NSW INDEPENDENT TRIAL EXAMS – 2008
CHEMISTRY TRIAL YR 12 EXAMINATION
MARKING GUIDELINES

Section I – Part A

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
C	A	B	A	C	B	D	B	A	C	D	B	C	D	A

Section II – Part B

16(a)

Criteria	**Marks**
$\begin{array}{cccccc} -CH_2- & CH & -CH_2- & CH & -CH_2- & CH- \\ & \vert & & \vert & & \vert \\ & OH & & OH & & OH \end{array}$	1

16(b)

Criteria	**Marks**
Bromine water is decolourised instantly by the monomer reacting with the double bond. The polymer has single bonds only and reacts very slowly or not at all.	1

16(c)

Criteria	**Marks**
Each unit in the polymer carries a hydroxyl group which is strongly polar and attracted to polar water molecules, forming hydrogen bonds.	1

16(d)

Criteria	**Marks**
PVA plastic is unsuitable for containing wet substances but when dissolved would rapidly break down, unlike polyethylene which is unaffected by water, but takes a long time to break down.	2

16(e) (i)

Criteria	**Marks**
As this is an esterification, a mixture of PVA and pure acetic acid would be refluxed together with a small amount of concentrated sulfuric acid as a catalyst and dehydrating agent.	2

16(e) (ii)

Criteria	**Marks**
Polyvinyl acetate would be insoluble in water as the ester groups have low polarity with little attraction to water.	2

17(a)

Criteria	**Marks**
Octane = $\frac{5500}{114}$ = 48.2 kJg^{-1} = 33 800 kJ/L Ethanol = $\frac{1371}{46}$ = 29.8 kJg^{-1} = 23 550 kJ/L	3

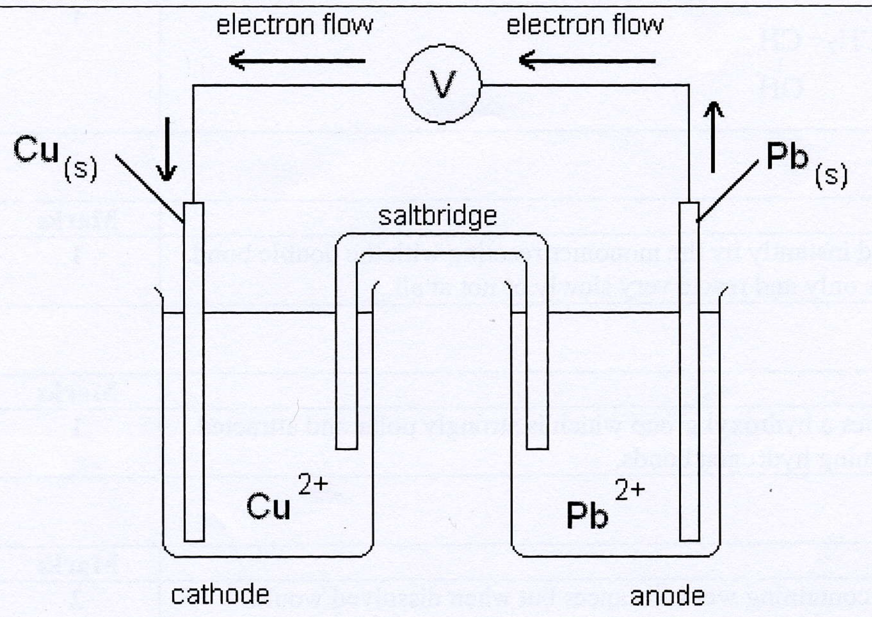
17(b)

Criteria	**Marks**
As each litre of ethanol delivers only 70% of the energy compared with octane, the vehicle will travel only 70% as far on a tank of fuel.	2

17(c)

Criteria	Marks
Ethanol has the advantage of being a renewable fuel which burns cleanly. However, as well as its lower energy content, the production of ethanol uses resources of land, water, fertilisers and energy. Diversion of grains and sugar to produce ethanol fuel competes with food production, resulting in food scarcity and higher prices. These issues are important considerations in determining the impact of using ethanol in preference to petrol.	3

18(a)(i)-(iii)

Criteria	Marks
	3

18(b)

