Question 1 **B**

In PbS, the oxidation number (ON) of Pb is +2. The ON of S is –2.
In $PbSO_4$, ON(Pb) = +2, ON(S) = +6. The oxidation number of lead does not change (so **A** and **C** are incorrect). The change for the oxidation number of sulfur from –2 to +6 is an increase, so the PbS has been oxidised. The oxidant (causing this oxidation) is H_2O_2.

Question 2 **B**

$$n(\text{PbS}) = \frac{m}{M} = \frac{4.91}{239.3} \text{ mol}$$

$$n(\text{H}_2\text{O}_2) = 4 \times n(\text{PbS}) = 4 \times \frac{4.91}{239.3} = 0.0821 \text{ mol}$$

$$c(\text{H}_2\text{O}_2) = \frac{n}{V} = \frac{0.0821}{0.100} = 0.821 \text{ M}$$

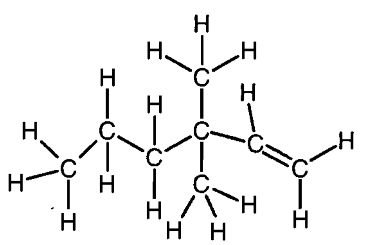
$$c(\text{H}_2\text{O}_2) = \frac{m}{V} = \frac{n \times M}{V} = \frac{2.79}{0.100} = 27.9 \text{ g L}^{-1}$$ or 2.79% m/v (hence **C** and **D** are incorrect)

Question 3 **C**

The polymer forms by condensation reactions between the hydroxyl (OH) and carboxyl (COOH) groups. When n monomers react, $n - 1$ molecules of water are produced.
Therefore M(polymer) = 500 × M(monomer) – 499 × $M(H_2O)$ = 500 × 104 – 499 × 18 = 4.3×10^4

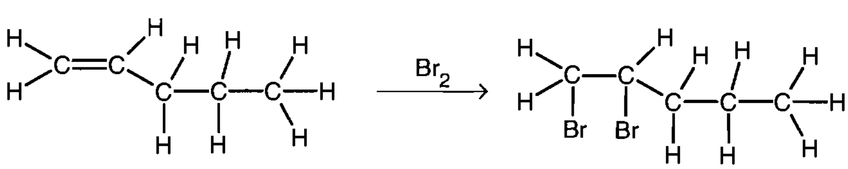
Question 4 **B**

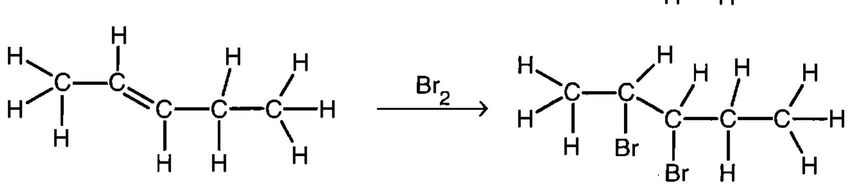
Draw the molecule and count the hydrogen atoms. The molecule is an isomer of octene (C_8H_{16}).



Question 5 **D**

The relevant addition reactions are shown below.



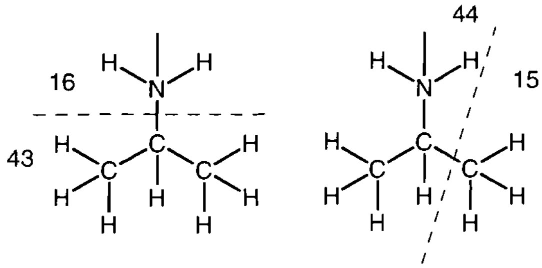


The products are 1,2-dibromopentane and 2,3-dibromopentane. These have the same molecular formula but different structural formulas. They are isomers, not the same compound (so **D** is correct, and **A** is incorrect). The products are saturated (so **B** is incorrect) and have a higher molar mass than the organic reactants (so **C** is incorrect).

