**SECTION A (Total 20 marks)**

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **1.** | A | **2.** | B | **3.** | B | **4.** | D | **5.** | B |
| **6.** | D | **7.** | B | **8.** | D | **9.** | C | **10.** | A |
| **11.** | A | **12.** | B | **13.** | D | **14.** | D | **15.** | A |
| **16.** | B | **17.** | A | **18.** | C | **19.** | C | **20.** | C |

**Guidelines for Section A solutions**

**Question 1**
Mass spectrometers are used for the purposes suggested in alternatives B, C and D. An atomic absorption spectrometer is a more likely instrument to be used for determining the elemental composition of a metallic alloy.
(Answer **A**)

**Question 2**
Rinsing a burette with water would result in the dilution of the solution to be accurately measured by the burette. Procedures I and III are correct.
(Answer **B**)

**Question 3**
The base peak (that representing the most abundant fragment formed and recorded by a mass spectrometer) for a small primary alcohol corresponds to M-18 (due to the loss of water) or has a *m/e* value of 31 corresponding to the $CH_3O^+$ species.
(Answer **B**)

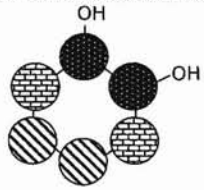
**Question 4**
$\eta$ CO = 15/28 = 0.5357 mol and $\eta$ $O_2$ = 9/32 = 0.2813 mol
2 mol CO reacts with 1 mol $O_2$
$\therefore$ 0.5357 mol CO reacts with 0.2679 mol $O_2$
Hence, oxygen in excess by 0.2813 – 0.2679 = 0.0134 mol = 0.4288 g
(Answer **D**)

**Question 5**
A saturated solution will not usually be used as the absorbance is likely to be outside the linear region of the calibration curve.
(Answer **B**)

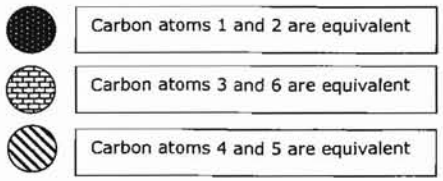
**Question 6**
GLC is generally used for stable volatile substances of low molar masses.
(Answer **D**)

**Question 7**
The $^{13}C$ NMR indicates three environments for the carbon atoms.

cyclohexan-1,2-ol




(Answer **B**)






**Guidelines for Section A solutions (continued)**

**Question 8**
The correct graph must indicate that initially a strong base was present (curves C and D) – shown by a high pH. After the addition of excess acid the graph must show that a weak acid is present – shown by a pH significantly higher than 1; the pH shown by a weak acid of 0.1 M (curve D).
(Answer **D**)

**Question 9**
The parent ion (molecular ion) is at *m/e* 74. This corresponds to the relative molecular mass of butan-1-ol. Hence, molar mass $C_4H_{10}O = 4 \times 12 + 10 \times 1 + 1 \times 16 = 74$ g $mol^{-1}$.
(Answer **C**)

**Question 10**
A high pH indicates a basic solution. Only $Na_2CO_3$ will react with water as a base. $Na_2SO_4$ and $NaNO_3$ solutions will be neutral while $NH_4Cl$ is acidic.
$CO_3^{2-} + H_2O \rightarrow HCO_3^- + OH^-$
(Answer **A**)

**Question 11**
Hydrogen atoms on hydroxyl groups do not usually couple to neighbouring hydrogen atoms and the methylene groups are equivalent. Therefore there are two environments for hydrogen atoms – neither showing any splitting.
(Answer **A**)

**Question 12**
First balance the oxygen atoms using 2 water molecules (x = 2), then balance the hydrogen atoms with 4 $H^+$ (y = 4) and next balance the charge using 3 electrons (z = 3).
(Answer **B**)

**Question 13**
Molecules with atoms of only one type of element do not form dipole moments and therefore will not absorb infrared radiation.
(Answer **D**)

**Question 14**
The more sites available for the molecules of a substance to hydrogen bond to water molecules the greater the likelihood that the substance will dissolve in water. Molecule Z has two hydroxyl groups compared to one for molecule Y and none for molecule X. Hydroxyl groups can form hydrogen bonds to water molecules.
(Answer **D**)