Criteria	Mark
$Pb_{(s)} + Cu^{2+} \rightarrow Pb^{2+} + Cu_{(s)}$	1

18(c)

Criteria	Mark
(+ 0.34) - (- 0.13) = + 0.47 V	1

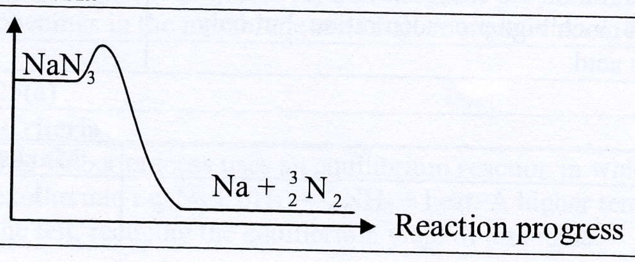
19(a)

Criteria	Marks
Lithium has low density, being at the left of the Periodic Table. It's position at the top of the Redox Table means that its cells have high energy density, delivering a large voltage with low mass.	2

19(b)

Criteria	Marks
The Redox Table shows the lithium reacts directly and strongly with water to produce hydrogen gas.	1

20(a)

Criteria	Marks
	1

20(b)

Criteria	Marks
Moles of N_2 required = $\frac{60}{24.79}$ =2.42 *(1 mark)* 1 mole of NaN_3 yields 3/2 moles of N_2 Therefore moles of NaN_3 needed = 1.61 x (23.0 + 3 x 14) = 105 g *(1 mark)*	2

20(c)(i)

Criteria	Marks
Sodium metal is highly reactive and would ignite in air and severely injure the occupants.	1

20(c)(ii)

Criteria	Marks
Sodium and potassium oxides are strongly basic.	1

20(d)

Criteria	Marks
Silicon dioxide is weakly acidic and neutralises the sodium and potassium oxides, forming sodium and potassium silicate.	2

21(a)

Criteria	Marks
Solution A: Acid concentration = $\frac{0.22 \times 0.12}{25}$ = 1.0 x 10^{-3} mol L^{-1} *(1 mark)* Solution B: Acid concentration = $\frac{13.1 \times 0.12}{25}$ = 0.063 mol L^{-1} *(1 mark)*	2

21(b)

Criteria	Marks
As sodium hydroxide is a strong base, phenolphthalein is the most suitable indicator with a pH range of 8 – 10.	2

21(c)

Criteria	Marks
A pipette is used. Between acids the pipette should be rinsed with water, then a small amount of the second acid.	2

21(d)

Criteria	Marks
Solution A is a strong acid which is at low concentration but fully ionised, for example, hydrochloric acid. Solution B is a weak acid, at a much higher concentration, but only slightly ionised, for example, acetic acid or citric acid.	3

22(a)

Criteria	Marks
10 μg per 100 mL = 10 μg per 100 g $\frac{10\times10^{-6}}{100} = \frac{1}{10}\text{x}10^{-6} = 0.1$ ppm	1

22(b)

Criteria	Marks
NaI, K_2CrO_3, etc in solution to give a coloured precipitate. For example: $Pb^{2+} + 2I^- \rightarrow PbI_2(s)$.	1

22(c)

Criteria	Marks
At less than 1 ppm, the concentration is too low to measure by precipitation. AAS can accurately measure low concentrations (also would be hard to obtain/observe a precipitate in a blood sample).	1

22(d)

Criteria	Marks
Dissolve 0.16 g of $Pb(NO_3)_2$, containing 0.10 g of lead ion, in 1.0 L of water. Dilute 1.0 mL of this to 1.0 L, resulting in 0.1 ppm.	2

22(e)

Criteria	Marks
The lead ion in the sample is at 0.27 ppm = 27 μg/100 mL.	2

23(a)

Criteria	Marks
Salinity prevents the growth of rice which requires freshwater and also reduces the numbers of freshwater animals, disrupting food chains and the food supply for people.	1

23(b)

Criteria	Marks
To a measured volume of water add an excess of barium chloride solution to form a precipitate of barium sulfate. Filter, wash and dry the precipitate. Compare the mass of dry precipitate with that obtained from the same volume of seawater.	3

23(c)