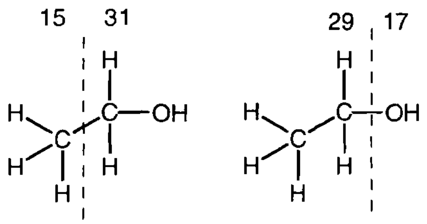
Question 6 **A**

Typical fragments are shown below.

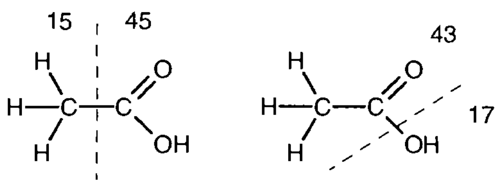
A.



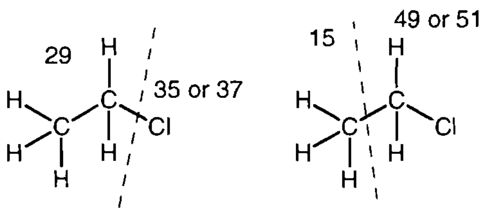
B.



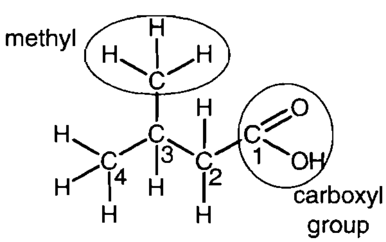
C.



D.



Question 7 **A**



The longest carbon chain has four carbons, giving the name butan (so answers **C** and **D** are incorrect). Numbering starts from the carboxylic acid carbon, so **A** (and not **B**) is the correct response.

Question 8 **D**

$$n(KH(C_8H_4O_4)) = c \times V = 0.0500 \times \frac{250.0}{1000} \text{ mol}$$

$$m(KH(C_8H_4O_4)) = n \times M = 0.0500 \times \frac{250.0}{1000} \times 204.1 \text{ g}$$

Question 9 **D**

Pipettes and burettes are given a final rinse with the solution they are to contain. This ensures that no dilution of the solutions occurs. Conical flasks serve as reaction vessels only, and are not used to measure volumes of solutions. They are rinsed with water, and do not need to be dried before use.

Question 10 A

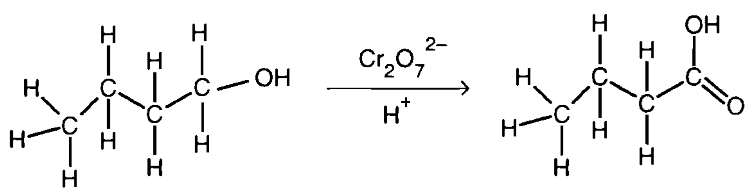
The relevant equation is $HCl(aq) + NaOH(aq) \rightarrow NaCl(aq) + H_2O(l)$.
The pH of the flask contents is increasing as the base is being added to the acid (so **C** is not the required response). The equivalence point occurs when equal amounts (in mol) of the acid and base have been mixed. As both the acid and base are 0.10 M solutions, equivalence will occur when 20.00 mL of base has been added (so **D** is not the required response). For a strong acid/strong base titration, the pH changes rapidly at the equivalence point (so graph **A** is correct, and graph **B** is incorrect).

Question 11 D

The relevant equation is $CH_3COOH(aq) + NaOH(aq) \rightarrow CH_3COONa(aq) + H_2O(l)$.
The equivalence point occurs when equal amounts (in mol) of the acid and base have been mixed. At this point the solution will contain the weak base ethanoate ion, CH_3COO^- (the conjugate base of the weak acid). The presence of this weak base makes the solution slightly alkaline, with a pH greater than 7.

Question 12 C

The relevant equation is



This conversion involves the addition of oxygen to the compound, and an increase in the oxidation number of the carbon atom (from –2 to –1). The conversion is therefore an oxidation.

