

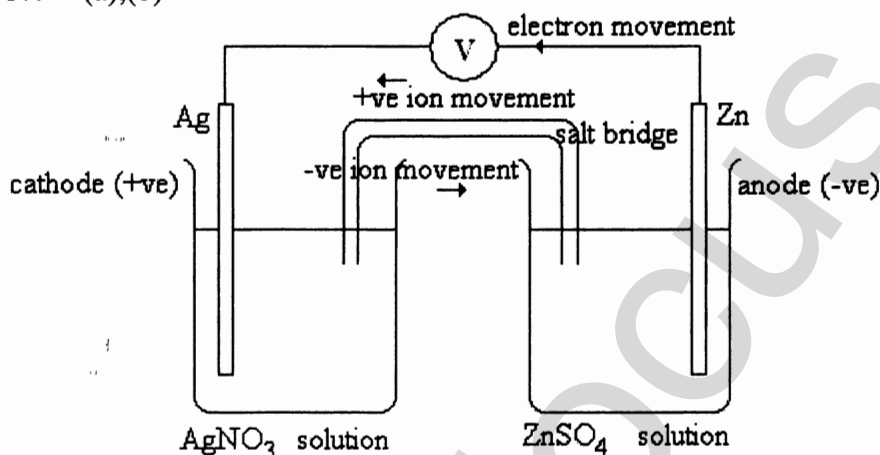
NSW INDEPENDENT TRIAL EXAMS – 2004

HSC CHEMISTRY - SUGGESTED ANSWERS**PART A**

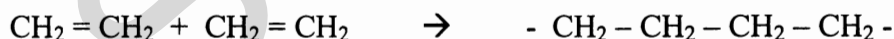
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
C	B	B	D	A	B	D	C	D	B	A	C	B	C	D

PART B.

16. (a) $\text{C}_2\text{H}_6(\text{g}) \rightarrow \text{C}_2\text{H}_4(\text{g}) + \text{H}_2(\text{g})$ 1
 (b) A high temperature both accelerates the reaction and drives the equilibrium to the right, increasing the yield of ethene. 1
 (c) When ethane is bubbled through bromine water there is no immediate reaction whereas when ethene is bubbled through bromine water the bromine water becomes colourless almost instantaneously. 2
 17. (a),(b) 3



- (c) $2\text{Ag}^+ + \text{Zn}(\text{s}) \rightarrow 2\text{Ag}(\text{s}) + \text{Zn}^{2+}$ 1
 (d) Cell potential = $0.80 + 0.76 = 1.56\text{V}$ 1
 18. (a) Glucose, $\text{C}_6\text{H}_{12}\text{O}_6$ 1
 (b) A condensation polymer is a polymer that forms with the elimination of a small molecule (often water) when monomer molecules join together. 1
 (c) Addition polymers form without the loss of any atoms when the monomer molecules join together. Polyethylene is an example of an addition polymer. 1



Ethylene monomer molecules

polyethylene

The double bond in the ethylene monomer molecules “open out” to allow them to join together without the loss of any atoms.

19. (a) $\text{Fe}(\text{s}) + \text{Cu}^{2+} \rightarrow \text{Cu}(\text{s}) + \text{Fe}^{2+}$ 1
 (b) Iron is a more active metal and so it is a stronger reductant (electron donor) than copper. 1
 Electrons can therefore be transferred from the $\text{Fe}(\text{s})$ to the Cu^{2+} forming $\text{Cu}(\text{s})$ – the red/brown deposit. The blue colour of the Cu^{2+} in solution faded as the Cu^{2+} was used up in the reaction. 1
 $\text{Cu}(\text{s})$, being a weaker reductant than $\text{Fe}(\text{s})$, is unable to lose electrons to the Fe^{2+} ion, therefore no reaction occurs in test tube 2, hence no observed changes. 1