Criteria	Marks
Measure total dissolved solids either by evaporation of a measured volume or by comparing the conductivity of the sample with freshwater.	1

24(a)

Criteria	Marks
Filtration physically removes all particles above a certain size. Sanitisation uses a strong oxidising agent such as chlorine (or ozone) to destroy microorganisms.	2

24(b)

Criteria	Marks
A micro-membrane uses layers of organic polymers supported on a fine mesh. The openings in the membrane are small enough to block the passage of microorganisms.	2

25(a)

Criteria	Marks
The Haber process uses an equilibrium reaction in which the forward reaction is exothermic i.e. $N_2 + 3H_2 \rightarrow 2NH_3$ + heat. A higher temperature shifts the equilibrium to the left, reducing the equilibrium yield of ammonia.	2

25(b)

Criteria	Marks
Iron/iron oxide is a catalyst. It reduces the activation energy for the reaction enabling equilibrium at a much lower temperature.	2

Section II

Question 26 – Industrial Chemistry

Q 26(a)

Criteria	Marks
• Soaps are sodium or potassium salts of long chain fatty acids and are therefore anionic surfactants. Non-ionic detergents are long chain compounds with highly polar groups (such as multiple OH groups) attached to a non-polar hydrophobic chain. *(2marks)* • Both soaps and detergents act by lowering the surface tension of water and forming an emulsion in which hydrophobic "dirt" molecules are dissolved into the non-polar core of an emulsion particle, called a micelle. *(1 mark)* • Soaps are relatively cheap and made from natural products, fats and oils. However being salts of weak acids they have a high pH which can damage the skin. Non-ionic detergents are synthetic but are neutral and much less damaging to the skin. They can also be "engineered" for special purpose detergents for domestic and industrial use. *(2 marks)*	5

Q 26(b)(i)

Criteria	Marks
A 90% yield can be obtained only at impractically low temperatures and high pressures. Below 400 degrees the ammonia synthesis reaction is far too slow to establish equilibrium.	2

Q 26(b)(ii)

Criteria	Marks
$[NH_3]$ = 20%x5.56 therefore $[N_2]$ = 20%x5.56 and $[H_2]$ = 60%x5.56 $K = [NH_3]^2/([N_2] \text{x} [H_2]^3) = 1.11^2/1.11 \text{ x } 3.34^3 = 0.030$ *(2 marks)* Increased temperature reduces the equilibrium yield of ammonia (graphs) and so decreases the value of the equilibrium constant. *(1 mark)*	3

Q 26(b)(iii)

Criteria		Marks
$K = [NH_3]^2/([N_2] \times [H_2]^3)$. If all values doubled, the top line of the expression increases by a factor of 4 and the bottom line increases by a factor of 16	*(1 marks)*	2
Since K is independent of concentration, equilibrium must shift to reduce the concentration of the reactants (bottom line) and increase the concentration of the products (top line) to keep K a constant value, hence an increase in the percentage of ammonia.	*(1 mark)*	

Q 26(c)(i)

Criteria	Marks
Safety glasses, chemical apron, fume hood and acid must be added to water, not vice-versa.	1

Q 26(c)(ii)

Criteria	Marks
• As a dehydrating agent: concentrated sulfuric acid carbonised a carbohydrate (sugar or paper) by removing water from its structure. *(1 mark)* • As an oxidising agent: Copper metal pieces were added to hot concentrated sulfuric acid. The copper was oxidised to the copper(II) ion as shown by the corrosion of the metal, production of pungent sulfur dioxide and the blue colour of the solution. *(2 marks)*	3

Q 26(d)(i)

Criteria	Marks
The products are hydrogen and chlorine gases and sodium hydroxide.	2

Q 26(d)(ii)

Criteria	Marks
The membrane cell combines the advantages of the other two, producing very pure sodium hydroxide at up to 40% concentration, with comparatively low energy input. It avoids the disadvantage of mercury pollution in the waste from the mercury cell, and the low concentration and purity of sodium hydroxide from the diaphragm cell, where the product contains significant amounts of sodium chloride.	3

Q 26(e)