**Question 15**
Alternative A indicates the synthetic pathway for the production of aminoethane from chloroethane.
(Answer **A**)

**Question 16**
A chlorine atom is **substituted** for a hydrogen atom on the ethane molecule.
(Answer **B**)

**Guidelines for Section A solutions (continued)**

**Question 17**
The general formula for a saturated fatty acid is $C_nH_{2n+2}O_2$. For each two hydrogen atoms removed from this general formula for a fatty acid a double bond is formed. Therefore $C_nH_{2n-2}O_2$ would be the general formula of a fatty acid with two double bonds – a polyunsaturated fatty acid. Linoleic acid has 18 C atoms and 32 (2 x 18 – 4) hydrogen atoms indicating two C to C double bonds.
(Answer **A**)

**Question 18**
Ethanol and methanoic acid react to form an ester. Alternative A is an aldehyde, alternative B is the ester formed from methanol and ethanoic acid. Alternative D is the ester formed from ethanol and ethanoic acid.
(Answer **C**)

**Question 19**
Biomass is matter obtained from living organisms. Cellulose is the major component of the cell walls of plants.
(Answer **C**)

**Question 20**
An homologous series is composed of organic compounds with the same functional group – compounds that differ by multiples of $-CH_2-$ only. Only alternative C has the same functional group and its structure differs from 1-fluoropropane by one $-CH_2-$ group.
(Answer **C**)



**SECTION B**

**Question 1 (Total = 9 marks)**

a) $\eta\ Na_2CO_3 = \frac{mass}{M} = \frac{2.65}{106} = 0.0250$ mol (1 mark)

$c\ Na_2CO_3 = \frac{\eta}{V} = \frac{0.0250}{0.0250} = 0.100$ mol $L^{-1}$ (1 mark)

b) $Na_2CO_3(aq) + H_2SO_4(aq) \rightarrow Na_2SO_4(aq) + CO_2(g) + H_2O(l)$ [Include states] (1 mark)

c) $\eta\ Na_2CO_3 = c\ V = 0.100 \times 20.00 \times 10^{-3} = 0.00200$ mol (1 mark)
$\eta\ H_2SO_4$ (in 26.10 mL) = $\eta\ Na_2CO_3$

$\therefore \eta\ H_2SO_4$ (in 250 mL of diluted solution) = $\frac{250.0}{26.10} \times 0.00200 = 0.019157$ mol

$\therefore \eta\ H_2SO_4$ (in original 10 mL) = 0.019157 mol (1 mark)

$\therefore c\ H_2SO_4$ (original solution) = $\frac{\eta\ H_2SO_4}{V\ H_2SO_4} = \frac{0.019157}{10 \times 10^{-3}} = 1.92$ mol $L^{-1}$ (1 mark)

d) The average titre should be twice that found when using $H_2SO_4$. (1 mark)

e) The diluted acid would have been twice as concentrated.
Therefore the average titre would be 13.05 mL. (1 mark)

f) Group A. The burette only has a volume of 50 mL and the expected average titre for this group would be 52.20 mL – more than the total volume of the burette. (1 mark)

**Question 2 (Total = 5 marks)**

$\eta\ Ba_3(PO_4)_2$ (collected) = $\frac{1.5}{602} = 0.00249$ mol (1 mark)

$\eta\ BaCl_2$ (in 20 mL) = 3 x $\eta\ Ba_3(PO_4)_2 = 0.00747$ mol (1 mark)

$\eta\ BaCl_2$ (in 250 mL) = $\frac{250}{20} \times 0.0074748 = 0.0934$ mol (1 mark)

mass $BaCl_2$ (assuming sample is pure) = $\eta\ BaCl_2$ x M $BaCl_2$
mass $BaCl_2 = 0.093435 \times (137.3 + 2 \times 35.5) = 19.46 = 19.5$ g (1 mark)

The maximum mass the students should use is determined assuming 95% purity of the sample. Note if the students assumed 90% purity **and** the sample turned out to be 95% pure they would need to be able to collect more than 1.5 g of barium phosphate.