Question 13 B

The broad band at 3300 cm^{-1} is typical of an OH (alcohol) group, as found in 2-propanol. Propene would show a peak in the range 1610 to 1680 cm^{-1} due to the C=C bond. Propanoic acid and propanone would show a peak around 1700 cm^{-1} due to the C=O bond.

Question 14 C

Bonding between amino acids involves a peptide link, including a covalent bond between the carbon and nitrogen atoms. Bonding between side groups on non-adjacent amino acids may involve hydrogen and ionic bonds, and dispersion forces, but this is not bonding between monomers to form the protein chain.

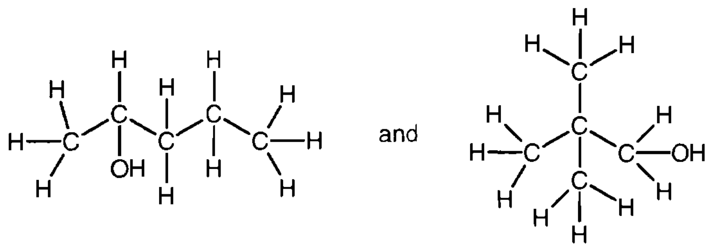
Question 15 A

A ten-carbon chain with the carboxyl group at one end is decanoic acid. Note that the carbon of the carboxyl group is counted in the carbon chain (so **C** and **D** are incorrect), and is numbered 1 (so **B** and **D** are incorrect).

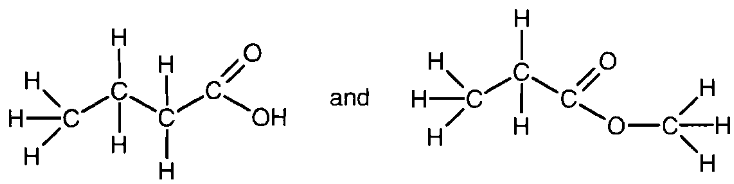
Question 16 **C**

Leucine and isoleucine are both amino acids with the same molecular formula. Drawing the other structures shows that the pair in C are the only pair where the two members do not have the same molecular formula, and are therefore not isomers.

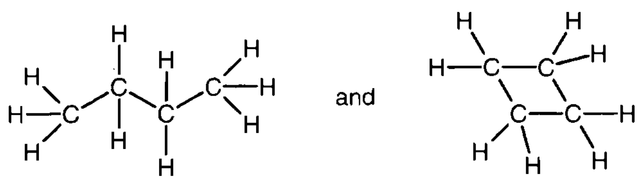
A.



B.



C.

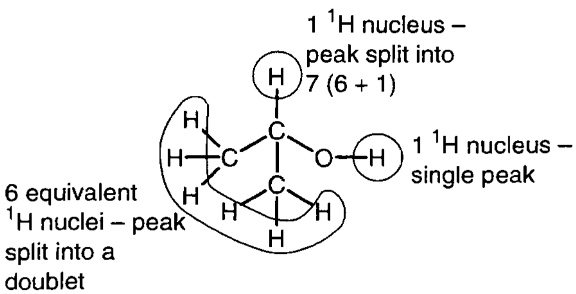


Question 17 **B**

For metal determination, AAS is used. HPLC and ^{1}H NMR are used to determine the composition and structures of organic compounds. Gravimetric analysis, while it could be used to determine metal concentration by precipitating the metal ion, is far less accurate than AAS and would not be suitable for high precision analysis.

Question 18 **C**

Draw the structure of 2-propanol and determine the number and types of ^{1}H nuclei present.