Criteria	Marks
• The Solvay process requires a high energy input as heat from combustion of fossil fuels. It also requires a supply of calcium carbonate (limestone) from which impurities form a waste sludge which must be disposed of. The other principal waste is calcium chloride solution which must be discharged into a large volume of oceanic water to avoid harmful effects. *(2 marks)* • The electrolytic method is much cleaner, using electricity from the grid and avoiding the production of large volumes of waste. It can also use carbon dioxide from flue gas which would otherwise enter the atmosphere. While the Solvay process is not suited to an urbanised area this is not the case for the electrolytic process. *(2 marks)*	4

Question 27 – Shipwrecks, Corrosion and Conservation

Q 27(a)

Criteria	Marks
The environment of this wreck is almost ideal for preservation. The deep water contains almost no oxygen and the low temperature greatly slows any corrosion or decomposition reactions. The freshwater conditions provide little sulfate or other nutrients for anaerobic bacteria. Oceanic wrecks are in an active electrolyte, accelerating corrosion. In shallow water oxygen results in rapid corrosion and decay while the sulfate ions in deep seawater nourish sulfur-reducing bacteria, which actively corrode steel and other metals.	4

Q 27(b)(i)

Criteria	Marks
• Galvanising provides both physical and electrochemical protection to steel. (*1 mark*) • Physical protection is provided by the galvanised film which excludes the access of oxygen and water to the steel. Galvanised roofing is protected by a tough impervious layer of zinc and aluminium oxides, which rapidly reforms if the surface is scratched. (*1 mark*) • Electrochemical protection is provided as both zinc and aluminium are more active (higher in the redox table) than steel. When water is present, acting as an electrolyte the steel becomes the cathode of the cell formed, creating a reducing, non-corrosive environment. (*2 marks*)	4

Q 27(b)(ii)

Criteria	Marks
Graphite will form a cathode creating a cell in which the voltage is high enough for zinc and aluminium (as the anode) to corrode quite rapidly, creating a corrosion channel in the galvanised layer and exposing the steel.	2

Q 27(c)(i)

Criteria	Marks
Half-reactions: $H_2O \rightarrow \frac{1}{2}O_{2\,(g)} + 2H^+ + 2e^-$ and $H^+ + e^- \rightarrow \frac{1}{2}H_{2(g)}$ (*2 marks*) Overall: $H_2O \rightarrow \frac{1}{2}O_{2\,(g)} + H_{2(g)}$ (*1 mark*)	3

Q 27(c)(ii)

Criteria	Marks
• The applied voltage: below a minimum threshold voltage little reaction occurred, above this voltage the rate of the reaction was increased as the voltage increased. (*1 mark*) • The concentration: The higher the concentration the faster the reaction at a given voltage. (*1 mark*) OR: Electrode surface area and/or electrode separation (perhaps also electrode composition).	2

Q 27(c)(iii)

Criteria	Marks
For example, highly oxidised metal artefacts can be placed as cathodes in an electrolytic cell using an inert anode. Under the right conditions the preferred cathode reaction will be reduction of the corroded material (oxide, carbonate, sulfate, etc) to the metal, which is thereby restored.	2

Q 27(d)(i)

Criteria	Marks
If the artefact is allowed to dry out by evaporation the crystalline solutes (sodium, potassium, calcium chlorides and sulfates) form within the grain of the wood, expanding and fracturing the fibres. The exposure to oxygen can also promote bacterial and fungal attack on the exposed wood.	**2**

Q 27(d)(ii)

Criteria	Marks
The artefacts are immersed for many months in deoxygenated freshwater baths, with frequent changes of water to carry away soluble salts as they are leached from the wood. After careful drying the artefact can then be impregnated with a clear resin to prevent further exposure to water and oxygen.	**3**

Q 27(e)