20. (a) The mass of the reaction vessel containing the fermenting mixture decreased during the fermentation process. This process produces CO₂ gas as shown in the equation below. 1



This gas was allowed to escape from the reaction vessel to avoid a build up in pressure, thus producing the observed decrease in mass. 1

- (b) Fermentation is caused by the action of enzymes present in yeast. which requires water and temperatures between 30 and 35°C. The fermentation was carried out by adding yeast to a dilute aqueous solution of glucose that was kept within this temperature range. The dilute aqueous solution also allowed significant amounts of ethanol to be produced without the ethanol concentration exceeding 15% as concentrations above this value kill the yeast and stop fermentation. Air was excluded from the reaction vessel as in the presence of oxygen the ethanol can be further oxidised to form different products. 2

21. (a) $\text{S}(\text{s}) + \text{O}_2(\text{g}) \rightarrow \text{SO}_2(\text{g})$

Mass of sulfur in lignite = $1000 \times 0.05/100 = 0.5\text{g}$

Moles of sulfur = mass/molar mass = $0.5/32.07 = 1.56 \times 10^{-2}$

Moles of sulfur dioxide = moles of sulfur = 1.56×10^{-2} 1

Volume of SO₂ = Moles x Molar volume

= $1.56 \times 10^{-2} \times 24.79$ 1

= 0.386 L

- (b) The impact of burning large quantities of high sulfur fuels is detrimental to the environment where that fuel is being burned.

- high sulfur fuels release large amounts of sulfur dioxide into the atmosphere. 1

- Sulfur dioxide is poisonous to living things 1

- Sulfur dioxide dissolves in water in the atmosphere to produce sulphurous/ic acid

- sulphurous/ic acids fall as acid rain lowering the pH of many natural systems with the potential to change the environment and the organisms in it 1

22. (a) A buffer is a system which can maintain approximately the same pH even when significant amounts of strong acid or base are added. 1

Buffered solutions contain comparable amounts of a weak acid and its conjugate base 1

- (b) (i) According to le Chateliers principle addition of H⁺ ions will move the equilibrium to the left, restoring the original H⁺ ion concentration. 1

(ii) addition of OH⁻ ions will move the equilibrium to the right, restoring the original H⁺ ion concentration. 1

23. (a) The hydrogen ion concentration in the HCl is 0.1 mol L⁻¹. This is 10 times the concentration in citric acid and 100 times the concentration in the acetic acid. 2

- (b) Hydrochloric acid is 100% ionised in dilute solution, so that the hydrogen ion concentration is equal to the acid concentration.(1mk) Citric acid is only partly ionised (~5%) and acetic acid is a still weaker acid and has lower degree of ionisation.(1 mk) In both weak acids the hydrogen ion concentration is much less than the concentration of the dissolved acid.(1 mk) 3

24. (a) The vinegar was diluted accurately using a pipette and volumetric flask. 1

The diluted vinegar was titrated against a standard NaOH solution 1

The end point was found using phenolphthalein indicator, and the concentration of the undiluted vinegar calculated from the titration result. 1



mass of acid in 5 mL = $5 \times 4/100 = 0.20\text{ g}$; mole mass of acetic acid = 60 g 1

moles of acid = mass/molar mass = $0.20/60 = 0.0033\text{ mole}$

moles of NaOH required = 0.0033 1

Volume of NaOH = moles/molarity = $0.0033/0.118 = 0.0280\text{ L} = 28.0\text{ mL}$ 1

25(a) A quantity of lawn fertiliser was ground up in a mortar and pestle
Set quantity weighed out eg 2.00 g and dissolved in dilute HCl and stirred.
Excess BaCl₂ was then added to the solution to precipitate the BaSO₄
The precipitate of BaSO₄ was filtered dried and weighed..