**Maximum mass of $BaCl_2$ sample** = $\frac{100}{95} \times 19.46 = 20.4869 =$ **20 g** (1 mark)

**Question 3 (Total = 4 marks)**

Example answers

| Information to be determined | Analytical technique |
|---|---|
| Concentration of a hydrocarbon in air from a mine shaft | **Gas (Liquid) Chromatography** |
| Concentration of mercury in Port Phillip Bay flathead fish | **Atomic Absorption Spectrometry** |
| Molecular mass of a primary chloroalkane | **Mass Spectrometry** |
| Amount of salt, NaCl, in dehydrated tomato soup | **Gravimetric Analysis** |

(4 x 1 = 4 marks)

**Question 4 (Total = 14 marks)**

a) $\eta C : \eta H : \eta O = 48.6 / 12.0 : 8.1 / 1.0 : 43.2 / 16.0 = 4.05 : 8.1 : 2.7$

Divide by 2.7 (then multiple by 2)

$\eta C : \eta H : \eta O = 1.5 : 3.0 : 1.0 = 3 : 6 : 2$

Therefore empirical formula is $C_3H_6O_2$ (2 marks)

b)

| **m/e value** | **29** | **45** | **73** | **74** |
|---|---|---|---|---|
| **Species** | $C_2H_5^+$ | $COOH^+$ | $C_3H_5O_2^+$ | $C_3H_6O_2^+$ |

(4 x 1 = 4 marks)

c) Molecular formula of the compound is $C_3H_6O_2$ (1 mark)

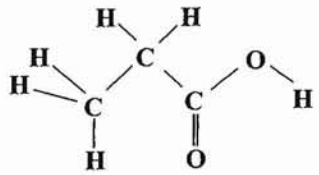
d) 3050 $cm^{-1}$: This is most likely to be due to: **O-H bonds.** (1 mark)

2920 $cm^{-1}$: This is most likely to be due to: **C-H bonds.** (1 mark)

1720 $cm^{-1}$: This is most likely to be due to a carbonyl group: **C=O group.** (1 mark)

e) (i) The peak at 0 ppm is due to the absorption of the H atoms in tetramethylsilane (TMS) (1 mark)
TMS is used a reference to determine the chemical shift scale. (1 mark)

(ii) **Propanoic acid**

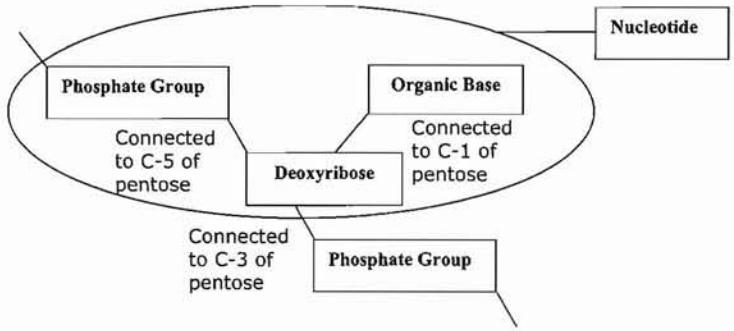


(1 + 1 = 2 marks)



**Question 5 (Total = 7 marks)**

a)




(2 marks)

b) (i)
- isolation of DNA sample and treating with **restrictive enzymes** which cut DNA into particular base sequences
- fragments are duplicated using the **polymerase chain reaction**
- DNA fragments separated using **gel electrophoresis**
- placed onto medium of nitrocellulose or nylon
- labelled using fluorescent dye (or radioactive segment of DNA)
- exposed to UV light (or X-ray film)

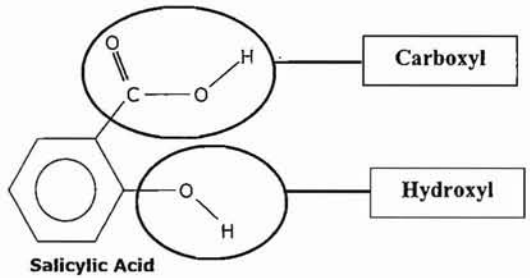
(3 bolded phrases and any other point for 4 marks)