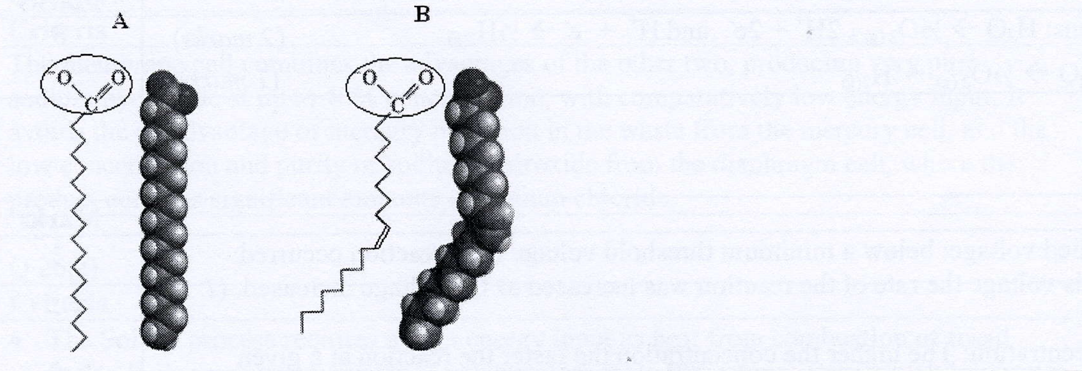
Criteria	Marks
• The magnesium provides cathodic protection to the steel by creating an electrochemical cell in which magnesium is the anode, the water is the electrolyte and steel is the cathode. The steel will not corrode until all of the magnesium has been oxidised which takes several years. (*2 marks*) • If a copper rod were used the steel would become the anode and its corrosion would be accelerated by the presence of the copper acting as the cathode. (*1 mark*)	**3**

Question 28 – The Biochemistry of Movement

Q 28(a)

Criteria	Marks
$CH_3(CH_2)_nCOOH$.	**1**

Q 28(b)(i)

Criteria	Marks
	**1**

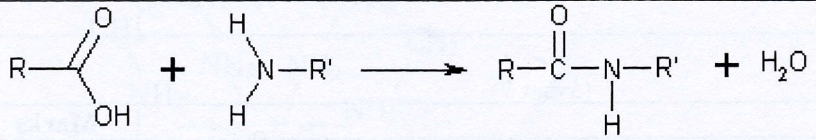
Q 28(b)(ii)

Criteria	Marks
The polar part of the molecule (the carboxylic acid) will dissociate in water or hydrogen bond with water. The tail of the molecule is hydrophobic and will associate with the non-polar parts of other molecules. The longer the tail the less soluble the molecule is in water; etc.	**3**

Q 28(c)

Criteria	Marks
Common name: glycerol, glycerine. Systematic name; propane-1,2,3-triol. (*1 mark for each*).	2

Q 28(d)

Criteria	Marks
	3

Q 28(e)

Criteria	Marks
Enzymes are peptides that catalyse reactions in living things. They have an active site that binds a specific substrate. E.g. The protease enzyme called chymotrypsin hydrolyses specific peptide bonds in proteins. Its active site contains a deep channel which binds the bulky hydrophobic side chains of the substrate protein. This brings the peptide bonds, near hydrophobic side chains, into a position where they can be cleaved. This is why chymotrypsin breaks specific peptide bonds that are next to large hydrophobic side chains.	5

Q 28(f)(i)

Criteria	Marks
Mitochondria are the site of aerobic respiration and most ATP synthesis.	1

Q 28(f)(ii)

Criteria	Marks
The process that couples the oxidation of NADH and $FADH_2$ to the production of ATP.	2

Q 28(f)(iii)

Criteria	Marks
Lactic acid is produced due to the need to regenerate NADH. A relatively small amount of ATP is produced (compared to oxidative phosphorylation). The pyruvate produced does not enter the citric acid cycle, as the final electron acceptor for the electron transport chain (oxygen) is not present. Instead the pyruvate is fermented into lactic acid. The presence of lactic acid inhibits ATP production (if the concentration of lactic acid is to high ATP production may stop). This impairs muscle function.	4

Q 28(g)

Criteria	Marks
Glucose is the monomer (single unit) that forms the polymer glycogen. The structure of glucose is $C_6H_{12}O_6$. Glycogen is formed from the D-glucose isomer and is formed by α-1,4 glycosidic bonds.	3

Question 29 – Chemistry of Art

Q 29(a)

Criteria	Marks
• Examples are hematite (iron oxide), galena (lead sulfide), and malachite (copper carbonate). (*3 marks*) • These compounds occur widely in nature, are chemically stable and insoluble in water. These properties together with their strong colours, orange-red hematite, grey-black galena and green malachite make them useful as pigments for body decoration or other artwork. (*3 marks*)	**6**