3

(b) Initial mass of ground lawn food weighed out eg 2.00 g.
The mass of SO₄²⁻ was determined in the BaSO₄
Mass of SO₄²⁻ in sample = (rel mass of SO₄²⁻ / rel mass of BaSO₄) x 2g
Then the % of SO₄²⁻ in lawn food = (Mass of SO₄²⁻ / 2g) x 100

3

26. (a) Any one of pH, turbidity, TDS, oxygen level, BOD etc

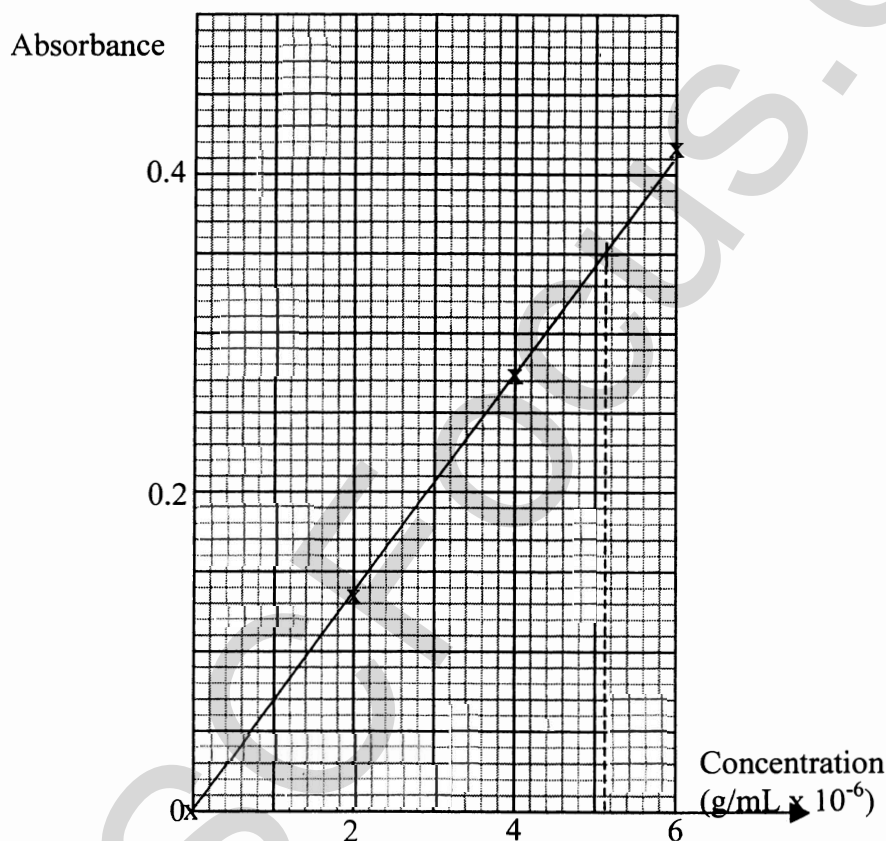
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(b) eg., High BOD. With a high BOD the oxygen demand from organic material in the water results in reduced oxygen levels, and the death of aerobic organisms including animals.
The growth of anerobic bacteria is promoted, resulting in release of acidic/toxic compounds such as hydrogen sulfide.

1

27. (a). Absorbance vs. concentration for standard nickel ion solutions

2



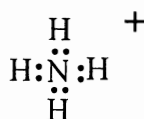
(b). From the calibration curve [Ni²⁺] = 5.1 x 10⁻⁶ g mL⁻¹
Concentration in water sample = 5.1 x 10⁻⁵ g mL⁻¹

1

1

28. (a)

1



(b) A coordinate covalent bond is one where the shared electron pair is provided by one of the bonded atoms. The ammonium ion forms when the unshared pair of electrons on the nitrogen atom in ammonia, is used to form a bond with a proton.