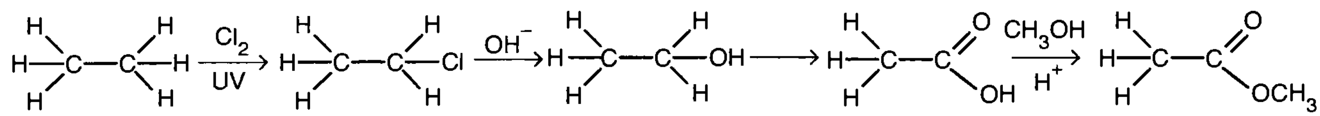


Question 19 **D**

Both molecules contain a carbonyl (C=O) group, and so both would include a strong band at approximately 1700 cm^{-1} on their infrared spectra (**A** is a correct statement and is therefore not the required response). The hydrolysis of the ester in methyl salicylate would produce salicylic acid and methanol (**B** is a correct statement and is therefore not the required response). The ^1H NMR spectra of both salicylic acid and methyl salicylate would include four peaks at chemical shift values in the region 7 to 8 ppm due to the four hydrogen atoms attached to the benzene ring in each molecule (**C** is a correct statement and is therefore not the required response). Salicylic acid and methyl salicylate have different molar masses and the same number of oxygen atoms per molecule. Their percentage by mass of oxygen could not therefore be the same (**D** is an incorrect statement and is therefore the required response).

Question 20 **A**

The relevant structures and names are shown below.



ethane — chloroethane — ethanol — ethanoic acid — methyl ethanoate

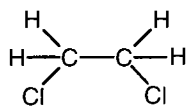
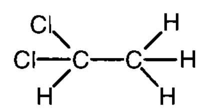
SECTION B: SHORT-ANSWER QUESTIONS

Question 1

a. substitution — 1 mark

b. It is a catalyst. It provides the energy needed to break the Cl–Cl bond — 1 mark

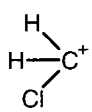
c. **i.**

	Isomer I	**Isomer II**
structural formula		
systematic name	1,2-dichloroethane	1,1-dichloroethane

4 marks
1 mark for each correct cell

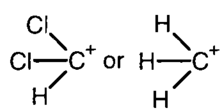
ii. 1,1-dichloroethane — 1 mark
Two peaks appear in the ratio 1:3, due to the single hydrogen nucleus on carbon 1, and the three hydrogen nuclei on carbon 2. — 1 mark
(The spectrum of 1,2-dichloroethane would show only one peak.)

d.



for 1,2-dichloroethane

or



for 1,1-dichloroethane

1 mark
Total 9 marks

Question 2

a. E ⟶ C ⟶ F ⟶ A ⟶ D ⟶ B ⟶ G

2 marks

b. **i.** to ensure that the precipitate was dry — 1 mark

ii. $\frac{1.109 + 1.110 + 1.108}{3} = 1.109$ g — 1 mark

iii. $n(\text{AgCl}) = \frac{m}{M} = \frac{1.109}{143.4} = 7.734 \times 10^{-3}$ mol — 1 mark

$n(\text{NaCl}) = n(\text{AgCl}) = 7.734 \times 10^{-3}$ mol

$m(\text{NaCl}) = n \times M = 7.734 \times 10^{-3} \times 58.5 = 0.4524$ g — 1 mark

iv. $\%\text{NaCl} = \frac{m(\text{NaCl})}{m(\text{extract})} \times 100 = \frac{0.4524}{5.112} \times 100 = 8.850\%$ — 1 mark

c. **i.** *Any one of:*

- Ions other than chloride contributed to the mass of the precipitate.
- The precipitate was still wet.
- any other suitable answer

1 mark

ii. *Any one of:*

- Some precipitate was lost during the filtration and transfer stages.
- Insufficient silver nitrate solution was added to precipitate all of the chloride ion.
- any other suitable answer

1 mark

Total 9 marks

Question 3

a. **i.** $n(\text{C}):n(\text{H}):n(\text{O}) = \frac{72.0}{12.0} : \frac{12.0}{1.0} : \frac{16.0}{16.0} = 6.0 : 12.0 : 1.0$

The empirical formula is $C_6H_{12}O$. 2 marks

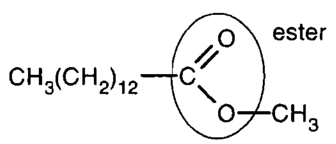
ii. EFM = (6 × 12.0) + (12 × 1.0) + 16.0 = 100

RMM = 200 = 2 × 100

The molecular formula is $C_6H_{12}O \times 2 = C_{12}H_{24}O_2$. 1 mark

b. saturated *(the formula, $C_{11}H_{23}COOH$, fits the general formula of $C_nH_{2n+1}COOH$)* 1 mark

c.