Q 29(b)(i)

Criteria	Marks
e.g. Manganese. Manganese has 7 valence shell electrons, 2 in the 4S orbital and 5 in the 3d orbitals, with identical or closely spaced energy levels. Between 2 and all 7 electrons can be involved in bonding leading to a range of oxidation states from +2 to +7 as well as zero for the metal itself.	**3**

Q 29(b)(ii)

Criteria	Marks
Starting with a solution of potassium permanganate $KMnO_4$, the deep purple colour turned green when sodium hydroxide was added, the oxidation state changing from +7 to +6 (MnO_4^{2-} ion). When sodium sulfite was then added the manganese was reduced to a brown precipitate of manganese dioxide (MnO_2 +4 state). When sodium sulfite was added to acidified potassium permanganate it slowly turned pink then colourless as it was reduced to the manganese(II) ion, Mn^{2+}.	**3**

Q 29(c)(i)

Criteria	Marks
An emission spectrum is formed when light is emitted from atoms excited by heat or an electric discharge. An absorption spectrum is formed when light of selected frequencies is absorbed by the electrons in atoms moving to higher energy levels.	**2**

Q 29(c)(ii)

Criteria	Marks
Potassium ions produce a lilac coloured spectrum in a flame test, much less intense than the yellow of sodium impurities. When light from the mixture passes through cobalt glass the emission from potassium is unaffected but the yellow sodium light is absorbed by the strong cobalt absorption band which includes the 590 nm region.	**3**

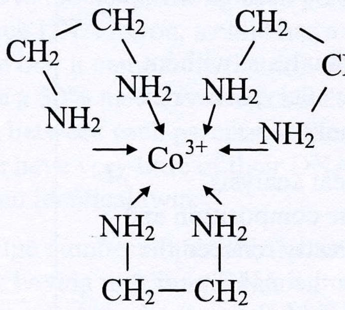
Q 29(d)(i)

Criteria	Marks
$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^3$	**2**

Q 29(d)(ii)

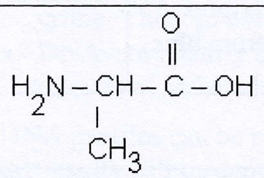
Criteria	Marks
• The sharp increase in ionisation energy after the 5th shows that the last valence electron has been removed and a new shell has to provide the electron for the 6th ionisation. (*2 marks*) • Therefore the maximum oxidation state is +5 and this is the state in the vanadate(V) ion VO_3^-.	**3**

Q 29(e)

Criteria	Marks
The ethylenediamine contains two amino groups each having an unshared electron pair which is available to form a coordinate covalent bond with a cobalt ion. The molecule acts as a bivalent ligand or "claw" with each end attached to the cobalt atom. The partially filled valence levels of the cobalt ion accommodate 3 chelating molecules, forming the complex ion $[Co(ED)_3]^{3+}$. (*2 marks*)  (*1 mark*)	3

Question 30 – Forensic Chemistry

Q 30(a)(i)

Criteria	Marks
	1

Q 30(a)(ii)

Criteria	Marks
Amino acids can be separated using differences in their mass and electric charge.	1

Q 30(a)(iii)

Criteria	Marks
To introduce a negative charge to the amino acid so that it would be attracted towards the positive electrode, a hydrogen ion would need to be removed from it. This could be achieved using an alkaline solution with a high pH, well above the isoelectric point for alanine.	2

Q 30(b)(i)

Criteria	Marks
A disaccharide consists of two monosaccharides (simple sugars) linked together. A polysaccharide consists of a large number of monosaccharides linked together forming a long chain.	1

Q 30(b)(ii)

Criteria	Marks
Different polysaccharides are produced by plants and animals. Starch and cellulose are produced by plants while glycogen is produced by animals. These three polysaccharides are all made from glucose monomer units but they are joined together in different ways. Cellulose is made of long chains of beta-glucose units joined together. Starch and glycogen are both made of alpha-glucose units. Glycogen has shorter chains (hence a lower molecular weight) and is more branched than starch. Therefore analysis of a polysaccharide determining its structure can determine whether a sample has animal or plant origins.	3