2

29. (a) The production of ammonia is exothermic. This is shown by the yield which decreases with temperature. Le Chatelier's Principle shows that increased temperature shifts the equilibrium to the left, absorbing heat energy and opposing the change. 2
- (b) An increase in temperature will increase the speed of the reaction, but decrease the yield at equilibrium. 1
- (c) Increased pressure results in an increase in the rate of reaction, from increased reactant concentrations. It also increases the yield as the reaction occurs with a reduction of pressure (4 gaseous molecules $\rightarrow$ 2). By Le Chatelier's Principle an increase in pressure shifts the equilibrium to the right, towards reduced pressure. 2

Section II Options:

Q28. Industrial Chemistry

(a) (i) $K = \frac{[I_3^-]}{[I_2][I^-]}$ 1

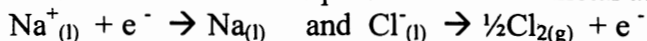
(ii) $K = 8 \times 10^{-2} \div (2 \times 10^{-2})^2 = 200$

(iii) Addition of potassium iodide crystals increases the iodide ion concentration, resulting in an increase in $[I_3^-]$ and a decrease in $[I_2]$, the equilibrium shifting to the right. 2

K remains constant. 2

(iv) This shows that the forward reaction is exothermic. 1

- (b) Molten sodium chloride produces sodium metal at the cathode and chlorine gas at the anode. 1

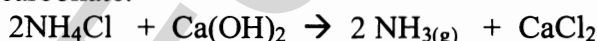


Concentrated sodium chloride solution produces hydrogen gas at the cathode and chlorine gas at the anode. 1



In the molten salt the sodium ion is the only species present to be reduced. In aqueous solution water is reduced more easily than sodium ion so that hydrogen is produced. 1

- (c) Ammonium chloride solution was heated with calcium hydroxide, producing ammonia gas. In the Solvay process this reaction is used to recover ammonia, and recycle it for the further production of sodium carbonate.



Ammonia is used in precipitating sodium hydrogen carbonate, by passing carbon dioxide gas into a strong solution of sodium chloride which is saturated with ammonia. Sodium carbonate is then obtained by heating the sodium hydrogen carbonate. 4

Alternative such as dry ice was added to solution saturated with ammonia and sodium chloride, forming a precipitate of sodium hydrogen carbonate.

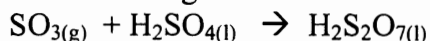


- (d) The three main steps in the production of sulfuric acid are:

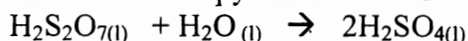
1. The combustion of sulfur, in excess oxygen to produce a mixture of sulfur dioxide and oxygen. $S_{(l)} + O_{2(g)} \rightarrow SO_{2(g)}$ 1

2. The conversion of sulfur dioxide to sulfur trioxide in the Contact Process. The gases are reacted at 400 - 500°C and a pressure of 1-2 atm over a vanadium pentoxide catalyst. A moderate temperature is used to achieve a high reaction rate without reducing the yield, as the reaction is exothermic. Excess oxygen and increased pressure also assist to increase the yield of sulfur trioxide. $SO_{2(g)} + \frac{1}{2}O_{2(g)} \rightarrow SO_{3(g)}$ 2

3. The dissolving of sulfur trioxide in concentrated sulfuric acid:



4. The reaction of pyrosulfuric acid with water to form sulfuric acid: 1



- (e) Soaps are anionic surfactants which are derived from long chain fatty acids. The carboxyl group (COO^-) acts as the hydrophilic group in these molecules. With calcium or magnesium ions, in hard water, these groups form insoluble precipitates (scum) which attaches to the

fabric and prevents lathering.

Synthetic soaps and detergents have been developed which do not form insoluble precipitates in hard water. These include alkyl benzene sulfonates containing the SO_3^- group as an anionic hydrophilic group. Cationic detergent based upon nitrogen compounds and non-ionic detergents containing highly polar groups in neutral molecules are also in widespread use. Detergents can have adverse environmental effects in several ways. As surfactants they reduce the surface tension of water affecting the survival of aquatic animals. Nitrate and phosphate ions are released as detergents decompose, stimulating plant growth and leading to the problem of eutrophication of waterways.