(ii) **Suspect C** (1 mark)

**Question 6 (Total = 5 marks)**

a) $C_9H_8O_4$ (1 mark)

b)




(1 mark)

(1 mark)

c) (i) Ester (1 mark)

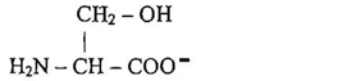
(ii) Esterification or condensation reaction (1 mark)

**Question 7 (Total = 8 marks)**

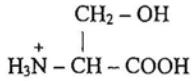
a) Amino group *or* $-NH_2$ (1 mark)

b) Amino acids, such as serine, are amphoteric.
Serine forms anions in alkaline solutions which are attracted to the positive terminal.
Serine forms cations in acidic solutions which are attracted to the negative terminal.
(1 mark)

Structure in alkaline solution



Structure in acidic solution

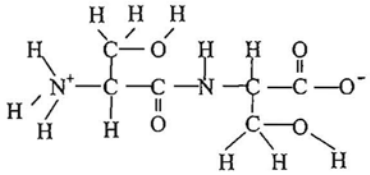


(1 + 1 = 2 marks)

c) (i) Condensation (1 mark)

(ii) $H_2O$ (1 mark)

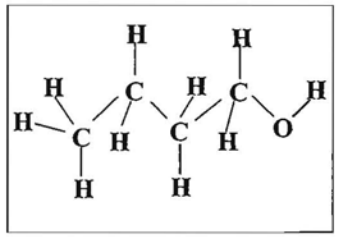
(iii)



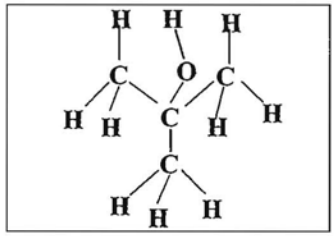
(1 for peptide bond and 1 for overall structure = 2 marks)

**Question 8 (Total = 10 marks)**

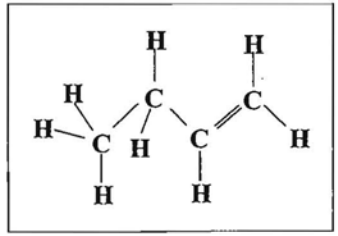
a)



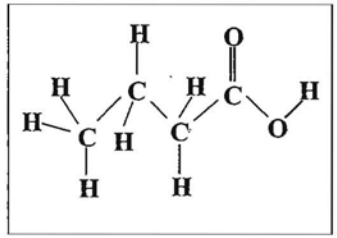
Butan-1-ol



Methylpropan-2-ol



But-1-ene



Butanoic acid

(4 marks)



**Question 8 (continued)**

b) Example answers only

(i) Add sodium carbonate solution

Butan-1-ol will not react. Butanoic acid will react and a gas will be given off. (1 mark)

$2C_3H_7COOH + Na_2CO_3 \rightarrow 2C_3H_7COONa + H_2O + CO_2$ (1 mark)

(ii) Add bromine water

But-1-ene will cause bromine water to change from orange-brown to colourless (*or* fade). Butan-1-ol will not react. (1 mark)

$C_4H_8 + Br_2 \rightarrow C_4H_8Br_2$ (1 mark)

(iii) Add acidified potassium dichromate and heat under reflux conditions.
The products can be separated using distillation.

Butan-1-ol will react to form a carboxylic acid (which can be tested using sodium carbonate solution – a gas will be produced).

Butan-2-ol will not react to form a carboxylic acid (but forms a ketone).
The product will **not** react with sodium carbonate solution.
(Either statement for 1 mark)

$2Cr_2O_7^{2-} + 3C_4H_{10}O + 16H^+ \rightarrow 4Cr^{3+} + 3C_4H_8O_2 + 11H_2O$ (1 mark)

*An alternative for part (iii) would be to check physical properties.*

*Butan-1-ol will be more dense and have a higher boiling point due to its more linear structure which allows closer packing together of the molecules.*

**END OF SUGGESTED SOLUTIONS**