Q 30(c)

Criteria	Marks
Any method of analysis that changes the evidence in any way is called destructive analysis. A result of destructive analysis is that the original material is not able to be recovered. This may be a problem in a forensic investigation as: • Evidence in court cases may need to be retained for legal reasons; • Once destroyed, the material cannot be subjected to other analyses and would not be available should new analytical techniques be developed in the future that would give vital information; • Certain objects cannot be altered, by the removal of samples for analysis, without causing unacceptable damage eg historical artefacts, valuable jewellery, artworks; • Tests cannot be repeated to increase validity of the results or conclusions. Examples of destructive analysis include just about all of the chemical analysis techniques. This type of analysis can be important in determining the composition and structure of a forensic sample. Advances in technology have now greatly reduced the amount of material, or size of a sample, needed for testing, allowing the majority of the evidence to remain intact and unaltered.	4

Q 30(d)(i)

Criteria	Marks
Glucose is a reducing sugar while sucrose is a non-reducing sugar. They can therefore be distinguished by testing a solution of each with Benedict's solution. When the mixtures are warmed, the glucose will react resulting in the Benedict's solution changing from blue to orange. The sucrose will not react.	2

Q 30(d)(ii)

Criteria	Marks
A small amount of sodium carbonate solution could be added to separate samples of each compound. The propanoic acid will react with the carbonate producing bubbles of carbon dioxide gas while the 1-propanol will not react.	2

Q 30(e)

Criteria	Marks
DNA carries the genetic code that determines all of the inherited characteristics of a living organism. Because all humans have a large number of characteristics in common, over 99% of a person's DNA will be identical to that of another person. Each DNA molecule contains thousands of genes, each gene separated from the next by a "non-coding" sequence of bases called introns. These introns vary significantly from one person to the next making each person's DNA unique. For each DNA intron, a child has a 50% chance that it came from the mother and a 50% chance that it came from the father. These probabilities mean that for a set of introns there will be a 50% match between brothers and sisters. It also means that there will be a 50% match between each parent and the child. Cousins show a 25% match while unrelated people have very little of their DNA introns matching. 100% matching would only occur between identical twins. The huge number of possible intron combinations means that the chances of unrelated people having matching DNA is one in many billion. Matches or % matches of DNA can then be considered a very reliable indicator of relationships. DNA analysis can be used in a variety of forensic investigations. For example: • DNA from different people can be compared to establish the relationship between them. • DNA samples from a suspect can be compared to samples obtained from the scene of a crime. This can assist in establishing the guilt or innocence of a person. • DNA can identify body parts remaining from accidents or terrorist attacks, in museums or even at archaeological sites. DNA profiles can be produced from very small samples from the body. The reliability of the results will be dependent on the procedures in place for preventing contamination of the samples being tested. Forensic scientists take great care to ensure that samples are not contaminated when collected or when being tested. Therefore, providing that procedures are in place to prevent the possibility of contamination, this DNA fingerprinting is a very important and reliable method for determining relationships between people or matching people to DNA samples.	5

Q 30(f)(i)

Criteria	Marks
The emission spectrum of an element consists of a number of discrete frequencies or colours of light characteristic of that element. This spectrum is produced when excited electrons in an atom move from a high energy level to a lower energy level. The frequency of the emitted light will correspond exactly with the difference in energy between the two energy levels that the electron moved between. Since each element has its own unique set of energy levels in its atoms, the frequency of light emitted by a sample of an element will be unique and characteristic of that element.	2

Q 30(f)(ii)

Criteria	Marks
Mass spectrometers separate and identify substances on the basis of the mass of the positive ions formed when a sample is bombarded by high energy electrons. The stream of high energy electrons causes the sample molecules to break into fragments and lose electrons, resulting in a positive charge. These fragments are accelerated by electric fields and then passed into a magnetic field. The radius of the curved path taken in the magnetic field depends on the charge/mass ratio of the fragments, allowing the different fragments to separate and be identified. Each peak present in the mass spectrum is produced by a different ion fragment. The mass spectrum of an organic molecule contains a large number of peaks due to the many different ion fragments produced when bombarded by the high energy electrons.	2