2 marks

*1 mark for part **i***

*1 mark for part **ii***

d. B 1 mark

Myristic acid has the same carboxyl group (COOH) as lauric acid, but a larger molar mass. The larger mass leads to stronger dispersion forces between the molecule and the stationary phase, and hence a longer retention time. 1 mark

Total 8 marks

Question 4

a. **i.** deoxyribose sugar 1 mark

ii. phosphate ion 1 mark

iii. hydrogen bonds 1 mark

b. amine 1 mark

c. **i.** The OH group on the phosphate is able to donate a proton, and hence acts as an acid. 1 mark

ii. Adenine and thymine are a complementary base pair. This means that for each adenine molecule there will be a thymine molecule, and vice versa. Thus the numbers of the two bases must be equal in any section of double-stranded DNA. 1 mark

Total 6 marks

Question 5

a. **i.** $M = \frac{mRT}{pV} = \frac{5.60 \times 8.31 \times 423 \times 760}{765 \times 101.3 \times 1.64} = 118 \text{ g mol}^{-1}$ — 2 marks

ii. EFM = (2 × 12.0) + (3 × 1.0) + (2 × 16.0) = 59
RMM = 118 = 2 × 59
The molecular formula is $(C_2H_3O_2) \times 2 = C_4H_6O_4$ — 1 mark

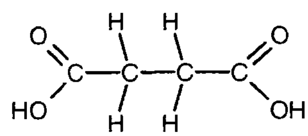
b. The band at 1700 cm^{-1} is due to the carbonyl group (C=O). — 1 mark
As this group is present in both esters and carboxylic acids (and other groups such as amides, aldehydes and ketones), we cannot be sure which functional group is present. — 1 mark

c. **i.** $n(C_4H_6O_4) = \frac{m}{M} = \frac{0.134}{118} = 1.136 \times 10^{-3}$ mol — 1 mark

$n(\text{NaOH}) = c \times V = 0.106 \times 21.43 \times 10^{-3} = 2.272 \times 10^{-3}$ mol — 1 mark
$n(C_4H_6O_4) : n(\text{NaOH}) = 1.136 : 2.272 = 1 : 2$ — 1 mark

ii. The molecule contains two acidic protons. — 1 mark

d.



1 mark
Total 10 marks

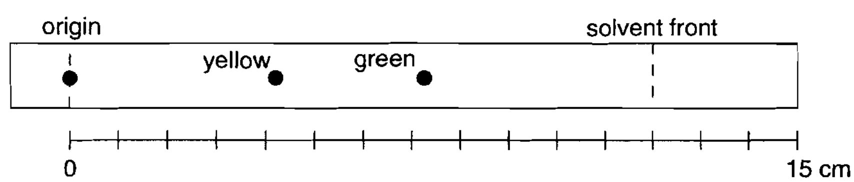
Question 6

a. **i.** electrophoresis — 1 mark

ii. fractional distillation — 1 mark

b. $R_f(y) = 0.35 = \frac{d(y)}{12}$, so $d(y) = 4.2$ cm

$R_f(g) = 0.60 = \frac{d(g)}{12}$, so $d(g) = 7.2$ cm — 1 mark



1 mark

c. **i.** From the graph, [Fe] = 5.5 mg mL^{-1} (for absorbance 0.55) — 1 mark

$5.5 \text{ g L}^{-1} = \frac{5.5}{55.8} \text{ mol L}^{-1} = 0.099 \text{ mol L}^{-1}$ — 1 mark

ii. A graph of absorbance versus wavelength for a solution of the iron/ferrozine complex would be obtained. — 1 mark
The absorbance of maximum wavelength would be chosen (provided that no other component of the bore water sample absorbed this wavelength). — 1 mark

Total 8 marks