Q29. Shipwrecks and Salvage

(a) (i) Zinc reacts with the oxygen in the air forming a stable oxide coat which prevents further oxidation. The oxide coat converts this active metal to a passive metal

(ii) Drilling or cutting breaks the continuity of the coat and exposes the mild steel to oxygen and water.

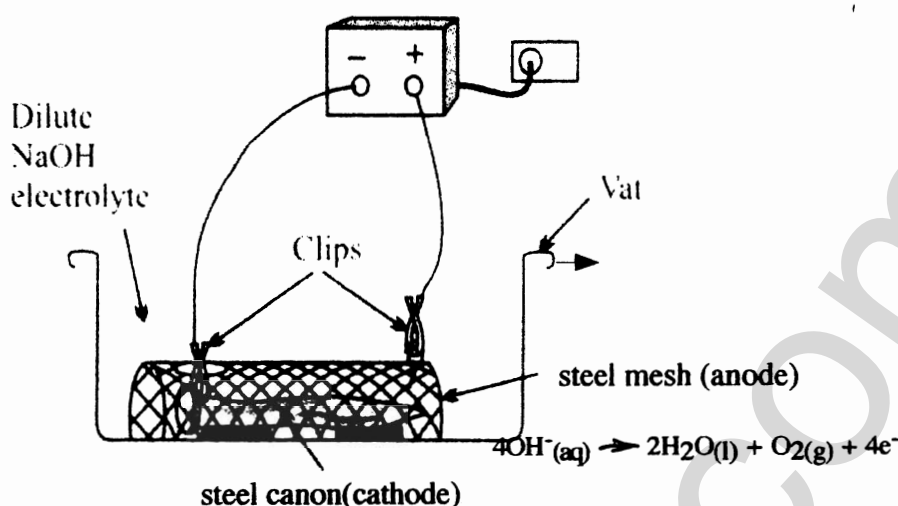
The mild steel under the zinc coat will not rust even though the coating is broken. The mild steel under the cadmium does rust

Zinc being a more active metal than iron gives up its electrons in preference to the iron and hence protects the iron acting as a sacrificial anode. The cadmium is less active than iron and does not offer the same protection. Iron loses its electrons to the oxidizing agent and corrodes

(b) Possible result table and explanations:

Substance coated on Steel	Observations	Explanation
Steel coated with enamel paint	No rust on steel other than where the paint does not cover the steel	Painting the steel excludes water and oxygen from rusting the steel but where the paint does not cover the steel rust occurs
Steel coated with anti-rust paint	No rust on steel other than where the anti – rust paint does not cover the steel	Painting the steel excludes water and oxygen from rusting the steel but where the paint does not cover the steel rust occurs
Steel coated with zinc	No rust at all	Zinc coating protects the steel from rusting as the Zn is more active than the steel and will oxidise keeping the steel in a reduced state.
Steel coated with tin	No rust on steel, but a crack in the tin coating has caused the steel to corrode.	Tin is less active than the steel and will not corrode and stops the water and oxygen from getting to the steel. When the tin layer is scratched the iron underneath begins to rust.

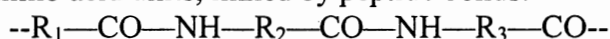
(c) (i) Any clear diagram showing the canon on a bath of NaOH surrounded by a steel mesh anode. Canon must be labeled as the cathode and the mesh the anode. A clear arrow must show the movement of chloride ions from the canon towards the steel mesh anode



