

(2 marks for a correct equation; 1 mark for an answer that that's incorrect but is similar to a correct answer)