- (ii) The sodium hydroxide solution provides an alkaline electrolyte. 1
 The alkaline electrolyte passivates the iron and prevents production of acid (H^+ ions) at the anode, by oxidation of water 1
- (d) (i) The environment in which a ship sinks is critical in determining its rate of corrosion 3
 The moderate levels of dissolved oxygen found in shallow waters will lead rapid corrosion of shipwrecks to iron oxides, and is faster than in anoxic deep waters. The conditions at depth are usually anoxic and bacterial induced corrosion occurs. 3
- (ii) sulfate-reducing bacteria obtain energy by reducing SO_4^{2-} to H_2S , using electrons from the oxidation of iron metal to Fe^{2+} . The Fe^{2+} reacts with water to form $\text{Fe}(\text{OH})_2$ 2
- (e) Volta's experiments lead to the first battery and rejected Galvani's idea of animal electricity and proved that two dissimilar metals need to be in contact for electricity to flow. 6
 Davy experimented with passing electricity through molten compounds using batteries eg KOH and NaOH. Predicted large scale use of electrolysis to make alkalis and isolating elements
 Faraday developed laws of electrolysis that followed on from Davy.
 Faraday's impact lead to Arrhenius theory of ionic solutions and used terms such as electrolyte, ions, cathode, anode etc and suggested the idea of flow of charges which we call electrons.

Q32. Biochemistry of Movement

- (a) (i) General formula is $\text{C}_x(\text{H}_2\text{O})_y$ 1
 Glucose is $\text{C}_6\text{H}_{12}\text{O}_6$ which is equivalent to $\text{C}_6(\text{H}_2\text{O})_6$ 1
- (ii) Glycogen is formed by condensation polymerisation of glucose. 1
 Glycogen is stored in the muscles and liver. 1
- (b) (i) In oxidative phosphorylation, oxidation of NADH to NAD^+ provides the energy to link a third phosphate group to ADP, forming ATP. 2
- (ii) Muscles contract in response to the release of calcium ions from a nerve impulse. The contraction involves the formation of temporary bonds between actin and myosin fibres. 1
 ATP provides the energy for the formation of these bonds, reverting to $\text{ADP} + \text{P}$ 1
- (c) Peroxidase is an enzyme which catalyses the breakdown of hydrogen peroxide. It is a polymer based upon amino acid units, linked by peptide bonds:



The shape of the enzyme is determined by its primary structure as well as intramolecular forces such as hydrogen and disulfide bonds. The shape of the enzyme molecule is critical to its function for which the enzyme must bind with the substrate molecule. Only with the correct geometry is this binding and the subsequent chemical reaction possible; this is similar to the fit of a key to a specific lock. For this reason each enzyme acts only on a specific substrate. 3

- (d) (i) $\text{CH}_2\text{OHCHOHCH}_2\text{OH}$ (1,2,3-trihydroxypropane) 1
- (ii) Glycerol is a small molecule with three highly polar hydroxyl groups, and strong hydrogen bonding. It is strongly attracted to water molecules, which have similar polar OH groups. As a result glycerol is fully soluble (miscible) with water. 2
- (iii) Glycerol stores fatty acids as esters, called triacylglycerols (TAGs). These esters have no polar hydroxyl groups but have long hydrophobic fatty acid (alkyl) chains. The nonpolar fatty acid chains dominate and TAGs are very insoluble in water. 3
- (e) Type 1 muscle cells are used in light exercise and involves aerobic respiration. These cells can metabolise glucose, fatty acids and proteins, oxidising them to carbon dioxide. Type 2 muscle cells are "fast" muscle cells used in bursts of strenuous activity such as sprinting. These cells mostly metabolise glycogen, stored in the muscles, and result in the conversion of glycogen to glucose then to lactic acid. Both Type 1 and 2 cells metabolise glucose, through the process of glycolysis which occurs in the cytoplasm. In glycolysis each glucose molecule is broken down to two pyruvate (3-carbon) fragments. In Type 1 cells the pyruvate enters the TCA cycle in the mitochondria, where oxygen is used convert the glucose fragments to carbon dioxide, in oxidative decarboxylation. In Type 2 cells the conversion of pyruvate to lactic acid occurs in the cytoplasm. For this reason Type 2 cells have few mitochondria, while Type 1 cells are dense in these organelles. Type 1 cells produce much more energy, in the form of ATP molecules than Type 2; however Type 2 are more capable of producing short and intense bursts of energy. 6
- Q31. Chemistry of Art
- (a) eg., Ancients used cinnabar (HgS , vermilion) as a red pigment for lipstick and rouge. and orpiment, As_2S_3 used a a yellow pigment in eye shadow. 2
These contain elements which a cumulative toxins, causing skin lesions and wrinkling and poisoning in prolonged use. 1
- (b) (i) Emission spectra are produced when gaseous atoms are excited by heat or electric discharge, and the light produced separated into its line spectrum. 1
Absorption spectra are produced when light passes through a substance as a vapour or solution and the transmitted light separated into its spectrum. 1
- (ii) Bohr proposed that the electrons in an atom could exist with precise energy values. The spectral frequencies are produced when electrons move between these energy levels, emitting or absorbing specific frequencies of light. 2
- (iii) The colour will be red-purple (magenta), as red and violet wavelengths are transmitted while orange/yellow/green and blue are absorbed. 2
- (c) (i) $1s^2 2s^2 2p^6 3s^2 3p^6 3d^7 4s^2$ 1
- (ii) Each complex ion consists of a cobalt(III) ion surrounded by molecules which have unshared electron pairs. 1
These molecules are called ligands, NH_3 in ion A and $\text{NH}_2\text{CH}_2\text{CH}_2\text{NH}_2$ in ion B. 1
In both ions the ligands attach to the cobalt ion by forming coordinate covalent bonds, using an unshared electron pair. In B each ligand has two attachment points, a type of bonding called chelation. 1
Cobalt ion can accept these electron pairs for bonding as it contains vacant orbitals in the valence levels. 1
- (d) (i) $\text{Na}_{(g)} \rightarrow \text{Na}_{(g)}^+ + e$ 1
- (ii) The ionisation energy increases as successive electrons are removed and the remaining atom becomes increasingly positive. 1

There is a sharp increase between the 1st and 2nd ionisation energy. The 1st ionisation removes the weakly held electron from the n=3 level, however the next electron must be removed from the filled n=2 level which is at much lower energy (closer to the nucleus). An even sharper jump occurs between the 9th and 10th ionisation energy as the latter requires removal of an electron from the lowest n=1 energy level.

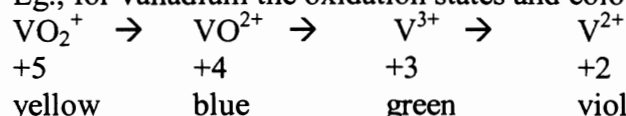
- (e) (i) A transition element is found in the block between the main groups 2 and 3 of the Periodic Table. Transition elements have partly filled d-sublevels

- (ii) Transition elements exhibit a range of oxidation states and associated colours.

A range of oxidation states is possible because of the closely spaced electron energies in the d and s subshells, allowing varying numbers of electrons to be lost by oxidation.

The colours of transition elements arise from electron movements between the closely spaced electron energy levels in the outermost d and s sublevels, the gaps corresponding to frequencies in the visible spectrum.

Eg., for vanadium the oxidation states and colours:



Transition metals also form a variety of complex ions; many of these ions are intensely coloured. The colour is determined by the central atom and the nature of the surrounding ligands, which determine the electronic energy levels.

Eg., $\text{Ni}(\text{H}_2\text{O})_6^{2+}$ is green, $\text{Ni}(\text{NH}_3)_6^{2+}$ is blue and $\text{Cu}(\text{H}_2\text{O})_2(\text{NH}_3)_4^{2+}$ is intense violet

Q32. Forensic Chemistry

- (a) (i) Organic compounds, often called carbon compounds, are compounds that contain mainly carbon and hydrogen. Inorganic compounds are those based on elements other than carbon.

- ii) 1. Addition of Na_2CO_3 . Alkanoic acids react with Na_2CO_3 to produce bubbles of CO_2 gas.

Alkanes, alkenes and alkanols do not react with Na_2CO_3 .

2. Addition of Br_2 (aq). Alkenes decolourise Br_2 (aq). Alkanes and alkanols do not react with Br_2 (aq).

3. Addition of Na (s). Alkanols react with Na (s) to produce bubbles of H_2 (g). Alkanes do not react with Na (s).

(Note – only 2 tests needed to distinguish between any THREE of these classes of compounds.)

- (b) (i) A disaccharide is a carbohydrate that can be hydrolysed into two simple sugars.

- (ii) Reducing sugars have an –OH group attached to the same C atom as a ring O atom is attached. These sugars, in their open chain structures, contain functional groups that are easily oxidized and so act as reducing agents. Oxidising agents such as Benedict's solution will react with these functional groups without oxidising the ordinary –OH groups present in all sugar molecules. Non-reducing sugars do not have an –OH group attached to the same C atom as a ring O atom. Non-reducing sugars therefore are not oxidised by Benedict's solution

- (c) Each element produces a unique line emission spectrum. To produce a spectrum, a sample of the material to be tested is vaporised in a flame and the light emission produced is detected using a photomultiplier and recorded on computer. A graph of light intensity as a function of wavelength can then be produced and compared to sample spectra allowing the identification of elements present in the sample.

Soil is a complex mixture of organic and inorganic material. Soils from different locations can differ greatly in colour, texture and pH. Measurements of these properties in small samples of soil cannot be done accurately, so analysis of soils is generally done by detecting the presence and amounts of some of the less common elements in the soil. This can easily be

achieved by producing and analysing the line emission spectrum of a soil sample. The detection of an unusual element in a sample can often pinpoint the location from which the soil came.

- (d)(i) 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 particles. The mass spectra of different compounds then are unique. If a data bank of mass spectra is available, the mass spectrum produced by a compound being analysed can be compared with those in the data bank and if a match is obtained the sample can be identified
- (ii) Each person's DNA is unique and so DNA analysis can be used to identify an individual. Matching DNA samples to those kept in data banks of DNA would allow for identification of a person who produced a biological sample at a crime scene. Data banks of DNA could also be useful in studying genetic diseases and tracing these diseases through family trees. There is considerable opposition based on issues such as the invasion of a person's privacy. An individual's non-criminal activities could be traced and used against them unfairly. An individual may be presented with genetic information about family history or a genetic disorder that they would prefer not to know about. The control of the use of information contained in a data bank of DNA would be very difficult. DNA information can still be obtained on a voluntary basis without the use of data banks.
- (e) Electrophoresis is a method of separating substances based on their charge and mass. A voltage is applied across the medium through which the substances are to be separated (often a strip of filter paper soaked in an electrolyte solution containing a suitable buffer). The direction and speed with which the substances move depend on their charge and mass. Amino acids are compounds that contain both an amine and a carboxylic acid functional group. They usually exist as dipolar ions (called zwitterions) in solution. At a particular pH (called the isoelectric point), the overall charge on these ions is neutral. If the pH is varied, the charge on the ion can be changed. The different possible charges depend on the structure of the amino acid. Each amino acid has a unique combination of structure, mass and isoelectric point.
- Electrophoresis is an extremely valuable method of identifying the amino acids present in a mixture as it allows the many different amino acids to be separated using this unique combination of structure, mass and isoelectric point. The degree of separation of different amino acids can be varied by varying the pH of the buffer solution used, making identification easier. Electrophoresis can be performed using relatively simple, inexpensive equipment compared to spectral analysis methods. Other methods such as chromatography are not as effective at separating and identifying amino acids.

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